EPA-901/9-76-003

SOCIOECONOMIC IMPACT ASSESSMENT OF PROPOSED AIR QUALITY ATTAINMENT AND MAINTENANCE STRATEGIES

By

Harbridge House, Inc.
11 Arlington Street
Boston, Massachusetts 02116

4 June 1976

Prepared under

EPA Contract No. 68-01-1561
Task Order No. 5

Prepared for

U.S. Environmental Protection Agency
Region I
Boston, Massachusetts

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EXECUTIVE SUMMARY

As part of the Air Quality Maintenance Planning (AQMP) procedure, Harbridge House, Inc., has assessed the socioeconomic impact of three strategies for attainment and short-term maintenance of sulfur oxide (SO_2) and particulate (TSP) standards in Connecticut. These strategies are:

- *The Permit Program:* This assessment addresses the potential impacts of the emission limitation [specified as Best Available Control Technology (BACT)] incorporated in Connecticut new source review procedure. Consideration was given to the entire Air Quality Maintenance Area (AQMA).

- *The Null Strategy:* Assessment of the null strategy addresses the potential impacts of constraints imposed by the air quality impact criteria incorporated in the new source review procedure. Analysis is based on the timing and location of potential violations of National Ambient Air Quality Standards (NAAQS) as provided by the Connecticut Department of Environmental Protection (DEP).

- *The Sulfur Strategy:* This assessment addresses the incremental impact of reducing the sulfur content limitation (in fuel) from 0.5 percent to 0.3 percent and applying this reduction to the seven towns in the Naugatuck Valley. Brief consideration was also given to the potential impacts of the Energy Supply and Environmental Coordination Act (ESECA), at the request of Region I, EPA.

The analysis has included evaluation of direct and indirect costs and benefits using quantitative as well as qualitative methods; it focused on incremental "order of magnitude" impacts of strategy implementation over a 10-year time frame.

Refinement of the DEP emission forecasts to make them more source specific and geographically precise provided a basic economic forecast which served as the point of departure for the impact assessments. The results of these analyses are briefly discussed below, and summarized in matrix form in Exhibits A and B. More detailed discussions of each strategy are presented at the end of Chapters III, IV, and V.

A. The Permit Program (Chapter III)

- Over the next 10 years the present value of program implementation costs is $990,000. This represents nearly 10 percent of the state's current budgetary expenditures for the DEP Air Section and 4.5 percent of the total (state and federal) annual Air Section allocations.

EXHIBIT A
DIRECT IMPACT SUMMARY

• Strategy – Sector	Costs Forecast Growth	Benefits Health and Welfare	 Demand Stimulation
• Permit Program			
– Manufacturing	I	M	M
– Commercial	I	M	I
– Institutional	I	M	I
– Municipal Waste Disposal	I	I	I
– Apartment Complexes	I	I	I
• Null Strategy			
– Manufacturing	I	S	NA
– Commercial	I	S	NA
– Institutional	I	S	NA
– Municipal Waste Disposal	I	M	NA
– Apartment Complexes	I	I	NA
• Sulfur Strategy			
– Manufacturing	I	M	NA
– Commercial/Institutional	I	M	NA
– Electric Utilities	I	M	NA
(Price of Electricity)	M	NA	NA
• ESECA			
– Electric Utilities	I	I	S
(Price of Electricity)	S	NA	NA

KEY
I = Insignificant Impact
M = Moderate Impact
S = Significant Impact
NA = Not Applicable

Source: Harbridge House, Inc. (1976).

EXHIBIT B
INDIRECT IMPACT SUMMARY*

	Costs															Benefits		
					Interaction with Other Programs**				Social Well-Being									
• Strategy – Region	Employ-ment	Population Distribu-tion	Develop-ment Patterns	Taxes	PEP – Resources	PEP – Forecasts	Economic Develop-ment	Land Use	Urban/ Rural	Planning Options	Local Decision Power	Income Distribu-tion	Recreation	Mobility	Community Structure	Attractive-ness	Orderly Growth	Resource Use Efficiency
• Permit Program – AQMA	M	I	I	M	M+	M-	M+	I	I	I	I	I	I	I	I	M	M	M
• Null Strategy – Six Airsheds	I	I	M	I	M+	M-	M-	M-	I	M	M	I	I	I	I	M	NA	M
• Sulfur Strategy – Naugatuck Valley	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	M	M	I
– ESECA – All of Connecticut	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	M

KEY

I = Insignificant Impact
M = Moderate Impact
S = Significant Impact
NA = Not Applicable (to either strategy under consideration or scope of evaluation conducted)

*Indirect impacts categorized as costs or benefits based on their origin in direct costs or benefits.
**Interaction with other programs can be conflicting (-) or complementary (+).

Source: Harbridge House, Inc. (1976).

- Over the next 10 years the present value of permit-related application and control costs is $20 million. Of these costs, 90 percent is incurred by the manufacturing sector. The impact of these costs was found most severe for:[1]

  - Fabricated metal products, with costs representing between 0.05 and 0.14 percent of the industry's value added in Connecticut. Slower growth in these industries in the state is expected through 1980 as a result of the permit program. No change in the industry's competitive advantage vis-a-vis other locations is expected to result from permit-related costs.

  - Primary metal products, with costs representing between 0.03 and 0.08 percent of the industry's value added in Connecticut. As with fabricated metal products, slower growth in the state is expected through 1980. No change in the industry's competitive advantage with regard to other locations is expected to result from permit-related costs.

- The present value of permit-related control costs alone over the next 10 years ($19.0 million) represents from 0.2 percent to 6 percent, on an annual basis, of the 1975 market for air pollution control equipment. Only modest stimulation of the air pollution control manufacturing industry is expected.

- The slowed rate of growth through 1980 in the primary and fabricated metal industries is expected to inhibit the rate at which 2,500 new jobs will be created in these industries and as many as 7,500 new jobs in supporting industries. The Central Connecticut, Central Naugatuck Valley, Greater Bridgeport, and South Central Connecticut RPA's would be most affected by this reduced rate of new job opportunities. Forecasted levels are expected to be reached by 1985.

- Implementation of the permit program was found to result in substantial costs savings in terms of air pollution damage. These savings are evident even at pollution levels below the standards.

- State sales and corporate income tax revenues are not expected to grow as rapidly through 1980 as forecasted.

- The permit program may indirectly promote more efficient use of resources, thereby complementing the objectives of the Department of Planning and Energy Policy (PEP).

- There is a conflict between the population projections adopted by the Department of Environmental Protection and the preliminary forecasts of PEP.

---

[1]The figures given for fabricated metal and primary metal products represent the high and low range of calculations.

- The permit program serves to mediate the environmental and economic goals of local development agencies.

- Permit program implementation will improve the quality of life for residents of the AQMA.

- The permit program will promote orderly growth.

- There is potential for the BACT requirement to promote more efficient manufacuturing processes though "productive" pollution control expenditures.

B. The Null Strategy (Chapter IV)

- Primary air quality standard violations are estimated in the following six towns within the AQMA:

New Britain:	TSP (1975); SO_2 (1978)
Hartford:	TSP (1978); SO_2 (1985)
Waterbury:	TSP (1978); SO_2 (1978)
Stamford:	SO_2 (1978)
Ansonia:	TSP (1980)
Middletown:	SO_2 (1985)

- Permit denials in these areas would preclude location of sources emitting TSP and/or SO_2 in from 3 to 11 percent of state's land area, populated by from 16 to 35 percent of the state's residents.

- The number of firms potentially affected by permit denials is estimated as follows:

  - 166 to 365 manufacturing firms (or 17 to 36 percent of forecasted AQMA expansion).
  - 154 to 297 commercial establishments (less than 3 percent of forecasted AQMA expansion).
  - 3 to 11 institutional establishments.
  - 2 to 5 municipal waste disposal facilities.
  - 3 to 5 apartment complexes.

- Three types of direct costs were assessed: growth-related opportunity costs, costs of dislocation, and costs of location at a less than optimal site. It was concluded that the impact of these costs on forecasted growth would be negligible in all sectors.

- Savings in costs associated with air pollution damage were found to be significant because of the danger of violating NAAQS.

- Job opportunities associated with establishments subject to permit denial will be relocated in the vicinity of the airsheds affected by such denial or at other centers of development in the Connecticut AQMA.

  - On an annual basis, the transitional unemployment in the airsheds represents, at most, 0.1 to 0.4 percent.

  - Population shifts accompanying employment shifts represent 2 percent or less of each airshed's projected 1985 population.

- Future development patterns will primarily reinforce current trends, with the exception of the airshed vicinities where unprecedented dispersion of development is likely.

- The null strategy will complement PEP's efficiency goals with regard to resource use, but indirectly may result in some adverse air quality impacts.

- Goals of the state's land use policy and of local economic development agencies will conflict with the null strategy.

- Local authority and the range of options for future planning considerations will be undermined.

- Residents of the affected airsheds will experience improved quality of life.

C. The Sulfur Strategy

- Assessment of the cost and availability of 0.3 percent sulfur residual indicates sufficient supply for Naugatuck Valley users at a price increase over 0.5 percent sulfur residual of not more than 6 percent.

- Increased costs of operation to manufacturers in the Naugatuck Valley are estimated to range from 0.003 to 0.2 percent. Increased costs of operation to the commercial sector are estimated to range from 0.003 to 0.008 percent. Negligible impact of the sulfur strategy is expected in both sectors.

- Electricity cost increases are estimated at about 2.2 percent.

- Both absolute and relative reductions in the costs associated with air pollution damage are expected. Health costs, in particular, will provide substantial benefits because of the higher proportion of elderly persons in the Naugatuck Valley versus the state as a whole.

- Fuel oil dealers may bear increased costs in providing storage facilities for 0.3 and 0.5 percent sulfur oil.

- The sulfur strategy will promote improved quality of life to residents, orderly growth within limits of NAAQS, and some increased conservation of energy.

- The impact of ESECA in Connecticut is estimated as follows:

  - Increased costs of pollution control equipment associated with conversion of four Connecticut plants from oil to coal firing would increase the average household's annual electricity bill by 8 percent.

  - The air pollution control expenditures required represent from 10 to 26 percent of the total U.S. 1975 market for control devices.

INTRODUCTION

A. Background

Pursuant to 40 CFR 51.12(a)-(h), as published in the *Federal Register* of 18 June 1973, and subsequently revised in 8 May 1974 (39 FR 16343), all states must identify geographic areas which exceed or have the potential for exceeding National Ambient Air Quality Standards (NAAQS) within the subsequent 10-year period. After these designated areas are reviewed, altered (if deemed necessary), and approved by the Environmental Protection Agency (EPA), each state is required to undertake a thorough analysis of the impact of growth and development on the area's air quality. Based on this analysis, the state is required to submit to EPA an Air Quality Maintenance Plan (AQMP). Where existing (measured and estimated) ambient levels of a pollutant exceed NAAQS, the plan must set forth a control strategy for reducing emission levels to the degree necessary for the attainment and then maintenance of the national standard. Where analysis shows that an area currently complying with NAAQS will not maintain pollutant levels consistent with the national standard over a 10-year period from the date of the AQMP's submittal, the state must develop an effective strategy to provide maintenance of air quality standards.

The original federal requirement called for submission of state plans by 18 June 1975. However, that date was substantially revised with the result that EPA's regional offices assumed a significant role in identifying plan requirements. The policy of Region I, under whose jurisdiction Connecticut falls, has been to concentrate on attainment and short-term (through 1978) maintenance strategies for particulates and sulfur oxides. Three New England states, including Connecticut,[1] were required to submit an appropriate plan by 31 December 1975.

1. AQMP in Connecticut

In May 1974, the Connecticut Department of Environmental Protection (DEP) identified a large region running north to south through the center of the state – roughly encompassing Fairfield, New Haven, and Hartford Counties – as having potential for exceeding NAAQS for particulates and sulfur oxides over the next 10 years. Designation of the area (shown in Exhibit 1) as an Air Quality Maintenance Area (AQMA) was approved by EPA.

In its first submittal of Air Quality Maintenance Plan information to EPA on 31 December 1975, DEP provided an analysis of air quality data and trends; a projection of the ambient SO_2 and TSP levels through 1985; and an identification of potential violations of the air quality standards by 1978. Strategies identified for avoiding potential violations did not constitute changes in any DEP regulations; instead, the state focused on a more rigorous application of existing regulations as well as increased efforts in promoting fuel conservation. The areas identified for application of the attainment/maintenance strategies are shown in Exhibit 1.

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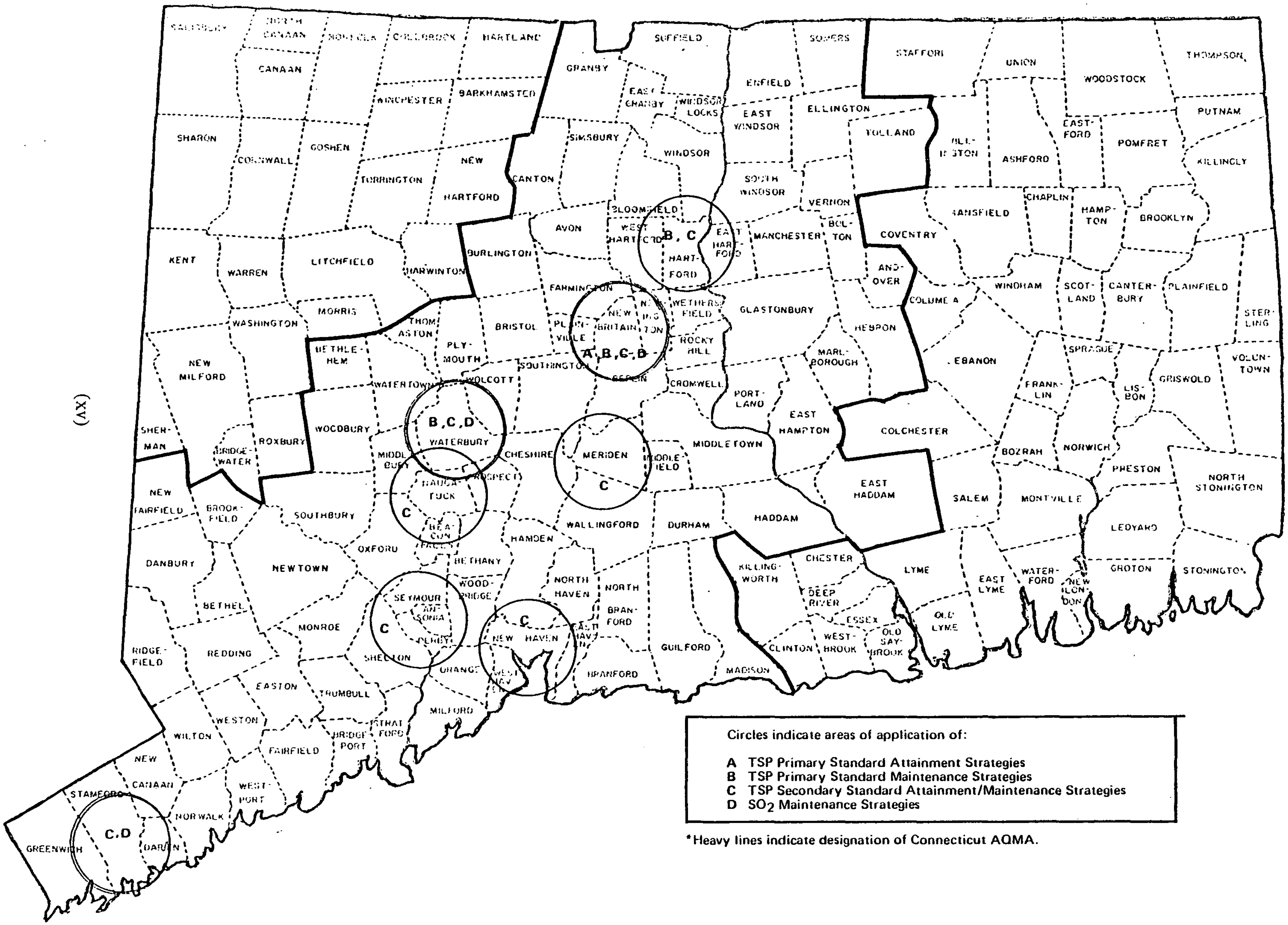
[1]The Region I Office of EPA has jurisdiction over all New England states. Rhode Island and Massachusetts were the other states required to submit plans by the end of December 1975.

EXHIBIT 1
STUDY AREAS FOR ATTAINING AND MAINTAINING AIR QUALITY IN CONNECTICUT*



Circles indicate areas of application of:

- A TSP Primary Standard Attainment Strategies
- B TSP Primary Standard Maintenance Strategies
- C TSP Secondary Standard Attainment/Maintenance Strategies
- D SO_2 Maintenance Strategies

*Heavy lines indicate designation of Connecticut AQMA.

(XV)

2. Study Purpose

A recommended part of the AQMP process involves evaluation of the socioeconomic impact of implementing proposed attainment/maintenance strategies. Harbridge House has been assisting the Connecticut DEP in this effort. Specifically, DEP selected three strategies for Harbridge House evaluation.

The first represents a continuation of the existing statewide permit system that requires all stationary sources of air pollution (except those sources specifically excluded) to show compliance with air quality criteria prior to initiation of construction and operation. In evaluating this strategy, referred to as the permit program, it was assumed that the ambient air quality impact of new stationary sources would not result in the denial of any permits. Consequently, the Best Available Control Technology (BACT) requirement of the permit program represents the major cause of socioeconomic impact.

The second strategy, referred to as the null strategy, is also a continuation of the new stationary source review procedure. For this evaluation, however, DEP provided estimates of the years in which ambient air quality impact of new sources would necessitate denial of permits in specified areas within the AQMA. The incremental impact of permit denials – over and above the impact of the permit program strategy evaluation – was analyzed in the null strategy.

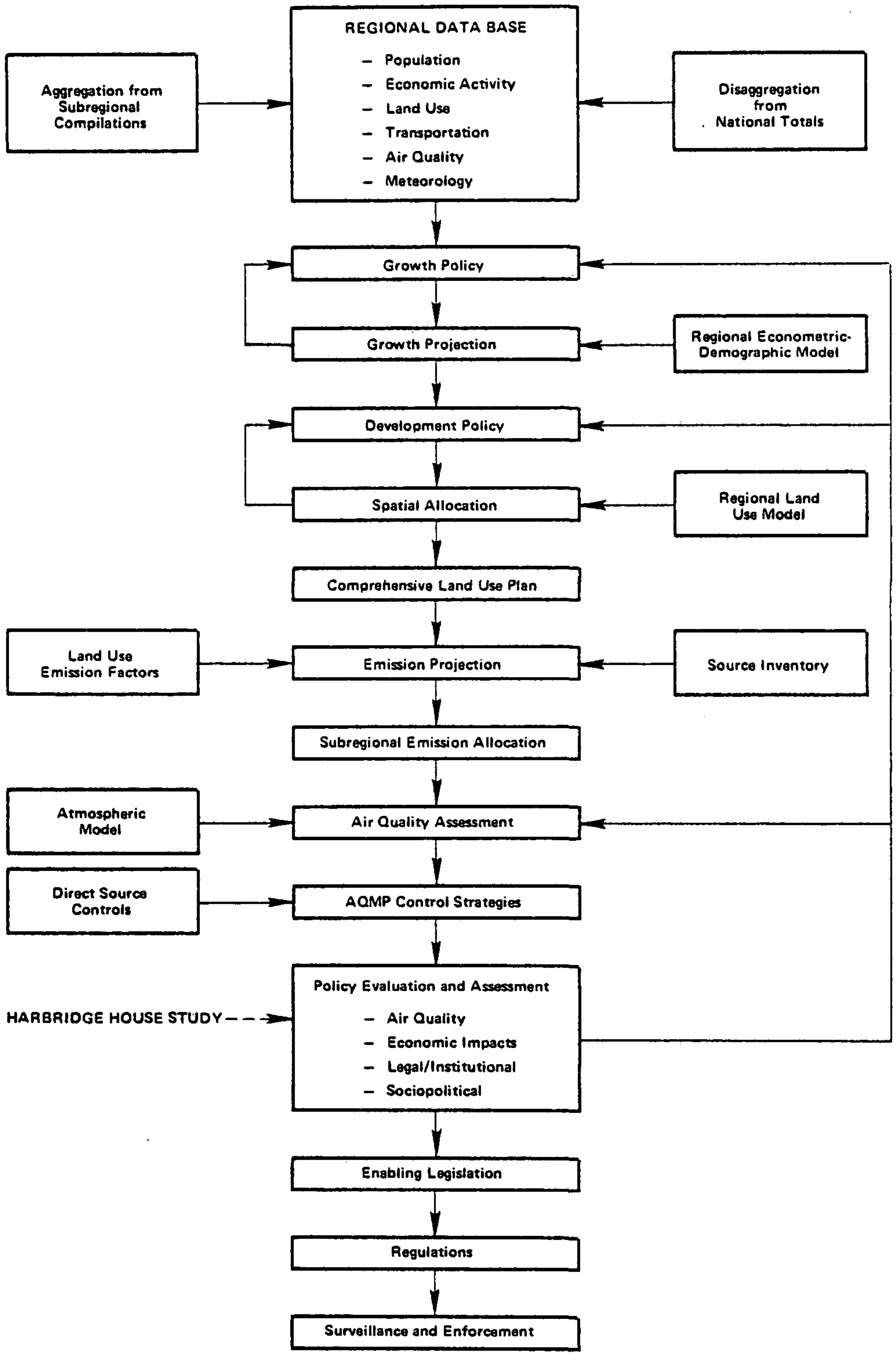
The third strategy is a variation of the DEP regulation limiting the sulfur content of fuels. Existing regulations limit sulfur content to 0.5 percent; the strategy evaluated by Harbridge House, however, examined the incremental impact of reducing the allowable sulfur content to 0.3 percent. Moreover, application of the sulfur strategy was limited to seven towns in the AQMA: Waterbury, Naugatuck, Beacon Falls, Seymour, Ansonia, Derby, and Shelton. (These towns are hereinafter referred to as the Naugatuck Valley.)

B. Approach and Scope

Exhibit 2 depicts the overall AQMP process and shows the point at which Harbridge House entered this process (see dotted arrow). As reflected in the exhibit, the present study represents a small portion of a much larger (and ongoing) process. However, the socioeconomic analysis can be considered an integral part of strategy development because of the interface between economic activity and air quality. To a large extent, this interface determines the need for ongoing maintenance strategies.

This study is primarily addressed to the economic activity-air quality interface. Just as the AQMP procedure requires emphasis on those pollutants having potential for exceeding NAAQS, this portion of the analysis calls for a more detailed evaluation of those sectors providing the greatest contribution to Connecticut's economic base, as well as those facilities having potential for contributing relatively greater amounts of the target pollutants to the ambient air. Furthermore, the Region I emphasis on the 1975 to 1978 period suggests that this analysis should focus on a similar time frame. However, because the indirect impacts of actions in this area cannot generally be identified over the short term, consideration has also been given to the 10-year period through 1985.

EXHIBIT 2
THE DEVELOPMENT AND IMPLEMENTATION OF AIR POLLUTION CONTROL STRATEGIES BASED ON AQMP



Source: *APCA Journal,* May 1975, p. 501.

Both the potential direct and indirect benefits and costs of strategy implementation have been evaluated in this study. The focus has been toward evaluation of incremental impacts, either quantitatively or qualitatively, depending on the reliability and detail of the available data base. All quantitative costs are represented in terms of present value. Because of the role of this analysis in the AQMP, emphasis has been placed on the relative ranking of costs, rather than absolute costs. In this manner, DEP's needs for socioeconomic input into its decision-making process could be met within the limited time available for the study.

C. Organization of the Report

The analysis and findings of this study are presented in five chapters and several appendices. The first two chapters reflect the data acquisition and forecasting efforts undertaken in preparing the impact assessments. Specifically, Chapter I introduces DEP's emission projections and their relationship to the study. This information provides the rationale for the level of analytic detail undertaken in subsequent chapters.

Chapter II summarizes the economic forecasts made by Harbridge House to serve as the basis for disaggregating the DEP emission projections by source type and location. The methodological assumptions and analytical limitations of the forecasts are also discussed.

The last three chapters describe the methods and findings of the socioeconomic impact assessment for each of the three strategies. Each chapter addresses an individual strategy.

A summary of the salient findings and conclusions has been included at the end of each chapter. In Chapters III, IV, and V matrices have been included to present the results without weighing one type of impact against another. The data are presented in this manner to allow decision-makers, at some future time, to assess the net impact of strategy implementation in light of a specific set of social goals and objectives.

The appendices included at the end of the report provide supporting data and more detailed descriptions of the methodological tools used in the assessment. Specific references to the appended materials are made throughout the study.

CHAPTER I: EMISSION PROJECTIONS

Exhibits 3 and 4 summarize DEP's particulate and sulfur oxide stationary source emission projections after control for the three counties that roughly comprise the AQMA. Based on the 1975 source contributions, electric utilities account for 71 percent of SO_2 emissions and 25 percent of particulate emissions; manufacturing accounts for 16 percent of SO_2 and 25 percent of particulate emissions; the commercial sector for 8 percent of SO_2 and 6 percent of particulate; and incineration (all types) for 3 percent of SO_2 and 38 percent of particulate.

Since this study addresses the future growth of specific sources as affected by air quality control strategies, it is important to note the major sources of emission increases (after control) from 1975 to 1985. During this period, a net increase in SO_2 emissions from all sources is forecast, as well as a net decrease in particulate emissions. Both SO_2 and particulate emissions from incineration and electric utilities are forecast to decrease or remain fairly stable over this same period. On the other hand, the manufacturing and commercial sectors are projected to represent over 75 percent of the gross forecasted increase in both particulate and sulfur oxide emissions. For SO_2, 54 percent of the gross increase is attributable to the commercial sector and 38 percent to the manufacturing sector. For particulates, the manufacturing and commercial sectors contribute 12 and 35 percent of the projected gross increase, respectively. These relative source contributions are summarized in Exhibit 5.

The DEP emission projections serve two purposes. First, they provide basic input to the DEP's air quality modeling effort, which identifies potential violations in the AQMA. (Moreover, since the manufacturing and commercial sectors are forecast to contribute over 75 percent of gross emission increases for both sulfur oxides and particulates, presumably, these sectors can be considered the major targets for maintenance strategies.)

Second, the emission projections, having been originally derived from economic activity forecasts (referred to as the OBERS-Series E) prepared by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce and the Economic Research Service (ERS) of the U.S. Department of Agriculture, provide a framework for the socioeconomic impact analysis. Moreover, the following growth assumptions were incorporated into the DEP projections:

- New, high-polluting industrial areas would not develop in the next 10 years.
- Economic and population growth rates are as derived from the BEA and ERS projections (OBERS-Series E).
- Electric utility and municipal and sewage sludge incineration source growth are based on planned capacity changes.

Using these growth assumptions, the Harbridge House analysis focused on potential modifications in the forecast growth that could result from implementation of the AQMP strategies.

EXHIBIT 3
DEP SULFUR OXIDE EMISSION PROJECTIONS
(tons/year)

SIC	Description	Fairfield County 1975	Fairfield County 1978	Fairfield County 1985	Hartford County 1975	Hartford County 1978	Hartford County 1985	New Haven County 1975	New Haven County 1978	New Haven County 1985	Total AQMA 1975	Total AQMA 1978	Total AQMA 1985
20	Food	53	56	66	57	58	67	99	102	118	209	216	251
22	Textiles	63	65	70	165	134	114	296	315	335	524	514	519
23	Apparel	18	19	22	2	2	2	27	28	31	47	49	55
24, 25	Lumber	1	1	1	10	11	13	31	33	40	42	45	55
26	Paper	53	63	1	527	493	504	311	335	397	891	891	982
27	Printing	4	4	5	49	52	63	36	42	54	89	98	122
28, 30	Chemicals, Rubber, Plastics	281	320	425	73	76	96	1,441	1,512	1,823	1,795	1,908	2,344
29	Petroleum, Asphalt	52	57	69	5	6	8	79	92	114	136	155	191
33	Primary Metals	116	120	131	77	74	76	1,429	1,414	1,414	1,622	1,608	1,621
19, 34	Fabricated Metals	474	511	626	364	382	454	713	762	922	1,551	1,655	2,002
35	Machinery	284	297	365	455	441	451	191	193	211	930	931	1,027
36	Electrical Machinery	411	439	578	422	443	523	54	101	124	887	983	1,225
37	Transportation Equipment	484	474	484	1,418	1,515	1,804	526	547	637	2,428	2,536	2,925
31, 32, 38, 39	Other Manufacturing	214	325	269	189	189	210	994	1,043	1,200	1,397	1,557	1,679
40 - 49	Transportation Communications	49	53	66	205	225	291	228	250	319	482	528	676
50 - 59	Wholesale, Retail Trade	72	77	95	221	239	296	252	265	314	545	581	705
60 - 69	Finance, Insurance	550	634	856	418	461	607	462	519	682	1,430	1,614	2,145
70 - 89	Services	1,023	1,138	1,549	1,108	1,260	1,727	2,291	2,642	3,777	4,422	5,040	7,053
91 - 93	Government	377	415	550	245	268	351	106	116	152	728	799	1,053
	Electric Utilities	19,724	19,724	19,724	3,889	3,889	3,889	32,392	32,392	32,392	56,005	56,005	56,005
	Sewage Incineration	4	4	4	4	5	6	5	7	9	13	16	19
	Municipal Incineration	1,081	850	–	334	–	–	263	271	25	1,678	1,121	25
	Other Incineration	10	10	10	22	22	22	254	254	254	286	286	286
	TOTAL	25,406	25,664	26,054	10,428	10,415	11,756	42,634	43,387	45,501	78,475	79,474	83,323

Source: Connecticut Department of Environmental Protection (1975).

EXHIBIT 4
DEP PARTICULATE EMISSION PROJECTIONS
(tons/year)

SIC	Description	Fairfield County 1975	1978	1985	Hartford County 1975	1978	1985	New Haven County 1975	1978	1985	Total AQMA 1975	1978	1985
20	Food	20	20	24	17	17	19	26	26	31	63	63	74
22	Textiles	15	15	17	28	24	20	72	81	86	115	120	123
23	Apparel	8	8	9	0	0	0	5	6	6	13	14	15
24, 25	Lumber	0	0	0	2	2	3	2	2	3	4	4	6
26	Paper	14	16	21	154	142	146	92	97	115	260	255	282
27	Printing	0	0	0	11	11	13	4	5	6	15	16	19
28, 30	Chemicals, Rubber, Plastics	84	98	131	17	19	24	400	429	519	501	546	674
29	Petroleum, Asphalt	24	28	35	3	4	5	11	14	18	37	45	56
33	Primary Metals	32	39	43	29	34	34	341	402	402	402	475	479
19, 34	Fabricated Metals	113	129	159	97	108	129	186	211	256	396	448	544
35	Machinery	72	76	94	169	164	169	43	44	49	284	284	312
36	Electrical Machinery	123	133	172	40	42	50	23	26	31	186	201	253
37	Transportation Equipment	139	134	138	662	694	829	224	229	264	1,025	1,057	1,231
31, 32, 38, 39	Other Manufacturing	58	61	74	54	54	61	525	554	641	637	669	776
40 - 49	Transportation, Communications	7	8	10	53	65	85	64	77	100	124	150	195
50 - 59	Wholesale, Retail Trade	9	10	13	41	49	62	45	52	63	95	111	138
60 - 61	Finance, Insurance	112	145	196	102	126	166	42	52	68	256	323	430
70 - 89	Services	145	181	244	183	231	316	352	454	649	680	866	1,209
91 - 93	Government	70	85	114	54	66	87	574	706	925	698	857	1,126
	Electric Utilities	1,403	1,403	1,403	1,050	1,050	1,050	1,493	1,493	1,493	3,946	3,946	3,946
	Sewage Incineration	14	15	16	13	17	21	18	27	34	45	59	71
	Municipal Incineration	2,165	99	–	1,326	–	–	1,987	2,043	122	5,478	2,142	122
	Other Incineration	74	74	74	278	278	278	257	257	257	609	609	609
	Agriculture, Mining, Construction	3	3	4	26	28	29	33	32	37	62	63	70
	TOTAL	4,704	2,780	2,991	4,427	3,244	3,616	6,819	7,319	6,175	15,950	13,343	12,782

Source: Connecticut Department of Environmental Protection (1975).

EXHIBIT 5
RELATIVE SOURCE CONTRIBUTIONS TO 1975 EMISSION INVENTORY AND GROSS EMISSION INCREASE, 1975 TO 1985
(AQMA only)

1975 Relative Contributions	**Particulates**	**Sulfur Oxides**
Electric Utilities	25%	71%
Manufacturing	25%	16%
Commercial	6%	8%
Incineration	38%	3%
Percent of Gross Increase, 1975-1985		
Electric Utilities	0	0
Manufacturing	42%	38%
Commercial	35%	54%
Incineration	(neg.)	(neg.)

Source: Based on Connecticut Department of Environmental Protection Projections (1975).

CHAPTER II. FACILITY FORECASTS

In order to use the economic growth assumptions incorporated in the DEP emission projections, certain refinements in the OBERS-E forecasts were required. Specifically, the Harbridge House study team used these forecasts as a basis for developing a more source-specific and geographically precise data base.[1] Furthermore, the forecasts developed attempted to take into account recent economic changes that were not available as input to the original OBERS projections.

Over the short term (1975 to 1978), a greater level of detail in the forecasts was sought for consistency with EPA Region I policy for the AQMA plans. The effort focused on telephone interviews with industry representatives and individual firms in Connecticut to identify known plans for expansion. The assistance of cognizant state and local agencies was also sought. In the absence of known expansion plans, interviewees were questioned as to which economic or demographic indicators were typically watched as a measure of future expansions. Linear regressions based on these economic indicators were then utilized to make long-term projections and to round out the short-term forecasts. The criteria used in making all the forecasts was that of reasonableness. Insofar as possible, assumptions have been noted and factors influencing any identified changes in historical patterns have been explained.

OBERS-E population projections were utilized as an indicator of demographic parameters. Preliminary results from 1974 population projections undertaken by the Connecticut Office of Planning and Energy Policy provided a basis for disaggregation of the statewide totals at the Regional Planning Agency (RPA) level. More recent population projections as well as the 1975 estimated population figures indicate that the OBERS-E population projections may be significantly optimistic. However, designation of the AQMA based on OBERS served as the guidepost in the Harbridge House decision to use the Series E input. Consequently, the results of this study, as they relate to future population growth, may tend to exaggerate certain costs as being higher than actually indicated by recent demographic trends.[2]

Whenever possible, projections were made at the RPA level. The delineation of these regions within the AQMA is shown in Exhibit 6. When a sufficient data base was not available at the RPA level, statewide forecasts were made and then disaggregated, based on the relative location of existing activity and a comparison with land use maps. This approach is consistent with that used for the air quality projections.

Similarly, the forecasting effort did not attempt to differentiate among the various products, processes, sizes, and so forth, comprising economic growth within individual industries. Instead, forecasts were developed to reflect the number of

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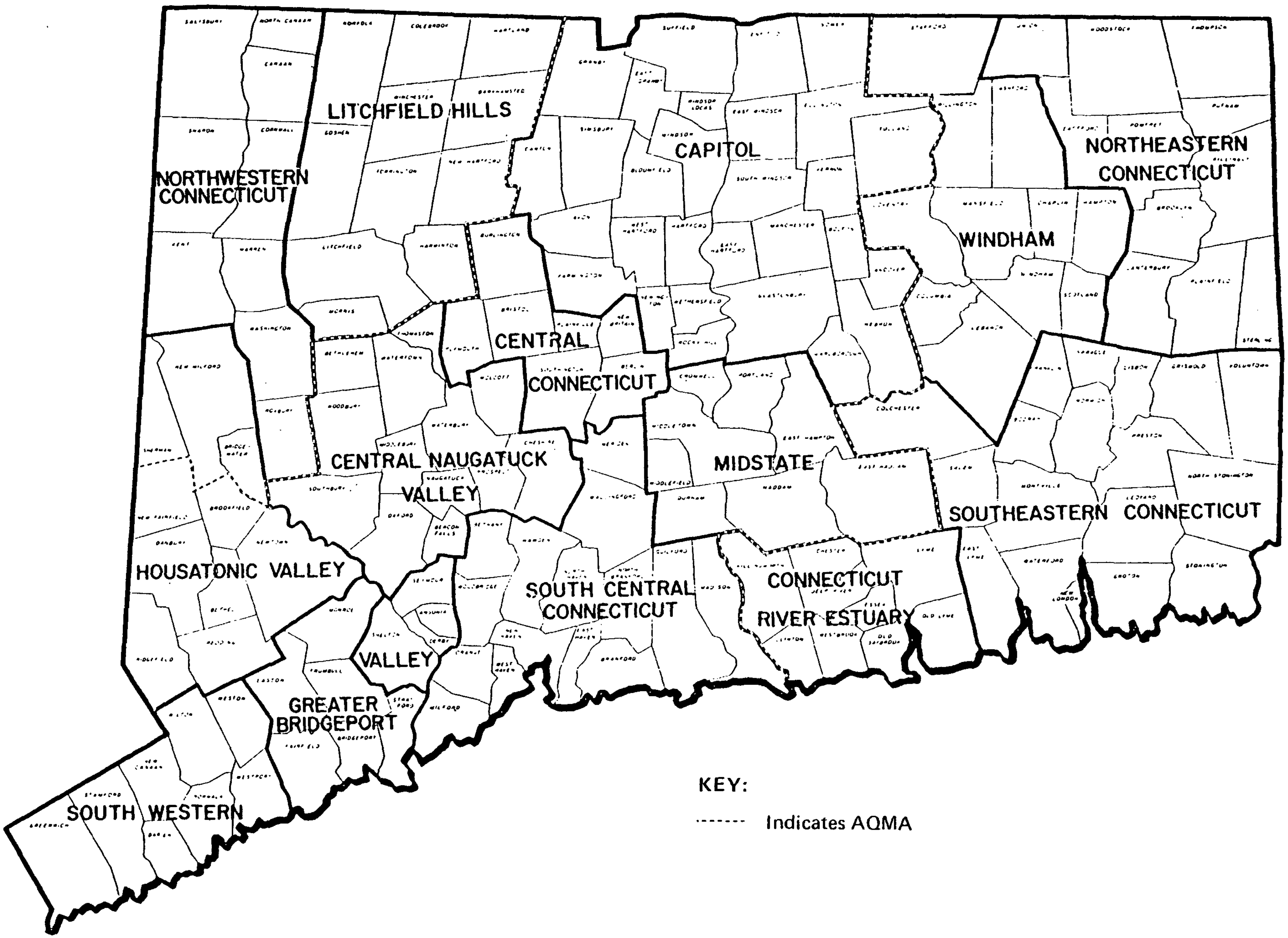
[1] As a rule OBERS information should not be stepped down below an SMSA level (SMSA's are the counties in Connecticut). Consequently, in refining the OBERS projections, supplementary data as site specific as possible were obtained and utilized.

[2] This issue is discussed further in Chapter III. C, and in Appendix A.

EXHIBIT 6
DEFINITION OF REGIONAL PLANNING AREAS (RPA'S) IN THE AQMA



KEY:

------ Indicates AQMA

representative facilities which could reasonably be expected to locate within an area. Moreover, the economic growth forecasts were reduced to projections of the number of new sources subject to review based on the exemptions written into the DEP regulations. Because of the specificity of the exemptions, the following assumptions were made:[1]

- Manufacturing: All new sources must make permit applications for either fuel burning, incineration, or process emissions.[2]
- Commercial: Permit approval must be obtained for both fuel burning and incineration (except restaurants which apply only for incineration permits).[3] Facilities with fewer than 20 employees were assumed to be exempt (based on the 1972 facility size distribution).
- Institutional: Permit approvals must be obtained for both fuel burning and incineration (except veterinary clinics which apply only for incineration permits). Permit exemptions are integrated into the forecasts.[4]
- Municipal Waste Disposal: All must apply.
- Electric Utilities: All fossil plants must apply.
- Apartment Complexes: Only those with more than six family units need apply for incineration or fuel-burning permits. Exemptions are integrated into the forecasts.

The forecasting procedures are summarized below by sector.

A. Manufacturing

Projections of industrial activity in Connecticut, as measured by value added, were developed by aggregating processing types at the two-digit Standard Industrial Classification (SIC) level.[5] The methodology for determining the specific long-term growth rate for each SIC involved interviewing Connecticut firms and national trade associations to determine economic indicators watched by each industry as measures of potential growth. Linear regressions were then calculated using the indicators most often cited by each

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[1]See Appendix B for a listing of permit exemption criteria.

[2]Process sources are defined by DEP as, "any operation, process, or activity except (1) the burning of fuel for indirect heating in which the products of combustion do not come into contact with process material, (2) the burning of refuse, and (3) the processing of salvageable material by burning."

[3]The DEP permit records showed several restaurants, all of which were fast food operations, applying for incineration permits.

[4]Based on DEP permit history.

[5]Value added, rather than manufacturers' earnings (as suggested in Volume I of EPA's *Guidelines for Air Quality Maintenance Planning and Analysis)*, was used to prevent double counting in the projection of an industry's long-term growth trend.

industry.[1] The projected value added was converted to number of establishments by using the average value added per establishment (1972), and assuming that facilities were operating at 80 percent of capacity in 1972.[2]

Several sources of information were used to refine and modify the forecasts as needed. In addition to the telephone interviews conducted by Harbridge House, surveys of plant expansions were made by the Connecticut Department of Commerce,[3] press releases were issued by the Connecticut Development Authority,[4] and insofar as time permitted, *Dodge Bulletins* of planned construction were utilized.[5] Appendix C describes these sources and their use in greater detail.

Once the forecasts were completed, allocation of establishments among RPA's was based on the 1974 distribution of employment by labor market area. As previously noted, it was assumed that all the forecast manufacturing establishments would require permits for fuel burning, incineration, or process emissions.[6]

B. Commercial Sector

The commercial (non-institutional) forecasts were developed for five groups: wholesale trade, retail trade (except restaurants), restaurants, finance insurance and real estate, and services (except health and educational).[7] OBERS-E projected earnings for each of these groups served as the projection base. In the case of retail establishments and restaurants, *Sales Management Magazine* was used to refine and modify the OBERS-E

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[1]Projections were based on disposable income for SIC's 20, 25, 28, 30, 39; housing starts for SIC's 22, 37; historical value added for SIC's 23, 24, 26, 27, 29, 31, 32; GNP for SIC's 33, 34, 35, 36; and new equipment purchases for SIC 38.

[2]Since 1950, the capacity utilization rate has ranged from 75 to 92 percent for all manufacturing nationwide. Specifically for 1969 through 1974 the rates were 1969 – 87%; 1970 – 78%; 1971 – 75%; 1972 – 79%; 1973 – 83%; and 1974 – 80%. Primary processing is usually slightly higher, while advanced processing is usually slightly lower. Source: U.S. Department of Commerce. *Statistical Abstract of the United States, 1974*, p. 715. It has been assumed that these nationwide figures are representative of Connecticut manufacturers.

[3]Connecticut Department of Commerce. *Statistical Survey of New Manufacturing Firms 1963-1972* and *Major Industrial and Corporate Expansion 1973, 1974.*

[4]Press releases from Connecticut Development Authority regarding firms which obtained financing through the Authority.

[5]McGraw-Hill Information Systems Co., *Dodge Bulletins.*

[6]In operation, the new source review procedure would probably not affect many small or otherwise exempt facilities. However, the forecasted growth is presumably representative of average facilities which would, more than likely, require permit approvals.

[7]Restaurants were separated from retail trade because the DEP permit records indicated that all restaurant applications were for incinerators at fast food establishments, whereas retail trade applications were for both incineration and fuel-burning permits. Health and educational facilities are treated under the institutional sector.

projections, particularly over the short term.[1] Conversion of projected earnings (OBERS-E) and sales *(Sales Management)* to the number of representative establishments required consideration of a hypothetical sales saturation point; that is, a point beyond which a market has expanded sufficiently to make the construction of a new establishment economically feasible. Historical data for Connecticut and the nation as a whole indicate about a 35 percent increase over five years in sales/earnings per establishment within each of the five commercial groups.[2] On this basis it was estimated that over the 10-year forecast period, 70 percent of increased sales would be absorbed by existing establishments. The facility forecast appeared reasonable in light of available data regarding existing establishments and planned expansion.

Based on the history of permit applications and the exemptions to new source review, it was assumed that only a small portion of the forecasted commercial facilities would require permits. Moreover, it was considered reasonable to base the exemptions on size. Using the 1972 employment size distribution, the percentage of establishments with fewer than 20 employees were excluded from the commercial permit forecasts. Allocation by RPA was based on total building permit distribution in 1974.[3]

C. Institutional Sector

The following types of facilities were identified as potential sources of air pollution: hospitals, mental health facilities, mental retardation facilities, nursing homes, veterinary clinics, and schools. Evaluation of future growth was based primarily on telephone interviews regarding planned expansion and future requirements. No growth is forecast for hospitals, mental health facilities, and mental retardation facilities. The basis for this conclusion is given in Appendix D. Forecast procedures for the other institutional groups are summarized below.

1. Nursing Homes

Chronic illness and convalescent nursing homes are expected to grow from 1975 to 1985. Connecticut currently has 19,592 licensed nursing home beds, for a ratio of 75.5 beds for every 1,000 persons over 65. An additional 4,979 licensed beds are expected to be constructed by 1980. The 1980 total of 24,571 beds, a ratio of 70 beds per 1,000 persons over 65, is expected to adequately serve the state's needs at that time.[4]

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[1] *Sales Management Magazine*, "U.S. Metropolitan Area Projections." 21 July 1975.

[2] At least two factors may be working here – an increase in the size of establishments and a sales saturation point. Consequently, conclusions drawn on this basis must be considered "best guesses." Historical data on Connecticut sales or earnings per establishment obtained from *Statistical Abstract of the United States 1974*.

[3] The 1975 building permit distribution was considered a more appropriate indicator of future commercial activity because of the rapid development in the Housatonic RPA which is not immediately reflected in population distribution. Overall, the *Construction Authorized by Building Permits* (Department of Community Affairs – 1974) corresponds well with population distribution.

[4] Thomas Redding, Chief of Health Facility Construction, Hospital and Medical Care Division, Department of Health, State of Connecticut. Telephone interview 24 November 1975.

Projected nursing home needs for 1985 were based on the ratio of beds/1,000 persons over 65. This ratio was derived for each regional planning area, based on population estimates by age distribution. The average ratio calculated for 1975 in the nine RPA's was 60.56 beds/1000. This ratio is at variance with the Connecticut State Health Department's 1975 ratio of 75.5 beds/1000 population of elderly. This discrepancy may be attributed to a difference in population estimates – that is, the Health Department's estimates are somewhat lower than those employed here. As a result, the needs projected by this analysis may be considered to be the maximum expected needs. Based on these regional calculations, the nine RPA's within the AQMA will require 854 additional beds between 1980 and 1985.

Current trends in size and location of nursing home facilities will affect the allocation of additional beds. In particular, the emphasis is toward larger facilities and suburban (as opposed to urban or rural) locations. To account for these trends, the average size of the largest 25 percent of existing nursing homes was calculated and found to equal 155 beds per facility. It was then assumed that nursing homes constructed over the next 10 years would contain approximately 150 to 160 beds each. Moreover, because of the relatively large average size of the forecast facilities it was assumed that 90 percent of the nursing homes would require permit approval. Taking into account the needs of more highly populated regions and the availability of suburban sites, facilities were allocated among RPA's within the AQMA.

2. Veterinary Clinics

In the absence of a more reliable basis for projecting the number of veterinary clinics, it was assumed that growth in the number of facilities requiring permits would be proportional to growth in population. As previously noted, all permits issued for veterinary clinics in the past three years were for operation of pathological incinerators.

3. Schools

Data on planned expansion and construction of new public school facilities were obtained from the Connecticut School Building Unit, which provides state financial assistance to public school projects.[1] The information was categorized by these types of activity: extensions, alterations, extension-alterations, purchases, site improvements, and new construction. For each facility the location and project cost were shown; some projects had a brief description indicating, for example, a gymnasium, or a given number of classrooms to be constructed.[2]

For the purpose of this analysis, it was determined that only new construction, extensions, and extension-alterations would be applicable. Inclusion of the extension-alterations was based on the determination that overestimation would be more consistent with the study's objectives ("worst-case scenario") than underestimation. Only those projects within the AQMA were considered (see Appendix E for listing). Since no data

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[1] Carl D. Paternostra, Unit Head. *Project Resume.* School Building Unit, State of Connecticut. 5 September 1975.

[2] More detailed data were not available within the time frame of the current study.

indicating construction starts were available, it was assumed that no construction would take place between 1975 and 1978. Moreover, only those projects with total costs of greater than $500,000 were assumed to require permits.

The long-term forecast of school facilities was based on indices of school needs described in Appendix E. It was concluded that no new school construction would be required from 1978 to 1985. Separate consideration of private school and public higher education facilities was not undertaken due to time and data limitations. In addition, it was assumed that no expansion of these schools will take place through 1985. Over the short term (1978), this assumption may be considered to have relatively greater reliability because of the state of the economy as well as the financial difficulties of private schools and higher education facilities nationwide. Furthermore, no evidence has indicated a deliberate departure from nationwide trends.

D. Municipal Waste Disposal

No new municipal refuse incinerators were forecast to come on line during the study period, based on interviews with representatives of the DEP and the Resource Recovery Authority.[1] This is largely because of the scheduled construction of 10 Resource Recovery Plants and their cost advantages for solid waste disposal. (The Resource Recovery Plan and plant construction schedule is described in Appendix F.) However, it is probable that new sewage sludge incinerators will come on line during the forecast period. Itemization of the planned capacity was obtained from DEP, based on the estimates of the department's Water Compliance Section (see Appendix G).[2]

E. Electric Utilities

The DEP projections assumed that the new fossil plant in New Haven Harbor came on line in 1975. Two small plants are under study for location in Wallingford;[3] their exclusion from DEP projections, however, indicated that a similar assumption should be made in this analysis. Consequently, no growth in fossil capacity is projected from 1976 to 1985.

F. Apartment Complexes

Projected apartment complex construction to 1985 was based on a continuation of past trends in residential construction activity in Connecticut at an average annual growth

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[1] Richard Chase, President, Resource Recovery Authority. Telephone interview 25 November 1975, and Charles Kurker, Principal Sanitary Engineer, Chief of Technical Services, Solid Waste Office, Connecticut Department of Environmental Protection 12 November 1975.

[2] Greg Wight Air Compliance, Connecticut DEP, Telephone interiew 8 March 1976.

[3] New England Power Planning. *New England Load and Capacity Report, 1974-1985.* 1 April 1975. Wallingford plants are indicated to be 9M and 20 MW respectively. (November 1975 update is not available as of March 1976.)

rate of about 2.81 percent.[1] This growth rate was then projected on a year-by-year basis, using as a base figure the number of 1974 building permits issued for residential dwellings of five units or more plus those issued for publicly assisted residential construction.[2] (It was assumed that all publicly assisted residential construction was comprised of complexes with more than six family units.)

Two considerations indicated that the forecast was overly optimistic. First, not all projects for which building permits are filed actually are constructed. Second, only some portion of those constructed would require permit approval (for either incineration or fuel burning). In order to accommodate these factors the DEP permit history was compared with building permits issued from 1972 to 1974. This ratio was used to convert the projected building permits to DEP permit applications.[3] Allocation by RPA was based on the 1974 residential building permit applications.

G. Summary

The purpose of the economic forecasts described in this section has been to break down the DEP emission projections (Chapter I) by type of source and location for use in subsequent impact analyses. Exhibit 7 gives a summary of these forecasts. It shows the number of facilities which are estimated to be subject to new source review from 1976 to 1985 by source type and by region. According to the results of the forecasts, 55 percent of the AQMA growth in facilities subject to new source review is estimated to be in the commercial sector, while 40 percent is estimated to occur in the manufacturing sector.

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[1] Historical data from *New England Economic Indicators* (Federal Reserve Board).

[2] State of Connecticut, Department of Community Affairs. *Construction Authorized by Building Permits.* (1974).

[3] Because the DEP permit history pertained only to the AQMA (whereas building permits encompassed the entire state) and because DEP permits were issued for only part of 1972, a 70 percent increase in the ratio of DEP permits to building permits was factored in. Although the 70 percent figure was arbitrary, the resulting forecast appeared to be reasonable.

EXHIBIT 7
FORECAST SUMMARY: ESTIMATED NUMBER OF FACILITIES SUBJECT TO NEW SOURCE REVIEW, BY REGION (1976 - 1985)

	Regional Planning Areas									
Sources by SIC	Capital	Central Conn.	Mid-state	Central Nauga-tuck	Housa-tonic	Valley	Greater Bridgeport	South Western	South Central Conn.	Total in AQMA
Manufacturing										
20	11			4			5	8	6	34
21										0
22	4		1	1			4	2	4	16
23	2		1				2	1	2	8
24	3	1	1		2				3	10
25	8	2	2		6	1	1		8	28
26	6	1	2	1	4	1			6	21
27	26			4			12	25	21	88
28	3		5	13				13	8	42
29	2		1	1	1		1	1	1	8
30	5		7	20		3	14		15	64
31	2		1				2	1	2	8
32	7	2	2	2	2		2	2	4	23
33	3			10		4	10		12	39
34	14	31	7	34	7	3	22	17	25	160
35	65	52	7	13	13	8	39	41	20	258
36	11	8	4	7	6		18	11	10	75
37	6	1		2		1	3		2	15
38	5			10	9		6	2		32
39	17	6	3	7	4	1	12	8	10	68
Commercial										
50	45	15	10	15	12	2	12	15	25	151
52 - 59 except 58	152	152	44	66	77	43	77	77	66	754
58	40	40	8	35	28	17	28	28	35	259
60 - 67	18	6	4	6	14	1	5	6	10	70
70 - 89 except 80, 82	53	18	4	18	5	2	14	18	30	162
Institutional										
Nursing Homes	2	2	3	3	3	2	0	2	2	19
Veterinary	3	2	2	3	3	2	2	3	3	23
Schools	12	0	0	2	0	0	7	8	1	30
Municipal Waste										
Resource Recovery	2	1	0	1	1	1	1	1	1	9
Sewage Sludge	2	0	1	0	0	0	0	0	2	5
Electric Utilities	0	0	0	0	0	0	0	0	0	0
Apartment Complexes	3	1	1	1	2	0	1	1	2	12

Source: Harbridge House, Inc. (1975). (See text for methodology and assumptions.)

CHAPTER III: IMPACT ASSESSMENT – THE PERMIT PROGRAM

A. Background and Approach

The forecasts presented in the preceding chapters represent a future pattern of land use, degree of economic activity, and a level of pollutant emissions in the Connecticut AQMA. These factors and others are implicit in the concept of growth. Within this context, the permit program imposes both constraints and incentives to growth and may differentially affect the various growth parameters. Consequently, this impact assessment must address the modification of forecasted growth implications resulting from strategy implementation.

A distinction has been made in this study between impacts attributable to strategy implementation and those attributable to other environmental programs, such as new source performance standards. The purpose of this differentiation has been to allow evaluation of the strategy's incremental impact.

A further distinction has been made between direct and indirect impacts. Such a delineation is admittedly hazy and is not intended to be an indication of the impact's intrinsic importance. In the interest of clarity and brevity, the study team found it generally useful to regard direct impacts on a sectoral basis and indirect impacts on a regional or topical basis.

Similarly, the distinction between quantitative and qualitative evaluation of impacts in this assessment should not be considered a reflection of the level of importance. In areas where measurement is largely subjective, such as in evaluation of health benefits, rigorous analysis of the approximate magnitude of the impact was considered less useful and substantially more prone to misinterpretation than definition of the relationships involved. Wherever possible, however, quantitative data developed for other areas have been referenced to provide a perspective on the potential impact levels.

In this assessment several references are made to "worst case" assumptions. Essentially, such references mean that the reliability of data was not sufficient to base a conclusion on the "reasonableness" criteria. As an alternative, therefore, the required assumption was designed to bracket the upper level of impact that could potentially result.

B. Direct Costs

1. Public

Current annual costs for implementation and enforcement of the permit program have been estimated at $78,800 as shown in Exhibit 8. Implementation costs represent $71,800, or 91 percent of this total. The types of activities included in implementation include review of permit applications and plans submitted by companies and agencies; participation in public hearings; and involvement in a form of pre-enforcement which involves review of current Dodge Construction Reports, notification of potential applicants, and distribution of questionnaires. Enforcement costs, accounting for the remaining 9 percent of the program's costs, include participation in the public hearing process, monitoring, enforcement of permit denials, and stack testing.

EXHIBIT 8
ESTIMATED CURRENT ANNUAL IMPLEMENTATION AND ENFORCEMENT COSTS OF THE PERMIT SYSTEM*

Implementation Costs		**Costs per Year**
Labor**		
6 engineers (part-time) @ $12,500	$52,500	
1 stenographer (part-time) @ $6,000	4,200	
1 technical administrator (part-time) @ $17,500	12,250	
Total Labor Cost	$68,950	
Computer**	300	
Supplies***	420	
Dodge Construction Report Bulletin**	1,500	
Travel – Car†	630	
Total Implementation Costs		$71,800.00
Enforcement Costs††		
Labor		
5 engineers (part-time) @ $1,300 per year	$ 6,500	
Travel	300	
Miscellaneous Materials & Supplies	200	
Total Enforcement Cost		7,000.00
TOTAL DIRECT COST OF PERMIT SYSTEM		$78,800.00

*Based on approximately 400 permits per year.

**Shelton Edwards, Principal Air Pollution Control Engineer, Air Compliance Unit, Connecticut Department of Environmental Protection, telephone interviews 24 October 1975 and 4 December 1975. Labor cost estimate – the engineers and support staff involved with the permit system allocate approximately 70 percent of their total time to the permit system and approximately 30 percent to the tax certification program. Therefore, cost estimates are for 70 percent of their total salary.

Computer Cost – Total cost estimate of $300 is exclusively for permit system. It should be noted that there are external requests for information on the permit system, and these costs may sometimes require an additional $1,000 per year. The amount varies with the nature of the request.

Dodge Construction Report Bulletin is used specifically by the engineers as an aid in determining who is planning construction and who will need permits.

***Robert Randall, Business Manager of the Air Compliance Unit, Connecticut Department of Environmental Protection, telephone interview in December 1975. Supply costs for the engineering department, which employs approximately 32 people, are approximately $2,500 per year. Based on the assumption that the amount of supplies consumed is directly proportional to the number of people working, it was determined that the eight people working on the permit system would use approximately $600 per year. However, only 70 percent of the $600 would be used in the implementation of the permit system.

†The engineers have access to cars from the state government car pool, and the cost of this is borne by the Air Unit of the Connecticut Department of Environmental Protection. In order to estimate a direct cost for the use of the government cars, we have used current economy car rental costs as a basis. (This methodology probably overestimates the cost of using government cars.) The estimated car costs were based on a utilization rate of 10 hours per month at 500 miles per month, cited by Shelton Edwards, Principal Air Pollution Control Engineer, Department of Environmental Protection, telephone interview 24 October 1975. A $75 monthly cost estimate was arrived at assuming $10 fee for use of car; $0.10 per mile; and gasoline at $0.60 per gallon with an average of 20 miles per gallon.

††James Vickery, Principal Air Pollution Engineer, Air Quality Enforcement, Connecticut Department of Environmental Protection, telephone interview 24 November 1975. The labor category is comprised of only engineers based on experience to date with program implementation. In using these costs to project future requirements, lawyers were not included because public hearings were not expected to pose an increased demand on the expertise of DEP personnel.

The total cost of $78,800 involves processing of about 400 applications – half for construction permits and half for operating permits. Processing each application, therefore, on the average requires about $200 of DEP funds. Increases in the number of permit applications over the next 10 years have been estimated to range from 50 to 100 per year by one source,[1] and at an average annual rate of 10 percent per year by another source.[2] Assuming a 10 percent annual growth rate (including permit renewals), the present value of the program costs over the next 10 years is about $990,000.[3] This represents nearly 10 percent of the state's current budgetary expenditures for the DEP Air Section and 4.5 percent of the total (state and federal) annual Air Section allocations.

2. **Private**

a. **Application Costs.** The direct cost initially experienced by the private sector involves the application for a permit to construct. Several types of costs may be incurred here. For example, all sources required to file a permit application have to bear the administrative costs of completing the appropriate forms. In addition, roughly 10 percent of the sources are required to submit documentation of stack emissions, which often requires additional expenditures. Another cost associated with the application procedure involves preparation for public hearings, which are currently required of all sources emitting more than 100 tons of pollutants per year (before control) or which may be requested by the general public.

Quantification of these types of costs was initially based on interviews with Connecticut firms that had already been through the application procedure. A number of the firms simply indicated that the overall costs of application were nominal; others preferred not to give any estimate of the costs. However, an order of magnitude estimate can be reasonably determined from the more specific responses received. Of the 14 estimates received, 10 were below $600 (range of $100 to $550), and three of these 10 were put at $200. The average of these 10 estimates is approximately $300. The four remaining estimates ranged from $1,200 to $50,000. The $50,000 estimate included consultants' fees; the second highest estimate dropped to under $7,000. No pattern could be distinguished in terms of SIC's.

Using these interview data as the starting point, Harbridge House estimated that roughly $400 (two days of work at $200 per day) could be considered representative of the administrative costs of application. It was assumed that this figure takes into account not

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[1]Shelton Edwards, Principal Air Pollution Control Engineer, Air Compliance Unit, Department of Environmental Protection, telephone interview 2 December 1975.

[2]Robert Rubino, Assistant Director of Air Compliance Unit, Department of Environmental Protection, 11 November 1975.

[3]A 6 percent interest rate was used; this figure is based on telephone interviews conducted with municipal bond officers in December 1975. First National Bank of Boston estimated the long-term lending rate for a Connecticut State bond at between 5 percent and 5.5 percent. First National City Bank of New York estimated the long-term lending rate at between 6.0 and 7.0 percent (see Appendix H). Note that the calculation assumes the same cost distribution for construction, operation, and renewal application review.

only the initial costs of the construction application but also incremental costs of operating and renewal applications.[1] Actual costs may vary significantly from the assumed $400 expenditure. For example, three of the firms interviewed noted that substantial effort is sometimes required to protect process and patent confidentiality in completing the application form. Such deviations from the norm cannot be taken into account within the framework of this study.

Connecticut DEP has estimated that, at most, 10 percent of the sources applying for permits submit documentation of stack emissions. In general, most of the stack tests received were from fuel-burning sources and chemical firms. (Incinerator manufacturers also send test results to DEP, but these documents do not require direct expenditure on the part of Connecticut firms.) The costs of stack testing and documentation can vary significantly. For the purpose of this analysis, it has been assumed that the provision of stack test documentation requires approximately $500.

Public hearings are required for all sources which emit more than 100 tons of pollutants (prior to control) per year. Hearings may also be initiated by the general public. To date, there have been 21 such hearings, seven of which took place in the last year. Only two have been initiated by the general public; both these hearings were for asphalt and concrete batching plants. Sources most often called to public hearings for exceeding the 100-ton rule are large fuel-burning facilities. However, there is no consistent industry breakdown since such sources can include facilities as diverse as hospitals and chemical manufacturing plants.

Although the actual hearings usually take less than three hours, the preparation required can involve substantial time and effort. Moreover, this preparatory effort is likely to be greater when a hearing is initiated by the public. Hearings required by the 100-ton rule may tend to require increasingly greater preparation in the future, if the public starts attending them. (To date no member of the general public has ever attended such a hearing.)[2]

The seriousness of the control problem as well as the image the applicant seeks to convey can also significantly affect preparation costs. Despite the various contingencies, Harbridge House has conservatively estimated that on average the following is required when a hearing is called: two days of legal preparation (at $500 per day) and one day of preparation, each, by three expert witnesses (at $300 per day). Furthermore, it has been assumed that this total cost of $1,900 will be incurred by an average of eight sources per year. Other cost estimates, obtained from sources at DEP, range from a low of $50 to a high of $3,000.

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[1]The $400 application cost is not based on statistical analysis for two reasons: (i) sufficient data for a statistical analysis were not available; (ii) the figure was developed with the intent of being representative of operating and renewal applications as well as the original construction application.

[2]Several DEP representatives expressed doubt that the 100-ton rule would continue in effect because of the lack of public participation as well as the objection of large sources to any interpretation that the 100 tons of pollutants be measured prior to control. If the rule remains in effect, it has been assumed that public participation will play a greater role.

b. **Control Costs.** The aim of the control cost estimation procedure was to obtain reasonable approximations of the incremental[1] expenditures required for compliance within the permit system. Because of the level of aggregation of source categories used in this analysis, the cost estimates reflect the application of several methodologies as well as extrapolation of data from divergent and often conflicting sources. For example, the current costs of different types of equipment were examined based on vendor estimates and were compared with individual estimates of control costs obtained from interviews with Connecticut firms. Nationwide studies of pollution control costs in various sectors were also examined and estimates of average control costs per unit of output were developed from these data. However, the fragmented nature and level of detail in the available data did not allow rigorous analysis of current and future incremental BACT costs by sector. Consequently, the low, high, and middle range estimates were developed based on examination of the cost figures collected (see Exhibit 9). Supporting data and criteria used for determining these ranges are described in Appendix I.

c. **Impact by Sectors.** The impact of direct permit-related costs on the private sector will vary by individual firms within each sector. For example, a large conglomerate may be in a better position to absorb the increased nonproductive costs than a small family-run business. Internal financial and operating characteristics, such as tax shelters and cost "pass-through" opportunities from vertical integration, can serve as important internal shields against the impact of pollution control costs. However, in a study of this nature, many of the key factors which determine financial feasibility for an individual firm are masked by the assumptions required in the analysis. As a result, this evaluation has focused on relative impacts and on representative situations. There can, of course, be substantial variation on a case-by-case basis from the scenarios presented here.

Another source of variation centers around the relationship of individual firms and economic sectors to nationwide macro-economic forces. During periods of recession or economic downturn, certain companies may be more sensitive to increased costs. Firms interviewed repeatedly noted cost factors (particularly Connecticut's corporate tax structure) in relation to other geographic locations as well as national economic conditions. Although an economic downturn most often represents a national phenomenon, it can result in increased sensitivity to incremental costs incurred at the regional level.

(1) **Manufacturing.** The total present value of permit-related costs incurred by the manufacturing sector over the next 10 years is approximately $18 million (assuming base control cost estimates and including public hearing and monitoring costs). As shown in Exhibit 10 there are large cost variations by SIC category – ranging from $8.6 million for the fabricated metals industry (SIC 34) to $13,000 for the leather products industry (SIC 31). The total median cost (over 10 years) for the 19 industrial groups is $160,000. Also shown in Exhibit 10 is the present value of permit-related costs per facility. These range from less than $2,000 to $60,000; the mean is approximately $18,000 per facility.

The method of financing pollution control expenditures varies from firm to firm. Many of the firms interviewed said that relatively small expenditures ($100 to $200) were

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[1]For the purposes of this analysis it was assumed that any control equipment required by a nationwide program such as New Source Performance Standards (NSPS) would not be included in the costs attributable to the permit system.

EXHIBIT 9
PERMIT-RELATED CONTROL COST ESTIMATES

	Capital Investment			Annual Operating and Maintenance Costs		
	Low	Middle	High	Low	Middle	High
Apartment Complexes						
Incineration	$ 150	$ 300	$ 450	$ 50	$ 75	$ 100
Fuel Burning	400	800	1,200	75	150	225
Nursing Homes						
Incineration	150	300	450	50	75	100
Fuel Burning	400	800	1,200	75	150	225
Schools						
Incineration	200	400	600	60	110	160
Fuel Burning	400	800	1,200	75	150	225
Commercial						
Incineration	300	600	900	80	160	240
Fuel Burning	500	1,000	1,500	75	150	225
Veterinary Clinics						
Incineration	150	300	450	50	75	100
Sewage Sludge Incinerators	1,000	2,000	3,000	100	200	300
Resource Recovery	1,000	2,000	3,000	100	200	300
Manufacturing (by SIC)						
20	1,800	3,500	5,300	180	350	530
22	1,800	3,500	5,300	180	350	530
23	500	1,000	1,500	100	200	300
24	500	1,000	1,500	100	200	300
25	500	1,000	1,500	100	200	300
26	2,500	5,000	7,500	250	500	750
27	500	1,000	1,500	100	200	300
28	5,000	10,000	15,000	500	1,000	1,500
29	1,000	2,000	3,000	100	200	300
30	5,000	10,000	15,000	500	1,000	1,500
31	500	1,000	1,500	100	200	300
32	5,000	10,000	15,000	500	1,000	1,500
33	30,000	60,000	90,000	3,000	6,000	9,000
34	25,000	50,000	75,000	2,500	5,000	7,500
35	5,000	10,000	15,000	500	1,000	1,500
36	5,000	10,000	15,000	500	1,000	1,500
37	5,000	10,000	15,000	500	1,000	1,500
38	4,000	8,000	12,000	400	800	1,200
39	5,000	10,000	15,000	500	1,000	1,500

Source: Harbridge House, Inc. (1975). See Appendix I for supporting documentation.

EXHIBIT 10
PRESENT VALUE OF TOTAL PERMIT-RELATED COSTS IN MANUFACTURING (1976-1985)

SIC	Medium Control Cost Total	Application Cost Total		Total	Average Cost per Facility
20	$ 124,000	$ 9,500		$ 133,500	$ 3,900
22	57,400	4,400		61,800	3,900
23	11,300	2,200		13,500	1,700
24	13,200	2,800		16,000	1,600
25	37,600	7,600		45,200	1,600
26	110,500	5,700		116,200	5,500
27	121,300	24,500		145,800	1,700
28	419,000	13,600	M	432,600	10,300
29	15,600	20,300	H, M	35,900	4,500
30	663,900	17,800		681,700	10,700
31	10,500	2,200		12,700	1,600
32	252,600	6,600		259,200	11,300
33	2,413,400	46,100	H, M	2,459,500	63,100
34	8,306,400	262,200	H, M	8,568,600	53,600
35	2,670,000	151,800	H, M	2,821,800	10,900
36	775,500	36,400	H, M	811,900	10,800
37	156,100	4,200		160,300	10,700
38	268,500	8,600		277,100	8,700
39	711,400	19,000		730,400	10,700
TOTAL	$17,138,200	$645,500		$17,783,700	$17,800

Note: H = Hearing costs included; M = Monitoring costs included.

Source: Harbridge House, Inc. (1975). (Interest rate of 7.25 percent assumed in present value calculations. See Appendix H.)

taken out of operating funds. The larger expenditures, however, usually come from the capital expansion budget or from separate monies put aside for pollution control. Many firms also indicated they relied upon bank financing and other outside sources for pollution control financing. This alternative of spreading out pollution control expenditures can provide significant advantages to firms facing high initial investment costs for control equipment.

The Connecticut Development Authority provides pollution control financing, with options ranging from 80 percent financing over 10 years to 100 percent for up to 40 years. Criteria for receiving funds rest primarily on demonstrable solvency. Other pollution control incentives provided by the state include tax credits, exemptions, and accelerated depreciation of pollution control equipment (see Exhibit 11). Of the other New England states, only New Hampshire provides more incentives. As a result of these tax incentives and financing options, the impact of the permit-related costs may be substantially mitigated.

Analysis of the relative severity of permit-related cost impacts on each industrial group could not, however, explicitly take into account the advantages provided by these financing options. Instead, the evaluation focused on a comparison of the incremental costs with industry-wide financial and production performance characteristics.

Expanding the annualized permit-related costs for each industry group as a percent of value added in manufacture provides a rough indication of the permit program's order of magnitude impact. As shown in Exhibit 12, the percentages range from a low of .0005 percent (for SIC 23 assuming the low control cost estimate) to a high of .14 percent (for SIC 34, assuming the high control cost estimate). Based on these data and the average cost per facility shown in Exhibit 10, it appears that under the medium and high control cost assumptions the fabricated metals (SIC 34) and primary metals (SIC 33) industries may be particularly impacted by the permit program's direct costs.

An indication of the ability of the fabricated and primary metals industries to absorb permit program costs is provided by examining nationwide average financial ratios.[1] Within the nation's fabricated metals industry, about 10 percent of that industry's 77 size and product classifications for which information is available were operating at a net loss before taxes during the 1972 to 1973 accounting period.[2] During that same period, the primary metals industry showed 18 percent of the 22 size and product classifications for which information is available operating at a net loss before taxes.[3] Moreover, interviews with Connecticut firms indicated that the metals industry is in a depressed state overall, with the primary metal manufacturers relatively more affected by the nationwide economic slump than the fabricators.[4]

It appears that the increased costs resulting from permit program requirements for new sources may not be easily absorbed, thereby necessitating some delay in expansion

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[1]Leo Troy, *Almanac of Business and Industrial Financial Ratios.* 1976 Edition. Prentice Hall (New Jersey).

[2]*Ibid.*, pages 62 through 68.

[3]*Ibid.*, pages 60, 61.

[4]See list of interviewees in Appendix J.

EXHIBIT 11
STATE INCENTIVES FOR INDUSTRIAL POLLUTION CONTROL

	Real Property Tax Exemption	Personal Property Tax Exemption	Sales/Use Tax Exemption On Purchase of Pollution Control Facilities	Sales/Use Tax Exemption Applicable to Lease of Pollution Control Facilities	Credit Against Corporate Income Tax	Maximum Dollar Limit Of Credit	Accelerated Depreciation Of Pollution Control Equipment	Exclusion of Pollution Control Investment From Corporate Franchise Tax	Exemption Applicable to Cost of Operating Pollution Control Facility	State Financing Program For Purchase and Installation Of Pollution Control Facilities
Alabama	•	•	•	•	•	No Limit	•	•		•
Alaska										•
Arizona							•			•
Arkansas	•	•	•							•
California							•			
Colorado										•
Connecticut	•	•	•		•	No Limit	•			•
Delaware	•	•	•	•			•			•
Florida		•								•
Georgia	•	•	•	•			•			
Hawaii							•			•
Idaho								•		
Illinois	•	•	•	•			•			•
Indiana	•	•								•
Iowa	•	•					•	•		•
Kansas							•			•
Kentucky			•							•
Louisiana	•	•					•			•
Maine		•	•				•			•
Maryland		•								•
Massachusetts					•	No Limit	•			•
Michigan	•	•	o	•	•					•
Minnesota	•	•			•	50 000	•			•
Mississippi			•				•			•
Missouri			•	•			•			•
Montana	•	•	•	•					•	•
Nebraska			•							•
Nevada				•	•					•
New Hampshire	•	•	•	•	•		•			•
New Jersey	•	•								
New Mexico	•	•			•	No Limit		•		•
New York	•	•	•	•	•	No Limit	•	•		•
North Carolina	•	•	•	•			•	•		
North Dakota		•			•					•
Ohio	•	•	•	•	•		•	•		•
Oklahoma										•
Oregon	•	•	•		•	5% of Facility Cost	•			•
Pennsylvania			•	•			•	•		•
Rhode Island	•	•	•	•	•	20% Year				•
South Carolina	•	•	•	•					•	•
South Dakota	•				•					•
Tennessee	•	•	•				•			•
Texas	•	•	•	•	•					
Utah										•
Vermont	•	•								•
Virginia	•	•	•				•			•
Washington						50% of Investment				•
West Virginia			•		•	Unlimited			•	•
Wisconsin	•	•	•		•	No Limit	•			•
Wyoming	•	•								•
Puerto Rico										•

Source: *Site Selection Handbook,* 1975, p. 340.

EXHIBIT 12
PRESENT VALUE OF ANNUALIZED PERMIT-RELATED COSTS TO THE MANUFACTURING SECTOR AS A PERCENT OF 1972 VALUE ADDED

SIC	1972 Value Added (millions)	Annualized Permit-Related Costs as Percent of Value Added (present value)	
		Low	High
20	246.6	.002	.007
22	195.3	.002	.004
23	137.3	.0005	.001
24	21.7	.004	.011
25	77.2	.003	.009
26	161.3	.004	.011
27	352.5	.002	.006
28	433.4	.005	.015
29	20.8	.009	.030
30	233.7	.015	.043
31	17.5	.004	.010
32	140.8	.009	.028
33	455.5	.028	.080
34	922.3	.048	.140
35	926.4	.016	.045
36	714.0	.006	.017
37	1,162.1	.0007	.002
38	369.4	.004	.011
39	233.4	.016	.047

Source: Harbridge House, Inc. (1975). Value Added from *Census of Manufactures.*

plans to accumulate the additional capital. The issue of whether such delay would precipitate a change in the level of growth forecast (as opposed to merely affecting the timing of future growth) has been examined in light of location quotients (LQ's). Both the primary and fabricated metals industries in Connecticut have LQ's greater than one (1.13 for primary, and 1.87 for fabricated at the two-digit SIC level). In rough terms this means that the state provides locational advantages to both industries. Moreover, when the LQ's are disaggregated to the three-digit SIC level, both industries show LQ's of greater than four. This indicates a solidly entrenched portion within both manufacturing groups. On this basis, then, it appears unlikely that a significant change in the growth level forecast for these metal industries will result from permit-related costs.[1]

(2) **Commercial Sector.** The total present value of permit-related costs incurred by the commercial sector over the next 10 years is almost $2 million (assuming medium control costs and no public hearing or monitoring costs). As shown in Exhibit 13, about 50 percent of these costs are incurred by retail establishments (exclusive of eating and drinking places). Eating and drinking establishments are estimated to incur the second highest total permit-related costs over the next 10 years. These were broken out separately from other retail trade because of the predominance of fast food restaurants seeking commercial permit applications during the 1972 to 1974 period. The lowest total costs in the commercial sector were projected for the finance, insurance, and real estate (F.I.R.E.) group. Comparison of the present value of costs per facility requiring a permit, however, shows that the F.I.R.E. group incurs a high of $1,700 per permit, while the eating and drinking establishments incur a low of $1,200.

Retail sales figures for 1974 provide a context for examining permit-related costs. On an annualized basis the present value of permit-related costs in the retail segment (exclusive of eating and drinking places) represents 1.5 percent of 1974 sales.[2] For the eating and drinking establishments, this figure is 5 percent of 1974 sales. The rapid growth expected in both the retail segments, however, suggests that these percentages may be substantially lower in the future. Comparable sales or revenue figures are not available for the other segments of the commercial sector.

Overall, it does not appear that permit-related costs will have a significant impact on the commercial sector. Although the total costs over the 10-year period appear quite high, the present value of costs per establishment seems to fall within a reasonable range. Furthermore, there is relatively greater flexibility within the commercial sector (as compared with manufacturing) for passing costs on to clients or customers, as well as for avoiding the permit procedure by utilizing municipal incineration facilities and/or converting to all-electric power.[3]

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[1]The derivation and use of location quotients is described in Appendix K.

[2]Retail sales in New Haven, Hartford, and Fairfield Counties totaled $7,049,560, of which $589,230 represented sales of eating and drinking establishments. (Source: *Sales Management Magazine.* July 21, 1975).

[3]The Resource Recovery Plants described in Chapter II and in Appendix F may become economically more attractive to a large portion of the establishments assumed here to use their own on-site incineration.

EXHIBIT 13
PRESENT VALUE OF TOTAL PERMIT-RELATED
COSTS TO THE COMMERCIAL SECTOR: 1976-1985
(MEDIUM CONTROL COST ESTIMATE)

SIC		Medium Control Cost Total	Application Cost Total	Total	Average Cost per Facility
50	(Wholesale)	$ 153,300	$ 42,300	$ 195,600	$1,300
52-59 (except 58)	(Retail)	737,000	209,600	946,600	1,300
58	(Eating and Drinking)	237,700	71,600	309,300	1,200
60-67	(Finance, Insurance, and Real Estate)	92,800	17,000	109,800	1,700
70-89 (except 80, 82)	(Services)	168,800	49,600	218,400	1,300
TOTAL		$1,389,600	$390,100	$1,779,700	$1,300

Source: Harbridge House, Inc. (1975). (Interest rate of 7.25 percent assumed in present value calculations. See Appendix H.)

(3) **Institutional Sector**

- *Nursing Homes*

It has been estimated that about 19 nursing homes in the AQMA will require permits over the next 10 years. Based on past permit applications, five of these have been assumed to incur control costs for fuel combustion, the remaining 14 for incineration control equipment. Assuming that no public hearing and monitoring costs are incurred by these facilities, the present value of total permit-related costs over the 10-year period ranges from $13,900 to $29,600, with the medium control estimate approximately $21,800. Since these nursing homes were assumed to have an average of 160 beds each (see Chapter II), the increased costs resulting from the permit program range from $4.60 to $9.70 per bed. Over the life of the buildings, the annual cost per patient will be minimal.

- *Veterinary Clinics*

Over the next 10 years, it has been assumed that 23 veterinary clinics using on-site incineration will locate in the Connecticut AQMA. Each must apply for a permit. It has been further assumed that no public hearing or monitoring costs will be incurred during the application procedure. Using the medium control cost estimate, about $16,900 in total present value costs will be incurred over the 10-year period as a result of the permit requirements. The estimated range is from $11,600 to $22,200. These increased costs will probably be passed on with minimum impact. Furthermore, interviews with previous permit applicants indicated that on-site incineration is not a necessary part of operations. In addition, future use of resource recovery plants will substantially reduce these costs.

- *Schools*

It has been estimated that 30 of the schools planned for construction before 1978 will require permits – 23 for fuel combustion and seven for incineration. Using the medium control cost estimates and assuming that no public hearing or stack test costs are incurred, the present value of the direct private costs is $36,300, or less than one percent (.03 percent) of estimated construction costs.[1] The present value total of permit-related costs ranges from $23,400 to $49,200, both well below one percent of construction costs. Assuming that about 13,000 students are served by the new construction,[2] the permit-related costs represent from $2 to $4 per pupil seat. Over the life of the buildings, the number of pupils attending the schools reduces the annual cost per pupil to a negligible amount.

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[1]Construction cost estimates are shown with the forecast in Appendix E.

[2]Assumes $8,000 construction costs per pupil based on *Means Construction Cost Data*, 1974.

(4) **Municipal Waste Disposal.** The five sewage sludge and nine resource recovery plants estimated to come on line within the AQMA from 1976 to 1985 will incur total permit-related costs ranging from $19,700 to $59,000 (present value). The present value of costs per plant average about $2,450 for the resource recovery plants and about $3,500 for the sewage sludge incinerators. The impact of these increased costs is expected to be minimal.

(5) **Apartment Complexes.** It has been estimated that 12 apartment complexes within the AQMA will require permits over the 10-year period. Based on past permit applications, eight of the complexes are expected to incur control costs for on-site fuel combustion, and four for incineration control costs. Using the medium control cost estimates and assuming that no public hearing or monitoring costs are incurred, the present value of direct private costs is $14,800, or 1.2 percent of estimated total construction costs.[1] High and low control cost estimates range from $9,100 to $20,400 (or 0.8 percent to 1.7 percent of estimated total construction costs). It can reasonably be assumed that these increases will be passed on in the form of rent increases over the life of the buildings. Consequently, no impact on the timing or level of growth forecast is anticipated.

d. **Summary.** Exhibit 14 itemizes the present value of direct private costs of the permit program, assuming the medium control cost estimate. As the exhibit shows, the manufacturing sector is expected to incur about 90 percent of total private costs, with the commercial sector incurring about 9 percent. Average total costs per permit range from $700 (veterinary clinics) to $63,100 (primary metals). Within the manufacturing sector, SIC 34 (fabricated metals) is estimated to incur the greatest costs (44 percent of total cost for all sectors), followed by SIC 35 (machinery) with 14 percent of total costs, and SIC 33 (primary metals) with 13 percent of total costs.

As discussed earlier in this section, these costs are expected to have an insignificant impact on most industry groups. The only exceptions are the primary and fabricated metals industries, which will be only moderately impacted. No change in the total growth in these industries is expected during the forecast period; however, a relatively slower growth rate through 1980 seems probable.

C. Direct Benefits

1. Improved Health and Welfare

Particulates and sulfur oxides have numerous adverse effects on health, property, climate, and aesthetic values. Normally these effects have some economic costs which can be translated into benefits of reducing pollution or stemming its growth (see Appendix L). Nevertheless, quantification of such benefits accruing to implementation of the permit program is constrained by at least three factors. First, there is substantial difficulty in estimating the incremental benefits that derive from the permit strategy within the context of the wide range of pollution abatement measures and technological innovations. Second,

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[1]Construction cost estimates based on the average of 1974 building permit applications for residential construction with six units or more plus publicly assisted residential construction (assumed to be multi-unit).

EXHIBIT 14
ESTIMATED DIRECT PRIVATE COSTS OF PERMIT PROGRAM (1976-1985)
(present value)

Sector	Permit-Related Cost*	Percent of Total**	Average Cost per Permit
Manufacturing (SIC)	17,783,700	90.3%	17,800
20	133,500		3,900
22	61,800		3,900
23	13,500		1,700
24	16,000		1,600
25	45,200		1,600
26	116,200		5,500
27	145,800		1,700
28	432,600		10,300
29	35,900		4,500
30	681,700		10,700
31	12,700		1,600
32	259,200		11,300
33	2,459,500	(12.5%)	63,100
34	8,568,600	(43.5%)	53,600
35	2,821,800	(14.3%)	10,900
36	811,900		10,800
37	160,300		10,700
38	277,100		8,700
39	730,400		10,700
Commercial (SIC)	1,779,700	9.0%	1,300
50	195,600		1,300
52-59	946,600		1,300
58	309,300		1,200
60-67	109,800		1,700
70-89	218,400		1,300
Institutional	75,000	0.4%	1,000
Nursing Homes	21,800		1,100
Veterinary Clinics	16,900		700
Schools	36,300		1,200
Municipal Waste Disposal			2,800
Sewage Sludge } Resource Recovery }	39,300	0.2%	3,500 / 2,500
Apartment Complexes	14,800	0.1%	1,200
TOTAL	$19,692,500	100.0%	

*Permit-Related Cost — assuming medium control cost estimate — for 1976 to 1985 period (present value).

**Numbers in parentheses are also percentages of total cost but are included in the 90.3 percent for the manufacturing sector as a whole.

Source: Harbridge House, Inc. (1976).

valuation of the qualitative attributes of reduced pollution levels is subject to only rough approximations based on those aspects with measurable monetary value. And, finally, the interaction of pollutants in the environment can often significantly affect the degree of impact experienced.

Studies that have attempted such quantification despite these and other limitations are summarized in Appendix L. Generally they fall into four categories of cost savings: human health, vegetation, materials, and residential property values.

Exhibit 15 compares nationwide pollution damage estimates and includes costs attributable to the four categories. The 1968 (base year) estimate by Barrett and Waddell is about $16.1 billion. By adjusting this estimate to 1975 dollars, the annual costs for 1975 air pollution damages become: health – $10.1 billion; materials – $7.8 billion; residential properties – $8.5 billion; and vegetation – $166 million. The total is $26.6 billion.[1] An updated study by Babcock and Nagda projected total annual pollution damages at $23.5 billion in 1976. Of this, $20.9 billion represented damages from stationary sources.[2] Although these figures show that significant savings potential is achievable from air pollution control, they in all likelihood underestimate the overall potential because such things as aesthetics, good health, and freedom from disease are difficult to assess monetarily. Furthermore, scientific investigation is finding more and more potential and demonstrated causal relationships between air pollution and different types of damage, particularly health-related.

As previously noted, disaggregating these nationwide damage costs to a level representative of the incremental benefits resulting from permit program implementation would be of little value in light of data and technical limitations. However, it is worthwhile to respond to a generic type of comment received by the Connecticut DEP in its AQMP public meetings[3] and by Harbridge House in telephone interviews that strategies should be implemented when ambient air quality standards are actually being jeopardized. Essentially, this type of comment arises from the intended design of the air quality standards as tools to protect health and welfare. In accordance with this goal, air pollution control benefits theoretically do not outweigh the costs until the standards are in danger of being exceeded. However, a growing body of evidence points to the conclusion that no such threshold exists; instead, reduction of pollution at any level has beneficial effects that may outweigh the costs of such reduction. Moreover, pollutants rarely, if ever, occur in isolation, and it has been clearly established that pollutants occurring in combination have a greater total effect than the sum of their individual effects. Consequently pollution control at ambient levels below the standards appears to be warranted. Moreover, the benefits of such control are likely to be substantial.[4]

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[1]Kenneth Ch'uan-k'ai Leung and Jeffrey Klein, *The Environmental Control Industry: An Analysis of Conditions and Prospects for the Pollution Control Equipment Industry,* for the Council on Environmental Policy, December 1975, p. 24.

[2]*Ibid.*

[3]Connecticut Department of Environmental Protection, *Connecticut Attainment/ Maintenance Report on Sulfur Oxides and Total Suspended Particulates,* December 31, 1975, p. XI-8.

[4]Appendix M provides further information and documentation regarding this discussion.

EXHIBIT 15
COMPARISON OF NATIONAL POLLUTION DAMAGE ESTIMATES

Media		Base Year	Range (in billions of dollars)
Air	Ridker (1966)	1970	$7.3 - 8.9
Air	Gerhardt (1969)	1968	6.0 - 15.2 (best 8.1)
Air	Barrett and Waddell (1973)	1968	16.1
Air	Babcock and Nagda (1973)	1968	20.2
Air	Justice, Williams, and Clement (1973)	1970	2.0 - 8.7
Air	Waddell (1974)	1970	6.1 - 18.5 (best 12.3)
Air	National Academy of Sciences (1974)	1973	15 - 30 (best 20)
Air	Heintz and Hershaft (1975)	1973	9.5 - 35.4 (best 20.2)

Source: Kenneth Ch'uan-k'ai Leung and Jeffrey Klein. *The Environmental Control Industry.* For the Council on Environmental Quality, December 1975, p. 25.

2. Stimulation in Demand for Pollution Control Equipment

Because the permit program requires additional expenditures over and above other programs for pollution control equipment, an incremental increase in the demand for control equipment may be expected. Total permit-related capital expenditures over the 10-year forecast period have an estimated present value of about $19 million.

Two estimates of the nationwide market for air pollution control equipment provide a context for these permit-related expenditures. One estimate puts the market for all air pollution control equipment at $850 million in 1975.[1] A 1974 estimate of $310 million includes stationary source pollution control equipment but not auxiliary equipment and erection services (which are presumed to be included in the permit-related cost estimates).[2] Assuming that these estimates provide a reasonable range for comparison, the permit-related control expenditures represent an incremental increase in equipment demand ranging from 0.2 percent to 0.6 percent, on an annual basis.

Firms in both Connecticut and the nation as a whole stand to benefit from the incremental demand stimulation. However, because of its relative proportion to total demand for pollution control equipment, the overall impact of permit program control expenditures is likely to be quite small. Nevertheless, the permit program does benefit an industry that has been characterized as "one of the relatively few areas of job strength during the recent recession."[3] Moreover, the cumulative effect of all federal, state, and local pollution control requirements is estimated to currently provide over a million jobs, with the potential for severalfold expansion over the next decade.[4]

D. Indirect Impact

The foregoing evaluation of the permit program's direct impacts focused on the discretely defined groups in the AQMA that are expected to experience some benefit or cost directly related to program implementation. The following analysis attempts to carry the impact assessment one step further by focusing on implications of the identified costs and benefits. To some extent the analysis presented below involves additional socioeconomic variables, but the analysis also rests largely on evaluating impacts from a regional perspective.

1. Costs

Exhibit 16 summarizes the permit-related costs in the private sector by RPA. The Central Naugatuck Valley RPA bears the greatest proportion of costs within the AQMA (18 percent), followed by the South Central and Greater Bridgeport RPA's (17 and 15 percent,

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[1] Arthur D. Little, Inc. *Fostering Industrial Growth in Massachusetts,* Volume II: "Strategies for Development of Selected Industries in the 1970's." (Springfield, Virginia; National Technical Information Service, 1973), pp 195-331.

[2] Leung and Klein, *op. cit.*

[3, 4] *Ibid.*, p. 1.

EXHIBIT 16
PRESENT VALUE OF TOTAL PERMIT-RELATED COSTS BY REGION: 1976 - 1985
(in thousands)

RPA	Manufacturing	Commercial	Other*	Total	Percent of Total
Capital	$ 2,403	$ 395	$ 34	$ 2,832	14%
Central Conn.	2,432	292	8	2,732	14
Midstate	710	96	9	815	4
Central Naugatuck Valley	3,256	176	12	3,444	18
Housatonic Valley	766	172	11	949	5
Valley	541	82	6	629	3
Greater Bridgeport	2,864	173	14	3,051	15
South/Western	1,819	182	17	2,018	10
South Central Conn.	2,993	212	18	3,223	17
	$17,784	$1,780	$129	$19,693	100%

Note: Medium control cost estimate used.

*Includes nursing homes, veterinary clinics, schools, resource recovery plants, sewage sludge, incinerators, and apartments.

Source: Harbridge House, Inc. (1976).

respectively). The Midstate, Housatonic Valley, and Valley RPA's each bears 5 percent or less of the total costs. Comparison of total permit-related costs with projected 1985 earnings indicates that on an annual basis the permit-related costs represent only 0.01 percent of projected earnings in all sectors.[1]

Exhibit 16 clearly indicates that costs are predominantly incurred by manufacturing firms within the AQMA. Comparison of the total manufacturing costs with projected 1985 earnings in the AQMA shows that permit-related costs are about 0.04 percent of projected earnings, on an annual basis.[2] In terms of only SIC's 33 and 34, which were found to be most heavily impacted, the permit-related costs represent 0.1 percent, on an annual basis, of projected earnings in each industry.[3]

Because of the relatively small size of these percentages, it is not anticipated that the economic stability of the AQMA will be significantly impacted by the permit program.

a. **Employment**. Exhibit 17 shows estimated employment increases by RPA that are associated with the forecast of manufacturing and commercial facilities requiring permits. Based on the direct cost evaluation, it is not expected that any existing employment will be jeopardized in Connecticut as a result of permit program requirements. On the other hand, employment opportunities in the fabricated metals and primary metals industries may grow relatively more slowly through 1980; however, they are expected to reach forecasted levels by 1985. This slowdown in employment may affect as many as 2,500 jobs in these two industries in the late 1970's. While it is likely that the majority of these jobs will still be generated during the 1976 to 1980 period, their rate of creation may be retarded.

Delay in the rate of new jobs created means a slower recovery from the high unemployment rates the state is now experiencing. The regions more highly impacted are likely to be those in which the metal industries represent a relatively larger proportion of total employment. As shown in Exhibit 18, the Central Connecticut, Central Naugatuck Valley, Greater Bridgeport, Valley, and South Central RPA's all have a higher percentage of employment in the metals industry than other regions of the state.[4] Nearly 75 percent of the jobs subject to permit-related delay are forecast to be located in these RPA's. Each of these areas also has experienced substantial unemployment during the past year.

Because the metal industries have location quotients greater than one (indicating an export orientation as explained in Appendix K), there is likely to be a ripple effect

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[1]Projected 1985 earnings in the counties that comprise the AQMA – New Haven, Fairfield, and Hartford – are estimated at $13,961 million (1967 $). Conversion to 1975 $ would result in an even smaller percentage. Source: OBERS-E.

[2]Manufacturing earnings in the three counties are estimated at $4,488,000. Source: OBERS-E.

[3]Earnings in the counties for SIC 33 and 34 are projected at $210 million and $799 million, respectively. Source: OBERS-E.

[4]The Capital region's dependence, as shown in Exhibit 18, is distorted by aggregation of the metals and aircraft industries.

EXHIBIT 17
ESTIMATED PERMIT-RELATED EMPLOYMENT (1976 - 1985)

	Manufacturing	Commercial	Total
Capital	3,610	6,160	9,770
Central Conn.	1,730	4,620	6,350
Midstate	940	1,400	2,340
Central Naugatuck Valley	3,545	2,800	6,345
Housatonic Valley	1,385	2,720	4,105
Valley	475	1,300	1,775
Greater Bridgeport	3,445	2,720	6,165
South/Western	2,275	2,880	5,155
South Central Conn.	3,430	3,320	6,750

Note: Representative of original forecast in Chapter II.

Source: Harbridge House, Inc. (1976). (Based on median employment in Connecticut establishments in 1973 from *County Business Patterns*.)

EXHIBIT 18
PERCENT OF TOTAL EMPLOYMENT IN SELECTED INDUSTRIES
(June 1974)

RPA	LMA(s)	Primary Metals	Fabricated Metals	Primary and Fabricated	Unemployment June 1975	Unemployment June 1974
Capital	Hartford*	—**	14%	14%	8.8%	5.4%
Central Conn.	New Britain	—	—	22%	13.5%	6.1%
	Bristol	N.A.***	16%	16%	15.9%	6.3%
Midstate	Middletown	N.A.***	4%	4%	11.1%	6.6%
Central Naugatuck Valley	Waterbury	5%	10%	15%	12.6%	5.7%
Housatonic Valley	Danbury	N.A.***	4%	4%	9.8%	5.1%
Valley	Ansonia	11%	6%	17%	16.1%	8.0%
Greater Bridgeport	Bridgeport	3%	7%	10%	13.5%	7.9%
South/Western	Norwalk†	N.A.***	6%	6%	9.1%	5.4%
	Stamford	N.A.***	3%	3%	7.8%	4.8%
South Central Conn.	Meriden	5%	6%	11%	12.5%	6.5%
	New Haven	2%	5%	7%	9.8%	6.1%
Statewide		2%	5%	7%	10.7%	5.9%

Note: Labor Market Areas (LMA's) do not correspond exactly to RPA's.

*Includes aircraft in fabricated metals employment.

**Less than 1 percent.

***Not available and generally indicates that employment in the industry is not a major portion of total employment.

†Includes instruments in fabricated metals employment.

Source: Harbridge House, Inc. (1976). Based on Connecticut Labor Department Data.

throughout the Connecticut economy as a result of the delayed expansion in these industries. Creation of one job in the metals industries (or other export industries) has been estimated to generate about three jobs in supporting industries around the state.[1] Consequently, the creation of as many as 7,500 new jobs in supporting industries may be subject to delay due to the permit program's impact on growth in primary and fabricated metals. Moreover, while the metals industries employment is expected to have regained the forecast levels by 1985, these supporting industry jobs may not reach forecast levels until a year or so afterward because of normal lags in the generation of secondary employment.

b. **Population Distribution and Development Patterns.** The forecasts in Chapter II were based on a continuation of current trends in population distribution and development patterns. The only significant change from past growth trends was found in the Housatonic region, which is experiencing substantially accelerated growth.

In the employment evaluation above, the only potential reason for change in the forecast patterns was the delay in expansion within the metals industries. However, this delay is not likely to cause substantial departure (if any) from the forecast distribution of population and/or development.

c. **State and Local Taxes.** Revenues from the state's corporate income tax may be marginally affected by costs incurred through the permit program. In particular, the short-term slowdown in the growth of the metal industries could cause a relative reduction (that is, compared to no slowdown) in the taxable base, thereby temporarily decreasing revenues. Although the magnitude of this reduction cannot be reasonably estimated from available data, the impact on total state revenues will probably be negligible. In 1973, for example, only 7 percent of the state's revenues came from corporate income tax.[2]

Similarly, state sales tax revenues may be reduced marginally as a result of the employment implications of the permit-related costs. Sales taxes comprised 43 percent of the state's total revenues in 1973.[3] Based on Internal Revenue Service deduction guidelines for Connecticut's sales tax, a family of four with an income of $9,000 to $12,000 pays about $150 to $180 in sales tax per year.[4] Assuming a one-year delay in the creation of new jobs in the metals industry and associated secondary jobs, the present value of sales tax revenues forgone over the five-year period is estimated at between $200,000 and $240,000, on an annual basis. This represents only 0.03 percent of the 1973 sales tax revenues. Moreover, loss of these revenues is highly dependent on the overall employment situation in the state, since revenues would not be lost if alternate job opportunities were available.

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[1] See Appendix N for a description of the multiplier effect and its derivation for Connecticut.

[2] John F. Tarrant. *TAXFAX: Some Things to Know About Connecticut Taxes.* Publication of Connecticut Tax Department. July 1, 1975.

[3] *Ibid.*

[4] *Ibid.* Income group reflects median wages in production jobs for affected industries.

In addition to these reduced (or forgone) revenues, the state's welfare expenditures may be increased as a result of delay in creation of the new and supporting jobs. Again, data limitations do not allow reasonable estimates of the magnitude of any increased expenditures. Moreover, the extent of welfare payments is highly dependent on the overall employment situation.

At the local level, only property taxes may be potentially affected by cost impacts related to the permit program. Since no significant shift in population or development patterns is expected, however, any impact on such revenues is likely to be minimal.

d. **Interaction with Other Programs and Policies.** Implementation of the permit program, along with its subsequent impacts, will interact in several ways with other state programs and policies. The nature of these interactions is both positive and negative, as described below.

- Particularly within the commercial and institutional sectors, the permit program may stimulate the use of the resource recovery plants as well as the use of electricity for power. In most cases this will result in a more efficient use of resources.[1] Consequently, the permit program is consistent with and a stimulus to goals of the Connecticut Department of Planning and Energy Policy.

- Air quality strategies also interact with the broader goals of the Department of Planning and Energy Policy. Research indicates that PEP's population forecasts are significantly lower than the OBERS-E Series upon which the Department of Environmental Protection has been relying. This raises questions which Harbridge House is unable to resolve within the scope of this study. However, if the PEP figures are correct, those economic sectors whose growth is heavily linked to population growth, such as the commercial and the retail sectors, may experience only very limited expansion in the future. If this is indeed the more likely case, it may be advantageous for the Department of Environmental Protection to issue permits only to manufacturers, thereby eliminating some of the public and private costs associated with implementation of the permit program. Thus, it may be beneficial for DEP to integrate its emissions forecasts with PEP's forecasts to determine whether a reduction in permits issued is a worthwhile course of action. The discrepancy between the DEP and PEP population figures indicates the need for close coordination between these agencies when the PEP figures become official. (For a further discussion of this area, see Appendix A).

- Based on the analysis in preceding sections the economic impact of permit program implementation is likely to conflict in a limited manner with the employment goals of local and state economic development agencies.

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[1] Electricity use has close to 100 percent efficiency as opposed to 60 to 75 percent for oil and gas. (Source: Connecticut Energy Advisory Board. *Connecticut's Energy Outlook 1975-1994,* p. c-68). Note, however, that a substantially increased demand for electricity may require construction of additional power plant capacity.

Nevertheless, a survey of target industries selected for concentrated marketing efforts by local development agencies indicates a growing orientation toward attraction of "clean" industry. Consequently, the permit program may be viewed as relatively consistent with goals of the economic development agencies in that its implementation mediates conflict between economic growth and clean air. Moreover, the wide-ranging tax incentives and financing options for pollution control complement the objectives of clean air and economic development.

e. **Social Well-Being**. Very limited evaluation of the impact on social well-being can be undertaken in light of the minimal disruption of various trends projected to result from program implementation. In particular, the short-term impact on the primary and fabricated metals industries does not represent a major change from current, relatively depressed conditions in the industry. Other industry groups and sectors are only negligibly affected by program implementation. Further, while the costs of certain services may increase slightly, the nature of the current economic situation is such that permit-related price increases will be negligible compared to increases stemming from other sources. Finally, the failure of the permit program to elicit significant changes in current and projected demographic variables indicates that no major dislocation of the social structure of communities in the AQMA would be created. Nevertheless, consideration was given to impacts on the following components of social well-being:

- *Urban/Rural Mix* – the continuation of the existing mix between urban and rural development levels.
- *Flexibility for Long-Range Response* – the range of options left open for further planning considerations.
- *Local Autonomy* – the amount of decision-making responsibility remaining at the local levels.
- *Income Distribution* – the increase in the income of low income groups in relation to middle and high income groups.
- *Recreational Opportunities* – the supply and choices for outdoor recreation.
- *Population and Employment Mobility* – ease of access in terms of transportation and economic means.
- *Institutional Relationships* – maintenance of traditional authority within community structure.

Consideration of these aspects of social well-being yielded no distinct evidence of potential impact.

2. Benefits

The discussion below focuses on the indirect benefits in terms of three categories: attractiveness, orderly growth, and efficient use of resources. Some aspects of the beneficial impacts of the permit program have been briefly discussed in preceding sections; the emphasis here, however, is on exploring the range and longer term implications of the benefits.

a. **Attractiveness.** Results of quantitative analyses on increased residential property values that would accompany reduced air pollution levels are summarized in Appendix L. These findings have been previously discussed with regard to the direct benefits of the permit program. The basis for these studies provides a key element in further exploration of the benefits accruing to reduced (or stable) levels of pollution: namely, the market price differentials associated with demands for relocation away from pollution. It is probable not only that property values will increase – or fail to decline – as a result of program implementation, but also that people and businesses may be stimulated toward location in Connecticut over the long term.[1]

Although it is difficult to ascertain which groups may be more attracted to Connecticut because of its air quality characteristics and to what extent this incremental stimulation will affect the facility forecasts, it seems reasonable to assume that flexibility with respect to siting may be a key pre-determinate of the demand for relocation away from pollution. Therefore, more highly skilled, professional persons and service-oriented sectors of the economy may be most stimulated toward location in Connecticut. This conclusion, however, is largely conjectural. Moreover, the extent to which any change in population patterns or facility location takes place is highly dependent on the air quality characteristics in adjacent states as well as within different regions of Connecticut. Consequently, the primary conclusion that can be drawn here is that those people and firms located in Connecticut will experience an improved or more desirable quality of life as a result of permit program implementation.

b. **Orderly Growth.** Pollution characteristics are increasingly being incorporated into the criteria used by Connecticut development agencies in identifying target industries for marketing activities. Within this context, the complementarity of objectives among development agencies and the permit program may be viewed as a benefit.[2] Moreover, the BACT requirement of the permit program provides for greater economic growth within the allowable NAAQS air pollution increments. Consequently, the permit program also serves the role of promoting orderly growth.[3]

In light of both these and the attractiveness considerations, it is likely that the air quality benefits of permit program implementation may result in an incremental

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[1]There are examples in which environmental regulations have decreased – or at least have not increased – property values. For example, experience with emission density zoning in Chicago showed that industrial concerns increased their land holdings, which effectively meant zoned land would be used less intensively. Acquisition of residential land by the Los Angeles airport authority in order to continue its operation while meeting environmental constraints is another example where property values were found *not* to increase. The applicability of these examples to the permit program is, however, subject to substantial uncertainty.

[2]Note that this study has not attempted to evaluate the relative priorities of local agencies.

[3]This evaluation of the permit program strategy has been based on the assumption that the ambient air quality impact of new sources will *not* constrain location.

increase in taxes, revenues, and employment; they may also provide for greater flexibility in future planning decisions.

c. **Efficient Use of Resources.** The role of the permit program in promoting more efficient use of resources, particularly within the commercial sector, has been discussed earlier. The conclusions were based on the potential conversion of mainly commercial facilities to resource recovery plants and all-electric power. With regard to the latter, consideration must also be given to the air quality trade-offs involved if additional power plant capacity is required. If such new generating capacity (necessitated by conversions resulting indirectly from the permit program) is nuclear based, then increased air quality benefits would clearly accompany design changes incorporating all-electric power sources. Addition of fossil generating capacity, however, would result in more spatially concentrated emissions, thereby posing a potentially greater air quality impact. These types of considerations may warrant further evaluation on the part of the DEP.

Another area involving potentially more effective use of resources involves the pollution control expenditures required under the BACT provision. Some BACT applications involve changes to more efficient processes or recovery of Connecticut materials otherwise lost as pollution. For example, in kraft paper mills electrostatic precipitators are used both to recover salt cake and as an air pollution abatement device. The installation costs of $4.5 million (1,000 tons of daily capacity) were offset by about $3.5 million per year in marketable salt cake recovered.[1] While savings in Connecticut may not be as great as those in this example, there are potential benefits connected with the pollution control expenditures. The case-by-case assessment required to estimate the extent of such "productive" control expenditures cannot be undertaken within the scope of this study. However, a generalized discussion of such occurrences is included in Appendix O.

E. Summary

The permit program strategy assessment has addressed the potential impacts of the emission limitation (specified as BACT) incorporated in the Connecticut new source review process. Direct and indirect costs and benefits have been evaluated, with analysis focusing on the incremental "order of magnitude" impacts, using both quantitative and qualitative techniques. Results of this assessment are summarized below and presented in matrix form in Exhibits 19 and 20.

Direct Costs

- Over the next 10 years, the present value of program implementation costs to the public sector is about $990,000. This represents nearly 10 percent of the state's current budgetary expenditures for the DEP Air Section and 4.5 percent of the total (state and federal) Air Section allocations, on an annual basis.

- Over the next 10 years, the present value of permit-related application and control costs is nearly $20 million. Of these costs, 90 percent are incurred by the manufacturing sector and 9 percent by the commercial sector.

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[1] Leung and Klein. *op. cit.*, p. 29.

EXHIBIT 19
DIRECT IMPACT SUMMARY: THE PERMIT PROGRAM

Economic Sectors	AQMA EMISSIONS* TSP % of 1975	AQMA EMISSIONS* TSP % of Gross Increase 1975 - 1985	AQMA EMISSIONS* SO_2 % of 1975	AQMA EMISSIONS* SO_2 % of Gross Increase 1975 - 1985	Direct Impact Cost Forecast Growth	Direct Impact Benefit Health and Welfare	Direct Impact Benefit Pollution Control Market
All Manufacturing	24.6	40.2	16.1	37.7	I	M	M
20 Food	0.4	0.5	0.3	0.6	(2)	(3)	(3)
22 Textiles	0.7	0.4	0.7	reduction	(2)	(2)	(2)
23 Apparel	0.1	0.1	0.06	0.1	(1)	(1)	(1)
24, 25 Lumber, Wood	0.03	0.1	0.06	0.2	(2)	(1)	(2)
26 Paper	1.6	1.0	1.1	1.4	(2)	(5)	(3)
27 Printing, Publishing	0.1	0.2	0.1	0.5	(2)	(2)	(3)
28 Chemicals } 30 Rubber, Plastics }	3.1	8.0	2.3	8.5	(3)	(10)	(5)
					(4)		(6)
29 Petroleum, Asphalt	0.2	0.9	0.2	0.8	(3)	(4)	(2)
33 Primary Metals	2.5	1.9	2.1	reduction	(5)	(5)	(7)
34 Fabricated Metals	2.5	6.8	2.0	6.9	(5)	(9)	(8)
35 Machinery	1.8	1.3	1.2	1.5	(4)	(6)	(7)
36 Electrical Machinery	1.2	3.1	1.1	5.2	(3)	(7)	(6)
37 Transportation Equip.	6.4	9.5	3.1	7.7	(1)	(11)	(3)
31 Leather }					(2)		(1)
32 Stone, Clay, Glass }	4.0	6.4	1.8	4.3	(3)	(8)	(4)
38 Instruments }					(2)		(4)
39 Miscellaneous }					(4)		(6)
All Commercial**	6.5	34.5	8.1	54.0	I	M	I
50 - 59	0.6	2.0	0.7	2.5	(1)	(1)	(3)
60 - 69	1.6	8.0	1.8	11.0	(1)	(2)	(1)
70 - 89**	4.3	24.5	5.6	40.5	(2)	(3)	(2)
All Institutional**					I	M	I
All Municipal Waste	34.6	1.2	2.1	0.1	I	I	I
Sewage Sludge	0.3	1.2	0.02	0.1	(1)	(2)	
Municipal – Refuse	34.3	reduction	2.1	reduction	(1)	(1)	
Electric Utilities	24.7	Zero	71.4	Zero	I	I	I

*Emissions after control (BACT) for point sources.

**Institutional emissions aggregated with SIC 70-79 (commercial).

Source: AQMA emissions from DEP; Economic analysis and rankings by Harbridge House, Inc. (1976).

KEY

I = Insignificant impact.
M = Moderate impact.
S = Significant impact.
( ) = Relative rankings within major sectors: (1) represents least relative impact. Impact on forecast growth rankings developed in Harbridge House analysis. Impact on health and welfare rankings based on contribution to gross emission growth. Impact on pollution control market rankings based on relative expenditures for pollution control equipment.

EXHIBIT 20
INDIRECT IMPACT* SUMMARY: THE PERMIT PROGRAM

	Costs						Benefits			
				Other Programs**						
	Job Opportunities	Population Distribution/ Development Patterns	State and Local Taxes	PEP — Resource Use	PEP — Population Projections	Economic Development,	Social Well-Being	Attractiveness	Orderly Growth	Resource Use Efficiency
All RPA's	M	I	M	M+	M-	M+	I	M	M	M
Capital	(2)	(1)	(1)	(3)	(1)	(1)	(1)	(2)	(2)	(3)
Central Connecticut	(5)	(2)	(1)	(3)	(1)	(1)	(1)	(2)	(2)	(3)
Midstate	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Central Naugatuck Valley	(4)	(2)	(1)	(2)	(1)	(1)	(1)	(3)	(3)	(2)
Housatonic Valley	(1)	(1)	(1)	(2)	(1)	(1)	(1)	(1)	(1)	(2)
Valley	(4)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Greater Bridgeport	(3)	(2)	(1)	(2)	(1)	(1)	(1)	(3)	(3)	(2)
South Western	(2)	(1)	(1)	(2)	(1)	(1)	(1)	(2)	(2)	(2)
South Central Connecticut	(3)	(1)	(1)	(2)	(1)	(1)	(1)	(3)	(3)	(2)

*Indirect impacts classified as costs or benefits according to their source in either direct costs or direct benefits.

**Indicated as conflicting (-) or complementary (+).

KEY

I = Insignificant Impact
M = Moderate Impact
S = Significant Impact
( ) = Relative ranking among RPA's based on impact analysis and forecasts. (1) represents least relative impact. When all rank (1) indicates no difference.

Source: Harbridge House, Inc. (1976)

- Average costs per permit range from $700 (veterinary clinics) to $63,000 (primary metals industry), with a median cost per permit of $2,500.

- Direct permit-related costs are estimated to have an insignificant impact on all economic sectors, with the exception of the primary and fabricated metal industries. On an annual basis, the total permit-related costs to these two metals industries represent from 0.5 to 0.14 percent (primary) and from 0.03 to 0.08 percent (fabricated) of their 1972 value added. The relatively depressed state of these industries in Connecticut indicates that the increases in operating costs would have a moderate impact on growth rates through 1980. However, because of the solidly entrenched portions of each industry in Connecticut it was concluded that the original forecasted growth level would be regained by 1985.

Direct Benefits

- On a nationwide level, significant savings from pollution control are apparent as a result of reductions in particulate and sulfur oxide concentrations. Even at levels below the standards there is substantial evidence of control benefits.

- Pollution control equipment manufacturers in Connecticut and nationwide stand to benefit from the stimulation in demand for their products resulting from the permit program. The $19 million in control expenditures estimated for the permit program over the next 10 years represents from 0.2 to 0.6 percent (on an annual basis) of the 1975 market for control equipment.

Indirect Costs

- The Central Naugatuck Valley RPA bears the greatest percentage of direct permit-related costs (18 percent), followed by the South Central Connecticut RPA (17 percent) and the Greater Bridgeport RPA (15 percent). The Midstate, Housatonic Valley, and Valley RPA's each bears 5 percent or less of the total costs.

- For the entire AQMA, permit-related costs are about 0.01 percent of projected 1985 total earnings, on an annual basis. Manufacturing costs represent 0.04 percent of 1985 manufacturing earnings; costs incurred by SIC's 33 and 34 represent 0.1 percent of their 1985 earnings, on an annual basis. The impact on the economic stability of the AQMA is expected to be insignificant.

- The direct cost impact of strategy implementation is expected to delay the rate at which 2,500 new jobs will be created in the primary and fabricated metals industries and as many as 7,500 new jobs in supporting industries. The Central Connecticut, Central Naugatuck Valley, Greater Bridgeport, Valley, and South Central RPA's will be most affected by the slowed-down creaction of job opportunities through 1980. Job opportunities are expected to have regained forecasted levels by 1985.

- Because of the short duration of potentially adverse employment impacts, only negligible change in forecasted population distribution and development patterns is expected.

- State sales and corporate income tax revenues are estimated to be reduced slightly over the 1976 to 1980 period (as compared to revenues that would be obtained in the absence of the permit program). Negligible impact on local revenues and expenditures is expected.

- Potential design changes, primarily in the commercial sector, incorporating all-electric power or rescource recovery plants reinforce DEP goals.

- Conflict exists between DEP population projections and the preliminary DEP forecasts.

- The permit program can be seen as mediating the environmental and economic objectives of local development agencies.

- The impact on social well-being is expected to be negligible.

Indirect Benefits

- Evidence of a demand to locate away from pollution indicates that AQMA residents will experience an improved quality of life.

- By providing for increased economic activity within the air quality limits imposed by the NAAQS, the permit program BACT requirement promotes orderly growth.

- Increased efficiency in the use of resources may be derived from the permit program's incentive for using resource recovery plants and all-electric power as well as from "productive" pollution control expenditures such as those contributing to the recovery of valuable materials.

CHAPTER IV: IMPACT ASSESSMENT – THE NULL STRATEGY

A. Background and Approach

Based on its air quality projections, the Connecticut DEP has indicated that the primary annual standards for TSP and/or SO_2 may be exceeded in six towns by 1985. These towns are shown in Exhibit 21 together with the pollutant that will exceed the standards; the year the violation is expected; and the towns in which sources most affecting the measured levels are located. Three of the six towns are expected to have ambient levels in excess of the primary standards for both TSP and SO_2 by 1985.

According to the DEP regulations regarding standards for granting permits, approval may not be given unless the new or modified source "will operate without preventing or interfering with the attainment or maintenance of applicable federal national ambient air quality standards."[1] This provision would require denial of permits in those towns shown in Exhibit 21 during and after the year in which standard is exceeded. Although a violation is expected in only one town within each airshed, factors such as stack height, volume of emissions, and topographical and meteorological conditions may cause sources in the other towns within each airshed to cause violations of the standard. Consequently, the number of permit denials required within an airshed is very much specific to the location and characteristics of the individual sources.

The Connecticut DEP in evaluating permit applications assesses the impact of each source on air quality at several receptors within each airshed, thereby empirically determining the need for permit denials. Since such detailed air quality analysis is not within the scope of this study, two scenarios have been developed for use in determining the low and high potential impact levels. In the low-impact scenario only those sources projected to locate within the towns in which a standard violation is expected are assumed to be subject to permit denials. The second, high-impact scenario, is based on the assumption that sources locating within all the towns in the specified airsheds are subject to permit denials. Both scenarios assume that 100 percent control of particulate and sulfur oxide emissions will not be obtained within the 10-year study period.

The facility forecasts made in Chapter II serve as the data base for this assessment. In order to address the constraint imposed by permit denials, the regional facility forecasts are further allocated by airshed and by town. Manufacturing allocations are based on an employment distribution function, while commercial and institutional facilities are distributed by population.

Evaluation of the Connecticut emission inventory indicated that nearly all the source categories, when aggregated at the two-digit SIC level, emit both particulates and sulfur oxides as a result of fuel combustion. For these sources, then, it has been assumed the permit denials will be required in the year in which a possible standard violation is first

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[1] Department of Environmental Protection. *Administrative Regulations: Abatement of Air Pollution*, p. 3.

EXHIBIT 21
POTENTIAL STANDARD VIOLATIONS IN CONNECTICUT AQMA

Town*	Pollutant	Year	Airshed**
New Britain	TSP SO_2	1975 1978	New Britain, Berlin, Plainville, Newington, Farmington
Hartford	TSP SO_2	1978 1985	Hartford, East Hartford, West Hartford, Wethersfield, Windsor, Bloomfield
Waterbury	TSP SO_2	1978 1978	Waterbury, Naugatuck, Beacon Falls
Stamford	SO_2	1978	Stamford, Greenwich, Darien, Norwalk
Ansonia	TSP	1980	Ansonia, Derby, Shelton, Seymour
Middletown	SO_2	1985	Middletown, Cromwell, Meriden

*Town in which standards are expected to be exceeded.

**Towns in which sources most affect measured levels in town wherein standards are expected to be exceeded.

Source: Connecticut Department of Environmental Protection (1976).

expected for either particulates or sulfur oxides.[1] Moreover, for those sources where a distinction could be made between emission of sulfur oxides and of particulates based on the emission inventory and/or the DEP permit history, the date of and sources affected by permit denials were so determined.

As in Chapter III, the assessment distinguishes between direct and indirect impacts based on sectoral/regional or topical delineation. Similarly, costs and benefits are addressed discretely – despite their substantial interplay – in order to provide a basis for others to weigh the net impact of the null strategy according to individual judgment or public policy. Both quantitative and qualitative analyses have been used to provide indications of the level and range of impacts. The type of analysis was dictated by data availability and is not intended to reflect an intrinsic level of importance attributable to the impacts.

Because the Chapter III analysis focused on the permit strategy in the absence of constraints imposed by permit denials, the evaluation in this chapter emphasizes the incremental impact of permit denials over and above the impact of permit strategy implementation. Consequently, only those economic sectors and regions potentially affected by permit denials are evaluated here. Furthermore, the air quality implications of modifications in development patterns of towns outside the affected airsheds has not been addressed.

B. Direct Impact

As shown in Exhibit 22, by 1985 from 3 to 11 percent of land in the state may be restricted from further development by sources emitting TSP and/or SO_2. Although this range appears relatively small, the tracts involved are some of the most densely developed areas in Connecticut. Exhibit 22 summarizes the land area and projected 1985 population of the towns potentially affected by permit denials under the two alternative scenarios. Under Scenario 1, in which it is assumed that only the town where the standard violation is expected will require permit denials, 3 percent of the state's land area and 16 percent of the projected 1985 population is potentially affected. With scenario 2, the high range of impacts that is based on the assumption that all the towns in the affected airsheds will be subject to permit denials, about 11 percent of the state's land area and 35 percent of the projected 1985 population is potentially affected.

1. Costs

The direct costs of the null strategy are borne by those firms which will be denied permits and, thus, restricted from expanding at their preferred site. Three general types of costs are potentially incurred: opportunity costs, costs of dislocation, and costs associated with a less than optimal alternative location.

Opportunity costs would be incurred when an establishment subject to permit denial is operating so close to the margin that expansion is economically feasible only at the preferred site denied by the permit. This cost, represented by the growth which

[1] This represents the worst potential impact since individually all sources do not necessarily emit both pollutants.

EXHIBIT 22
LAND AREA AND POPULATION AFFECTED UNDER ALTERNATIVE SCENARIOS: 1985

	Scenario 1*		Scenario 2**	
Town	Land Area (Square Miles)	1985 Population	Land Area (Square Miles)	1985 Population
Stamford	37.3	122,980	120.5	310,620
Hartford	17.2	176,690	126.2	396,130
Ansonia	6.2	24,030	56.3	85,170
Middletown	41.7	41,700	77.7	114,490
Waterbury	28.6	127,220	54.6	159,020
New Britain	13.3	90,470	91.6	174,920
Total	144.3	583,090	526.9	1,240,350
Percent of State	3%	16%	11%	35%

*Scenario 1 is based on the assumption that permit denials will be required only in the towns shown.

**Scenario 2 is based on the assumption that permit denials will be required in entire airshed of which the town is a part.

Source: Connecticut Department of Commerce, *Connecticut Market Data, 1974 - 1975,* and OBERS-E population projections, assuming the relationship between town and state populations is constant.

is foregone, would primarily affect existing establishments which would otherwise expand on site. The firm-specific information needed to evaluate the extent and "order of magnitude" of growth-related opportunity costs is not available within the scope of this study. Consequently, subsequent evaluation has recognized these costs without assessing their impact.

The costs resulting from dislocation involve such things as additional site selection expenditures, possible land holding and resale expenses, and, in some cases, loss of economies of scale. Except for loss of economies of scale, these incremental costs largely result from abrupt interruption of growth trends and therefore can be minimized by adequate warning of imminent permit denials. Because of the small average size of Connecticut firms (less than 20 employees), it is not expected that loss of economies of scale will pose significant constraints on growth in any of the economic sectors. However, for individual firms there may be substantial losses resulting from an inability to take advantage of such economies. Evaluation of the magnitude of impact of the dislocation costs is substantially limited by this study's level of detail. The types of indicators that could be used include the lead time required to make new facilities operational; evidence of decreasing costs as facility size increases; and, to some extent, the capital intensity of production facilities.

The third type of costs results from location at a less than optimal alternative site. For many industries these costs may be negligible or nonexistent because of inherent flexibility regarding site selection. Furthermore, the site selection process involves optimization of several locational requirements such that restrictions on expansion at a preferred site may increase certain costs while decreasing costs associated with other locational objectives. Exhibit 23 illustrates the types of trade-offs involved by depicting the major locational inputs and their price gradations in the Boston metropolitan region. As the exhibit indicates, a central city location, for example, offers the highest land costs and the lowest costs associated with obtaining medium skilled labor. To evaluate the incremental cost of location at an alternative inner city site, for instance, the firm's relative preferences for land versus labor as well as its requirements regarding transportation, customer contact, and business services must be known.

To some extent, surrogate indicators of industry-wide preferences for the various locational inputs can be used to assess the impact of location at an alternative site. These indicators include the durability or nondurability of the product, the market orientation, the wage or skill levels, firm size, and the value of the product per pound. Exhibit 24 summarizes the rationale for and use of the indicators. The exhibit shows that durable producers are less oriented toward population density and more toward land than nondurable producers, which generally find significant advantages in densely developed locations. Generally, nondurable producers also have a local market orientation.

There are exceptions to this relationship, however; thus, the location quotient is used in subsequent analysis to provide a supplementary indicator of market orientation. Average wage levels provide insight into the skill mix required and can be used to match industry groups with alternative locations. Average firm size can be useful in evaluating trade-offs between land or labor inputs and other types of locational requirements, while the value of a product per pound is only of significance in very low value, heavy goods.

EXHIBIT 23
INPUTS AND RELATIVE INPUT PRICES IN THE BOSTON REGION

	Relative Price by Zone			
Type of Input	**Central City**	**Other Core**	**Inner Ring**	**Outer Ring**
Land				
Land Cost	Highest	High	Low	Lowest
Labor				
High-skilled	Highest	Low	Lowest	High
Medium-skilled	Lowest	Lowest	High	Low
Low-skilled	Lowest	High	Highest	Low
Transportation				
Intrametropolitan truck	Low	Low	Lowest	High
Extrametropolitan truck	Highest	High	Low	Lowest
Rail	High	High	Low	Lowest
Plane	Lowest	Low	High	Highest
Ship	Lowest	Low	High	Highest
Customer contact (market information)				
Primarily face-to-face	Lowest	Low	High	Highest
Primarily phone/mail		[site invariant]		
Business services				
Machine repair and custom contract	Lowest	Low	High	Highest
Legal, accounting, advertising		[site invariant]		

Source: Donald N. Stone. *Industrial Location in Metropolitan Areas: A General Model Tested for Boston.* Praeger Publishers (1974).

EXHIBIT 24
SUMMARY OF RATIONALE FOR AND USE OF INDICATORS OF LOCATIONAL PREFERENCE

1. **Durability/Nondurability**

   - Durable producers usually require more space per worker in order to provide internal services on site which nondurable producers provide jointly with other firms in the industry.

   - Density and concentration are usually advantageous to nondurable producers because of:

     – Expanded market exposure and face-to-face customer contact.

     – Minimized cost of uncertainty associated with product changes related to facility of subcontracting and industrial integration.

     – Common markets for supplies of raw materials, unfinished goods, and labor, thereby providing a cost savings.

2. **Local, Regional, or National Market Orientation**

   - Local market orientation indicates limited locational radius and use of intra-metropolitan trucking.

   - Regional or national market orientation indicates more flexible siting and, in conjunction with (5), the preferred mode of transportation.

3. **Wage or Skill Levels**

   - Over the short term a firm is likely to treat the existing distribution of labor skills as fixed.

4. **Firm Size**

   - Provides indication of the strength of preference for land and labor.

5. **Value of Product per Pound**

   - The higher the value of the product per pound, the less transportation sensitivity of the firm.

Source: Donald N. Stone. *Industrial Location in Metropolitan Areas: A General Model Tested for Boston.*

Even with the aid of these indicators of relative industry preferences, there remains substantial uncertainty regarding the potential impact of location at an alternative – and perhaps less than optimal – site. For example, absolute costs cannot be estimated in a generalized fashion. Use of relative costs and preference indicators often results in conflicts that cannot be resolved from available data. In addition, cost increases of the same magnitude can have substantially different impacts on the growth prospects of firms within the same industry and among different industries. Finally, only generalized locational requirements are taken into account by this approach such that individual firms or industry segments may encounter greater or lesser costs than would be expected from subsequent analysis.

Because of the foregoing limitations, the direct cost analysis rests largely on reasoned assessments of relative impact. Additionally, as a prelude to the analysis, demographic, land use, and transportation system maps were examined to assess the availability of alternate sites for manufacturing and non-manufacturing development. Since sufficient availability was found within the Connecticut AQMA, it was implicitly assumed that firms would first seek alternate sites within the AQMA. Each sector is evaluated below separately.

a. **Manufacturing.** Exhibit 25 shows the number of establishments subject to permit denials by industry group. Under Scenario 1 (low impact), 166 firms, or 17 percent of the forecasted expansion in the entire AQMA, are affected. With Scenario 2, 365 firms, or 36 percent of the forecasted expansion, are subject to permit denials. In terms of the number of establishments affected, the printing and publishing, fabricated metal, and non-electrical machinery industries are most impacted under both scenarios. When viewed in relation to projected growth by industry, however, food products and chemicals manufacturing experience relatively greater impact under Scenario 2; food, chemicals, and miscellaneous manufacturing appear relatively more affected under Scenario 1.

Assuming that growth-related opportunity costs are not incurred, the firms denied permits are expected to seek alternate locations.[1] In doing so, costs resulting from dislocation and costs caused by location at perhaps a less than optimal site may be incurred. Assessment of the relative magnitude and extent of these costs is discussed below. In addition, the costs and number of establishments affected by permit denials are integrated into an evaluation of the impact of the two scenarios on the growth prospects of each manufacturing group in Connecticut.

(1) **Relative Magnitude of Dislocation Costs.** Although several indicators could be used to estimate the relative costs imposed on each industry by dislocation, data availability substantially constrains their application. Moreover, it is likely that cost variations are more a function of individual firm characteristics than industry-wide practices. Therefore, assessment of dislocation costs has focused on gaining a perspective on the extent of any impact.

Statistics regarding establishment of new firms in Connecticut from 1963 to 1972 provide some insight. Of the 1,620 new manufacturing firms that started operations during

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[1]Note that this assumption is required because data limitations preclude evaluation of the extent or magnitude of potential opportunity costs.

EXHIBIT 25
MANUFACTURING PERMIT DENIALS
UNDER ALTERNATIVE SCENARIOS (1976-1985)

		Number of Establishments				
SIC	Description	Permits Denied Scenario 1	Percent of Expansion	Permits Denied Scenario 2	Percent of Expansion	Forecast AQMA Expansion
20	Food and Kindred Products	8	(24%)	18	(53%)	34
22	Textile Mill Products	0	–	3	(19%)	16
23	Apparel and Products	0	–	0	–	8
24	Lumber and Wood Products	1	(10%)	1	(10%)	10
25	Furniture and Fixtures	2	(7%)	5	(18%)	28
26	Paper and Allied Products	1	(5%)	5	(24%)	21
27	Printing and Publishing	22	(25%)	43	(49%)	88
28	Chemicals and Allied Products	11	(26%)	19	(45%)	42
29	Petroleum and Coal Products	0	–	2	(25%)	8
30	Rubber and Plastic Products	8	(13%)	15	(23%)	64
31	Leather and Leather Products	1	(13%)	2	(25%)	8
32	Stone, Clay, Glass Products	1	(4%)	7	(30%)	23
33	Primary Metal Industries	7	(18%)	12	(31%)	39
34	Fabricated Metal Products	26	(16%)	57	(36%)	160
35	Machinery, Except Electrical	47	(18%)	113	(44%)	258
36	Electrical Equipment	12	(16%)	25	(33%)	75
37	Transportation Equipment	0	–	6	(4%)	15
38	Instruments and Related Products	5	(16%)	9	(28%)	32
39	Miscellaneous Manufacturing	14	(21%)	23	(34%)	68
	TOTAL	166	(17%)	365	(36%)	997

Source: Harbridge House, Inc. (1976).

that period, only 5.9 percent were branches of Connecticut firms.[1] However, these establishments accounted for 24.4 percent of employment and 22.4 percent of the total floor space of new firms. Consequently, it appears that costs of land holding and resale would not affect a great number of firms, and any such costs would probably be incurred by relatively large firms. The increased site-selection costs imposed by dislocation would be incurred universally during the first year or two of permit denials and would probably vary with the flexibility of siting requirements as described below.

(2) **Relative Magnitude of Locational Costs.** For each of the industry groups subject to permit denials, the generalized locational preferences were evaluated based on the indicators previously described – product durability or nondurability,[2] market orientation as indicated by the location quotient,[3] wage levels,[4] firm size,[5] and product value per pound.[6] Exhibits 26 through 29 summarize the pertinent indicators and categorize the industry groups according to product durability and market orientation. The analysis is based on comparison of these industry groupings with Exhibit 30, which summarizes the population density and relative wage levels of the Connecticut Labor Market Areas (LMA's). Pertinent conclusions are shown below:

- *Durable Producers Serving National Markets (see Exhibit 26).* These industries (SIC's 33 to 38) are most flexible with respect to siting. Transportation costs and proximity to concentrated development are of minimal importance. Labor skills and land costs (particularly for SIC's 33, 36, and 38) may be significant factors in selection of alternative sites. SIC 36 industries are relatively more constrained because of their lower skilled labor requirement and need for a relatively larger parcel of land. The other industry groups are likely to find suitable sites within the AQMA. None of these six industry groups is expected to incur substantial locational costs.
- *Nondurable Producers Serving National Markets (see Exhibit 27).* These industries (SIC's 27, 30, and 39) are also relatively flexible with respect to

[1]Connecticut Department of Commerce. *Statistical Survey of New Manufacturing Firms in Connecticut: 1963-1972.*

[2]Product durability or nondurability is a sometimes vague distinction at the two-digit SIC level of aggregation. The delineation used here is based on Federal Reserve Board categorizations of durable and nondurable manufacturers.

[3]See Appendix K.

[4]Wage levels by industry obtained from Connecticut Department of Labor's average hourly earnings of production workers in January 1975. Plus or minus 10 percent of the average hourly earnings for all manufacturing was used as the middle range in the relative industry comparisons.

[5]The median firm size for each manufacturing industry in Connecticut in 1973 was obtained from *County Business Patterns.* The median firm size for all manufacturing industries was used as the middle range in the relative comparisons.

[6]Precise estimates of product value per pound were not available except for a few industries based on national statistics in the *Industrial Outlook, 1975.* Since only very low value, heavy products were important to identify, judgment was used to supplement statistics.

EXHIBIT 26
LOCATIONAL PREFERENCE INDICATORS FOR DURABLE PRODUCERS WITH LOCATION QUOTIENTS GREATER THAN ONE

SIC*	Description	Employment Size	Production Wages
33	Primary Metals	Larger	Average
34	Fabricated Metals	Average	Average
35	Machinery	Smaller	Higher
36	Electrical Machinery	Larger	Lower
37	Transportation Equipment	Average	Higher
38	Instruments	Larger	Average

*These industry groups serve national markets and are not tied to areas of concentrated development. Land costs may be an important factor in site selection, particularly for SIC's 33, 36, and 38 because of their relatively greater size. All are relatively transportation insensitive because their products are in the medium- to high-value range.

Source: Harbridge House, Inc. (1976). See text for explanation of relative rankings.

EXHIBIT 27
LOCATIONAL PREFERENCE INDICATORS FOR NONDURABLE PRODUCERS WITH LOCATION QUOTIENTS GREATER THAN ONE

SIC*	Description	Employment Size	Production Wages
27	Printing and Publishing	Smaller	Higher
30	Rubber and Plastics	Average	Lower
39	Miscellaneous Mfg.	Average	Lower

*These industry groups serve national markets and are relatively more closely tied to areas of concentrated development than are other groups serving nationwide markets. All three groups are relatively transportation cost insensitive.

Source: Harbridge House, Inc. (1976). See text for explanation of relative rankings.

EXHIBIT 28
LOCATIONAL PREFERENCE INDICATORS FOR DURABLE PRODUCERS WITH LOCATION QUOTIENTS LESS THAN ONE

SIC*	Description	Employment Size	Production Wages
24	Lumber and Wood	Average	Lower
25	Furniture	Average	Lower
32	Stone, Clay, and Glass	Average	Average

*These industry groups serve local or regional markets and are not closely tied to concentrated development. However, SIC 32, which is primarily comprised of concrete, plaster products, and gypsum manufacturers, may be relatively more oriented toward areas of high construction activity. Similarly SIC 32 is likely to be more transportation cost sensitive than SIC's 24 and 25.

Source: Harbridge House, Inc. (1976). See text for explanation of relative rankings.

EXHIBIT 29
LOCATIONAL PREFERENCE INDICATORS FOR NONDURABLE PRODUCERS WITH LOCATION QUOTIENTS LESS THAN ONE

SIC*	Description	Employment Size	Production Wages
20	Food and Kindred Products	Average	Average
22	Textile Mill Products	Larger	Lower
26	Paper and Allied Products	Larger	Average
28	Chemicals and Allied Products	Average	Higher
29	Petroleum and Coal Products	Smaller	Average
31	Leather and Leather Products	Average	Average

*These industry groups serve local or regional markets and are closely tied to areas of concentrated development. SIC's 22 and 26 may place relatively greater emphasis on land costs and labor availability because of their larger average size. SIC 29 is primarily comprised of asphalt batching plants which, because of their heavy, low-value products, are relatively sensitive to transportation costs. The other industry groups are relatively transportation cost insensitive.

Source: Harbridge House, Inc. (1976). See text for explanation of relative rankings.

EXHIBIT 30
POPULATION DENSITY AND RELATIVE WAGE LEVELS OF CONNECTICUT LABOR MARKET AREAS

Labor Market Areas Skill Classification	Population Density of Major City
High Wage	
Meriden (1 of 3)*	2,379.7
New London	5,722.2
Bristol	2,113.6
Hartford (8 of 26)*	9,029.1
Average Wage	
Stamford (3 of 4)*	2,898.1
New Haven	7,277.2
Norwalk (1 of 4)*	3,565.2
Bridgeport (1 of 8)*	9,779.9
Danbury	1,309.5
Middletown (2 of 16)*	880.1
Waterbury (3 of 12)*	3,909.1
Ansonia (3 of 4)*	3,419.4
New Britain (3 of 3)*	5,985.0
Low Wage	
Willimantic	749.1
Norwich	1,716.5
Danielson	427.9
Tarrington	815.7

*Indicates Labor Market Areas (LMA's) which encompass towns in the airsheds. Parentheses indicate number of towns in airshed of the number of towns in LMA.

Source: Harbridge House, Inc. (1976). Based on Connecticut Department of Labor 1975 (Sept.) wage levels and *Market Data Book 1974 - 1975.*

siting. Although transportation costs are not a major factor in locational decisions, proximity to concentrated development may be of significant concern. SIC 27, which requires comparatively small numbers of higher skilled labor, should not be significantly affected by location of an alternate site within the AQMA or elsewhere in Connecticut. SIC's 30 and 39, however, may encounter greater difficulty because the labor market areas which characteristically provide lower skilled labor are not in areas of concentrated development. Nevertheless, within the average skilled LMA's there are likely to be substantial proportions of lower skilled labor, and population densities are sufficiently high to support the business service requirements of these two groups. None of these industries is expected to incur substantial locational losses.

- *Durable Producers Serving Local or Regional Markets (see Exhibit 28).* These industries (SIC's 24, 25, and 32) are relatively less flexible with respect to siting. Although they are not tied to areas of concentrated development, their local/regional market orientation indicates that they are likely to seek suitable locations in the vicinity of the airsheds. Because of the lower skilled labor requirements of SIC's 24 and 25, greater locational costs may be incurred by these industries. SIC 32 is relatively more constrained by its transportation costs sensitivity; thus it also incurs greater locational costs.

- *Nondurable Producers Serving Local or Regional Markets (see Exhibit 29).* These producers (SIC's 20, 22, 26, 28, 29, and 31) are least flexible with respect to siting because of their dependence on locations with concentrated development and their orientation toward local/regional markets. Because of the market orientation of these firms, they will probably attempt to find suitable locations in the vicinity of the airsheds. SIC 22 firms may be substantially more affected by locational costs particularly because of their lower skill requirement and relatively large average firm size. The transportation sensitivity of SIC 29 may result in substantially greater locational costs for firms in that sector.

(3) **Conclusions.** The preceding analysis has emphasized the relative magnitude of costs resulting from permit denials. Seven manufacturing groups have been singled out as being likely to incur greater locational costs as compared to the others in their respective groups. Together, the permit denials in these industries represent from 12 percent (Scenario 1) to 25 percent (Scenario 2) of AQMA forecasted expansion for the seven industries. Although these groups may bear relatively greater costs, the absolute magnitude of the costs is not likely to significantly affect growth or product prices, particularly in the five industries that are constrained by a lower skilled labor requirement.

The higher prices that may have to be bid for the labor input will be substantially mitigated as population shifts take place within the AQMA or as marginally increased commuting distances become the norm rather than the exception. A similar situation may also mitigate the increased transportation costs at least initially incurred by SIC's 32 and 29, both of which serve the construction industry; that is, as shifts in development occur, the transportation efficiency of alternative sites will change and shipment distances will probably decrease. In the interim, price increases rather than a reduced rate of growth will most likely absorb the incremental cost increases.

b. **Commercial Sectors.** Exhibit 31 summarizes the permit denials by SIC under the two alternative scenarios. From 154 to 297 establishments are likely to be affected, about half of which are in the retail trade group. However, because of the number of commercial establishments which do not require permit approvals (see Chapter II), those establishments that are affected by permit denials represent, at most, about 3 percent of growth within each group. The types of costs incurred and their potential impact on each group are described below. Again, because of data limitations, it has been assumed that opportunity costs are not widely experienced.

(1) **Relative Magnitude of Dislocation Costs.** Because of the nature of establishments in the commercial sector, the costs resulting from dislocation are expected to relate primarily to additional site selection expenditures. For the most part, these costs will be minimal. However, in the case of planned large multi-use or shopping center developments, the delay incurred by the requirement to repeat a part of the site selection process may represent a significant cost factor.

(2) **Relative Magnitude of Locational Costs.** The major locational requirements for commercial sector establishments are likely to concern customer contact and accessibility of business services. Consequently, location near population centers would be of utmost importance. In such areas, there is likely to be sufficient availability of labor in white collar occupations as well as adequate transportation accessibility.

Subgroups within each of the commercial SIC's have location quotients greater than one, indicating that the establishments probably serve national markets (see Appendix K); these subgroups have the option of locating in or around another population center. Those establishments serving local or regional markets, however, will most likely seek alternate locations in the vicinity of the affected airsheds (or major airshed towns). The firms which have to locate near their original (preferred) site will probably experience relatively greater costs because of incrementally increased distances from the population center. Nevertheless, suitable sites are available within five to 10 miles of each airshed – thus, the magnitude of the costs is likely to be small.

(3) **Conclusion.** In assessing the impact of permit denials on the commercial sector, it is essential to recognize the flexibility of these establishments to rely completely on electricity for power and/or to use municipal incineration facilities. Consequently, some firms may find that costs are fairly readily absorbed by these changes and remain at their preferred sites. Moreover, changes in development patterns described in detail in Section C, above, may substantially alter the desirability of alternative locations over time. Depending on each firm's long-term plans, such changes may weigh in favor of an otherwise less desirable location. As a result of these considerations, it appears unlikely that permit denials will have a significant impact on growth or prices in the commercial sector.

c. **Institutional Sectors.** Based on the forecasts in Chapter II, no permits will be denied to hospitals, and mental retardation, mental health, and educational facilities in the AQMA. However, some permit denials will probably be required for nursing homes and for veterinary clinics. Under the low-impact scenario, no nursing home permits and three veterinary permits will be denied; under the high-impact scenario, five nursing homes and six veterinary clinics will be restricted from locations in the airsheds. An important mitigating factor regarding the costs that may be incurred by these facilities is the flexibility to utilize municipal waste incinerators (instead of on-site incinerators) and to obtain power from

EXHIBIT 31
COMMERCIAL PERMIT DENIALS UNDER ALTERNATIVE SCENARIOS (1976-1985)

		Number of Establishments	
SIC	Description	Permits Denied Scenario 1	Permits Denied Scenario 2
50	Wholesale Trade	18	35
52-59 (except 58)	Retail Trade	77	147
58	Eating and Drinking Establishments	28	52
60-67	Finance, Insurance, and Real Estate	8	16
70-89 (except 80, 82)	Services	23	47
	TOTAL	154	297

Source: Harbridge House, Inc. (1976). See text for explanation of scenarios.

all-electric sources. Under such circumstances the affected facilities could remain at the originally planned location. Moreover, location at an alternate site would not be expected to impose substantial costs on these facilities because of their relative flexibility vis-a-vis siting and availability of suitable land. No significant impact on growth or service fees is expected.

d. **Municipal Waste Disposal.** Of the nine resource recovery plants forecast in the AQMA, five could be located within the affected airsheds. However, at this stage plans for siting and scheduling of the plants are not yet firm and are subject to major changes. For example, it has been proposed that the plant planned for the South/Western Region (possibly in the Stamford airshed) be combined with the Greater Bridgeport plant. Similarly, plants planned for New Britain, Hartford, and New Haven may be integrated into one plant. If these combined plants locate outside affected airsheds, then only two plants would potentially be subject to permit denials. However, since the site selection process is still under way and no major limitations on alternative sites are evident, it appears likely that any siting constraints imposed by permit denials in the six airsheds will not have a significant impact on the continuing implementation of the Resource Recovery Program. None of the forecast sewage sludge incinerators will be subject to permit denials under either scenario.

e. **Apartment Complexes.** From three to five apartment complexes are likely to be affected by permit denials. Both dislocation costs (resulting from additional site selection expenditures) and locational costs (in the form of reduced occupancy, perhaps) may be incurred. As in the commercial sector, however, the total costs resulting from permit denials may not exceed the incremental costs of redesigning the facilities to utilize all-electric power. Moreover, changes in development patterns triggered by the permit denials may substantially increase the desirability of alternate locations outside the airsheds or major airshed towns. It appears, then, that apartment complex builders have substantial flexibility to respond to the constraint imposed by permit denials in a cost-effective manner. Consequently, no significant change in the growth outlook or rental prices in the sector is expected.

2. Benefits

The direct benefits of permit denials to prohibit NAAQS violation are the costs of air pollution damage that would occur in the absence of permit denials. Efforts aimed at quantifying these cost savings are discussed in Chapter III and summarized in Appendix L. The incremental benefits, over and above those accruing to program implementation, cannot, however, be assessed with any degree of reliability because of the paucity of data relating pollutant concentrations to effects on health and welfare. Discussion in this area is therefore deferred to Chapter III.B.2 and Appendix L.

C. Indirect Impact

The distinction between costs and benefits becomes vague when evaluating indirect impacts. Neverthless, such a delineation was found useful in indicating those indirect impacts that result from the direct costs versus those resulting from the direct benefits of the null strategy. Consequently, no explicit value judgments are made in the following categorization of indirect impacts. As in Chapter III, this assessment of indirect impacts involves analysis of additional socioeconomic variables as well as evaluation of impacts from a regional perspective.

1. Costs

Exhibit 32 summarizes the number of facilities by region that will probably be denied permits under the two impact scenarios. The Hartford area is most affected under both scenarios in terms of number of establishments potentially affected. New Britain, Stamford, and Waterbury also show a considerable number of facilities affected, while Ansonia and Middletown are expected to have relatively few permit denials. These distributions clearly reflect the facility and permit application forecasts in Chapter II as well as the estimated years of standard violations as provided by Connecticut DEP.

The analysis of direct costs indicates that adjustments to permit denials could be made by each sector without significantly affecting the forecast growth or product/service prices in Connecticut. However, there are some significant spatial, developmental, and social implications of the null strategy. These are discussed below in terms of the geographic areas affected.

a. **Employment/Unemployment.** The major impact on the employment situation within each of the six airsheds is likely to revolve around the manufacturing and commercial sectors' response to permit denials. It has been established that firms in the manufacturing sector will seek alternate sites according to their locational requirements (that is, in the vicinity of the airshed or in other areas of Connecticut). On the other hand, some portion of the affected commercial firms may choose to modify original plans for the type of energy used or the use of on-site incineration. For the purposes of this analysis, it has been assumed that half of the commercial establishments make such modifications and remain at sites within their respective airsheds.[1]

The employment potentially foregone within the discrete areas specified under the two scenarios has been estimated based on the median employment by SIC for Connecticut firms. Exhibit 33 summarizes the results in each airshed for manufacturing and commercial facilities from the start of permit denials through 1985. Based on the projected 1985 labor force in the major city (Scenario 1) or entire airshed (Scenario 2), the incremental unemployment attributable to permit denials was calculated (see Exhibit 33). On an annual basis, this addition to unemployment ranges from 0.2 percent to 0.4 percent.

Exhibit 34 puts these annualized unemployment increments in historical perspective. Waterbury and Ansonia are relatively more severely impacted by incremental unemployment attributable to permit denials; further, both areas have historical unemployment rates above the statewide average. The Middletown airshed also experiences a relatively greater impact from permit denials. However, because past unemployment rates in that city are about the same as statewide rates, the overall impact is likely to be less severe than in Waterbury and Ansonia, but substantially greater than in Hartford and Stamford, where unemployment rates have been consistently below the state average. In New Britain, where null strategy-related unemployment is relatively low, since 1970 average unemployment rates have been substantially higher than the statewide average. As a result, the incremental

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[1] By 1985 it is estimated that about 40 percent of the commercial sector's energy use will be electricity. *Connecticut's Energy Outlook 1975-1994,* by Connecticut Energy Advisory Board (1975).

EXHIBIT 32
ESTIMATED PERMIT DENIALS BY REGION: 1976-1985

	Scenario 1 (low)						Scenario 2 (high)					
	New Britain	Hartford	Stamford	Waterbury	Ansonia	Middletown	New Britain	Hartford	Stamford	Waterbury	Ansonia	Middletown
Manufacturing	32	43	43	43	3	2	68	98	103	70	22	5
Commercial	47	49	7	47	4	0	92	109	20	60	15	1
Nursing Homes	0	0	0	0	0	0	1	1	0	1	1	1
Veterinary Clinics	0	1	0	1	1	0	1	2	0	2	1	0
Resource Recovery Plants	0	0	0	1	1	0	1	1	1	1	1	1
Apartment Complexes	1	1	0	1	0	0	1	2	1	1	0	0
TOTAL	81	95	50	94	10	2	166	215	126	136	42	8

Source: Harbridge House, Inc. (1976).

EXHIBIT 33
EMPLOYMENT POTENTIALLY RELOCATED: 1976-1985

		Scenario 1		Scenario 2	
	Number of Years*	Number of Jobs	Incremental Unemployment	Number of Jobs	Incremental Unemployment
New Britain	10	995	2.3%	2,030	2.4%
Hartford	8	1,310	1.4%	2,775	1.3%
Stamford	8	770	1.3%	1,945	1.3%
Waterbury	8	1,480	2.8%	2,330	3.4%
Ansonia	6	105	1.3%	615	2.1%
Middletown	1	40	0.2%	135	0.3%

*Number of years from date of first permit denial to 1985. Number of jobs and incremental unemployment are cumulated over this period.

Source: Harbridge House, Inc. (1976). Incremental unemployment estimation based on OBERS-E population projections allocated according to 1973 distribution by town and 1973 labor force participation rate by Labor Market Area.

EXHIBIT 34
ESTIMATED INCREMENTAL UNEMPLOYMENT
IN COMPARISON TO HISTORICAL RATES

	Incremental Unemployment per Year*	Estimated Unemployment by Labor Market Area**						
				Annual Averages				
		June 1975	Jan. 1975	1974	1973	1972	1971	1970
New Britain	.2%	13.5%	14.4%	6.7%	7.3%	10.6%	11.6%	7.1%
Hartford	.2	8.8	7.5	5.4	5.6	7.8	7.2	4.7
Stamford	.2	7.8	6.3	5.3	6.0	6.6	5.7	4.1
Waterbury	.4	12.6	10.2	6.3	6.2	9.4	10.1	7.9
Ansonia	.2 to .4	16.1	9.2	7.3	6.8	9.9	10.0	6.0
Middletown	.2 to .3	11.1	9.4	6.7	6.6	8.4	8.2	5.3
Statewide	0	10.7	9.0	6.1	6.3	8.6	8.4	5.7

*Attributable to permit denials. Range indicates low and high impact scenarios when there is a differential. Note that no incremental unemployment is expected statewide.

**Labor Market Areas do not correspond directly with airsheds. Major cities in the LMA are matched with the major cities in the airsheds in the figures presented here.

Source: Connecticut Department of Labor.

unemployment caused by the permit denials will probably have a relatively more severe impact than indicated by the 0.2 percent rate.

To understand the employment impact of permit denials it is important to realize that the incremental unemployment and figures on jobs foregone represent a limited view of the potential situation in the major city or airshed. The jobs are not actually lost, but are relocated in areas where permit approval can be obtained. To the extent that the firms relocate in the vicinity of the airsheds and employees are willing to commute, adverse employment implications for the individual towns and airsheds will be substantially mitigated. Moreover, incremental unemployment resulting from the permit denials will have only a short-term, transitional impact. In fact, it may have significance only when compared with population/labor force trends that would likely occur in the absence of the permit denials (as in the analysis above).

To help determine any employment shifts that may take place, it was assumed that manufacturing industries serving local or regional markets, as indicated by LQ's less than one, would relocate in the vicinity of the airsheds, while those industries serving national markets would do one of two things: (i) all would locate outside the commuting radius of the major airshed towns or (ii) only nondurable manufacturers would locate outside the commuting radius because of their greater need for proximity to concentrated development.[1] Exhibit 35 shows the results of these calculations. Based on the first assumption (Case 1), from 50 to 75 percent of future employment subject to permit denials will shift to other areas in Connecticut. Assuming that only the nondurable manufacturers with nationwide market orientation (Case 2) relocate outside the commuting radius, from 0 to 50 percent of the respective airshed's foregone employment may shift to other areas. (Note that 0 and 50 percent are extremes and that the range of 5 to 20 percent is more representative.) The magnitude of these numbers indicates that the transitional unemployment situation may be relatively acute in all the airsheds. However, even in the case of the greatest employment shift the incremental unemployment figures cited previously (100 percent employment shift) will be from 25 to 50 percent lower based on this analysis.[2]

Using wage levels as an indication of skill levels, under the Case 1 assumption (in which all industries serving national markets seek locations some distance from the affected airsheds) roughly 80 percent of the more highly skilled employment that was forecast to be generated from 1976 to 1985 in the airsheds or major cities would shift away from the original airshed locations. Similarly, about 80 percent of the forecasted average skilled employment subject to permit denials and nearly 90 percent of the growth in lower skilled employment will be affected by shifting industrial locations. Alternatively, under the Case 2 assumption (in which only nondurable manufacturers serving national markets seek locations some distance from the affected airsheds), about 20 percent of the growth in

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[1]Here it is assumed that the required density and concentration would not be available within the commuting radius, thereby necessitating a move to another population center.

[2]The calculation of incremental unemployment assumed that 100 percent of the employment subject to permit denials would shift away from the area. Since it has been estimated that at most 50 to 75 percent would actually move from affected airsheds or major towns, the incremental unemployment is expected to be at least 25 to 50 percent lower than previously calculated.

EXHIBIT 35
POTENTIAL EXTENT OF EMPLOYMENT SHIFTS BASED ON TWO ALTERNATIVE ASSUMPTIONS

Case 1: Assuming All Manufacturers Serving National Markets Relocate Away from Airshed

	Scenario 1		Scenario 2	
	Employment Shift	Percent of Total*	Employment Shift	Percent of Total*
New Britain	465	49%	990	49%
Hartford	655	50	1,315	47
Stamford	575	75	1,335	69
Waterbury	905	61	1,450	62
Ansonia	65	62	415	67
Middletown	20	50	95	70

Case 2: Assuming Only Nondurable Manufacturers Serving National Markets Relocate Away from Airshed

	Scenario 1		Scenario 2	
	Employment Shift	Percent of Total*	Employment Shift	Percent of Total*
New Britain	55	6%	105	5%
Hartford	185	14	255	9
Stamford	135	18	305	16
Waterbury	195	13	300	13
Ansonia	0	0	75	12
Middletown	20	50	20	15

*Percent of Total indicates the percent of total employment subject to permit denials that is likely to shift to another area.

Source: Harbridge House, Inc. (1976).

higher skilled employment, 35 percent of the growth in lower skilled employment, and none of the forecast growth in average skilled employment in the airsheds and major cities would be shifted to other areas of the state.

b. **Population Distribution.** As employment opportunities shift to other areas, the population projections require modification to reflect changing employment and residential patterns within the state. It has been assumed that those industries relocating in the vicinity of the affected airsheds will not cause population shifts. This assumption is based on the consideration that 15 or 20 miles added to daily commuting distances will not provide sufficient motivation for changing place of residence. There is no known empirical evidence to support (or refute) this assumption. However, a nationwide transportation study found that from 15 to 20 percent of home-to-work trips made by private transportation were for distances of 15 miles or more.[1] On this basis, the two cases evaluated above are used here to indicate a reasonable range of population shifts.

An indication of the extent of changes in population distribution can be obtained by assuming that the labor force participation rate in each of the airsheds remains constant through 1985. This implies that such demographic features as age and income distribution also remain fairly stable throughout the 10-year period. Exhibit 36 depicts the potential population shifts away from airsheds and major cities by 1985 for Scenarios 1 and 2. Only in Waterbury is as much as 2 percent of the 1985 population potentially affected. Moreover, evaluation of the income distribution impact of the population shifts, based on the average wage levels in the industries relocating to other areas, shows no change in the proportional representation of income levels within each airshed or major city.

c. **Development Patterns.** The foregoing evaluation of the extent of any modifications in employment and population trends by geographic area has indicated that the incremental shifts likely to occur by 1985 are not of significant magnitude. However, over the longer term, the shifts will be cumulative such that permit denial in the six airsheds will effect a change in the orientation of development patterns. To some extent this change is expected to reinforce new trends in Connecticut development patterns. For example, the Danbury area (Housatonic Valley RPA) is one of the fastest growing regions in the state and is also a likely candidate for relocation by firms that may be denied permits in the six airsheds. Similarly, areas of concentrated development such as New Haven, Bridgeport, and Bristol will probably have incrementally increased growth as a result of permit denials.

The major change in development patterns, however, is likely to occur in the vicinity of the six airsheds. Firms with local or regional market orientations are likely to seek alternate locations in the vicinity of the airshed in which permit denials are effected. Thus, the dispersion of development is likely to occur at an unprecedented rate, particularly under the Scenario 2 assumptions in which permit denials are required in all towns in each affected airshed. Because of the relatively higher growth originally forecast for the Hartford, New Britain, Waterbury, and Stamford areas, the impact on development patterns will probably be greatest in the vicinity of these airsheds.

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[1] U.S. Department of Transportation, *Nationwide Personal Transportation Study,* Report No. 8, August 1973, p. 31.

EXHIBIT 36
POTENTIAL POPULATION SHIFTS AWAY FROM AIRSHEDS AND MAJOR CITIES BY 1985

	Scenario 1		Scenario 2	
	Population Shift	Percent of Total*	Population Shift	Percent of Total*
Case 1				
New Britain	970	1%	2,060	1%
Hartford	1,200	1	2,400	1
Stamford	1,150	1	2,670	1
Waterbury	2,080	2	3,330	2
Ansonia	190	1	1,240	1
Middletown	50	**	230	**
Case 2				
New Britain	110	**	220	**
Hartford	340	**	470	**
Stamford	270	**	610	**
Waterbury	450	**	690	**
Ansonia	0	0	220	**
Middletown	50	**	50	**

*Indicates original forecast population.

**Indicates percentage is less than 0.5.

Source: Harbridge House, Inc. (1976). (See text for explanation of Cases and Scenarios.)

d. State and Local Taxes. Since no alteration in statewide growth or development is expected to result from permit denials, corporate income tax revenues should not be significantly affected by the null strategy. On the other hand, local property tax and user charge revenues may become redistributed in response to changes in development patterns. Depending on the speed with which such changes occur, there may be an adverse impact on the revenues and expenditure requirements of some communities. For example, if development shifts rapidly to areas of relatively slow growth, the increased revenues may not be sufficient to cover the sudden rises in capital spending required for such things as schools, sewer extensions, local roads, and so forth. Conversely, a rapid reduction in development concentration within the airsheds may result in insufficient revenue to cover debt and financing expenses from prior investment programs. In either case the tax rate will have to be increased or the assessment ratio altered to balance revenues and expenditures over the short term. These tax changes, however, are likely to be only temporary measures. Further, they are highly dependent on the extent of and rate at which population and employment shift.

e. Interaction with Other Programs and Policies. The denial of permits suggests several conflicting and complementary areas vis-a-vis other programs in Connecticut. These areas are summarized below.

- Within the commercial and institutional sectors, in particular, denial of permits is likely to increase design changes to accommodate use of the resource recovery plants (rather than on-site incineration) and/or use of all-electric power (rather than on-site power generation). In most cases these changes will result in more efficient use of resources, thereby complementing the objectives of both the Resource Recovery Authority and the Connecticut Department of Planning and Energy Policy. There may, however, be an air quality trade-off in a case of wholesale conversion to electrical power. For example, conversions may necessitate construction of new generating capacity. If such new capacity is nuclear, the net air quality impact would be positive. However, with additional fossil-generating capacity, emissions would be more spatially concentrated, producing an adverse air quality impact. The DEP may want to further evaluate pollution control and fuel-type implications of conversions and the net impact on air quality.

- Dispersion of development as a result of permit denials suggests potential conflict with the federal policy of nonsignificant deterioration of clean air. However, under both the House and Senate versions of the Clean Air Act Amendments as well as the EPA's version of applicable regulations, it is unlikely that pristine area designations would apply to any facility siting in Connecticut. Moreover, facilities which may be denied permits are expected to relocate primarily within the AQMA. Consequently, no conflict in policies or objectives is expected.

- In Chapter III the permit program was characterized as a mediating force between the employment/economic and environmental objectives of local development agencies. Under the null strategy, however, the balance is slanted toward environmental objectives, with little flexibility for mediation of local economic goals. Consequently, local decision-making power is effectively usurped by state/federal air quality requirements. The result is that substantial conflict with objectives of local development agencies is likely.

- The *Connecticut Plan of Conservation and Development* (State of Connecticut, September 1974) is not an officially sanctioned land use plan for the state, but it does represent a major step toward development of a consensus on land use policy. Accordingly, evaluation of the interaction between the null strategy and the land use policies proposed in the Plan was undertaken. Three policies, summarized below, indicate potential for conflict.

  – *Policy No. 5:* Direct urban development to those areas identified as "Suitable for Urban Development," preferably close to existing urban, commercial, and employment centers.

  – *Policy No. 6:* Encourage urban development to be at sufficient densities for the economical provision of services.

  – *Policy No. 7:* Promote staged, contiguous development within areas "Suitable for Urban Development."

The major point of conflict arises in Policy No. 5, which calls for high priority to be given to revitalization of the physical, social, and economic structure of the central cities. Although some development can and will continue to take place in the central cities where permits are subject to denial, substantial potential for development will be foreclosed. Under such circumstances, revitalization may be significantly more difficult to achieve. Moreover, an implicit objective in all three of these policies is toward concentration of development rather than the limited dispersion necessitated by the null strategy.

f. **Social Well-Being** Several components of social well-being were considered with regard to the null strategy impact. Each of these is discussed below:

- *Urban/Rural Mix:* Prior evaluation of the alternative siting decisions of facilities subject to permit denials and the potential changes in population distribution and development patterns indicated that a limited degree of dispersion from urbanized areas would result from the null strategy. However, most shifts were expected to take place within the AQMA, which is characterized for the most part by urban as opposed to rural development. The small pockets of what may be considered rural development are unlikely to be significantly affected by the null strategy. Consequently, no change in the existing mix between urban and rural development levels is expected. Nevertheless, within the predominantly urbanized areas, there is likely to be a shift toward greater development of the less developed areas, particularly in the vicinity of the six airsheds. Because of the general reinforcement of trends in development patterns, however, no significant impact on social well-being is expected.

- *Flexibility for Long-Range Response:* This component of social well-being may be a significant factor in areas subject to permit denials. As noted above, substantial potential for development will be foreclosed as a result of permit denials. Future improvement in the efficiency of pollution control equipment may increase the types and sizes of facilities that can meet air quality limitations. However, over the study period, the range of options for economic development in areas subject to permit denials is limited. This situation has potential for creating a sense of stagnation in the affected areas, thereby causing uncertainty about the future for cultural and social institutions. The strength and adaptability of local and regional planning efforts can be important factors in determining the extent to which permit denials affect the stability of basic community institutions.

- *Local Autonomy:* The null strategy usurps local decision-making power with regard to balancing environmental and economic objectives.

- *Income Distribution:* Calculations based on median wage levels and employment by industry indicate that no significant change in the income distribution within the affected areas would occur as a result of permit denials required by Scenario 1 or Scenario 2.

- *Recreational Opportunities:* No evidence of any signficant impact on the supply and range of recreational activities was found.

- *Population and Employment Mobility:* In evaluating the ease of access in terms of transportation and economic means it appears that no significant constraints are imposed by permit denials; however, commuting times may be somewhat increased in the vicinity of the airsheds because of changes in employment locations.

- *Institutional Relationships:* There is no evidence that any traditional authority relationships within community structures would be undermined as a result of the null strategy.

2. Benefits

The air quality benefits experienced from permit program implementation are likely to be even more strongly experienced under the null strategy because of the danger of standard violation. Unfortunately, data relating the level of beneficial impact to air quality are limited to the extent that any assessment of the incremental order of magnitude is impossible at this time. (For a discussion of attractiveness and efficient use of resources, refer to Chapter III and Appendix L.)

D. Summary

The null strategy assessment has addressed the potential impacts of the constraints imposed by the air quality impact criteria of the new source review procedure. Estimates of potential primary standard violations for TSP and SO_2 were provided by the DEP for the period from 1975 to 1985. Violations are estimated in six towns within the AQMA as shown below:

New Britain:	TSP (1975), SO_2 (1978)
Hartford:	TSP (1978), SO_2 (1985)
Waterbury:	TSP (1978), SO_2 (1978)
Stamford:	SO_2 (1978)
Ansonia:	TSP (1980)
Middletown:	SO_2 (1985)

Evaluation of the strategy focused on the incremental impacts over and above those incurred by the permit program BACT requirement (see Chapter III). Two scenarios were developed to determine the low and high ends of the potential impact range. Scenario 1 assumes that only those facilities forecast[1] to locate in the town where standard violations are expected would be subject to permit denials (low impact). Scenario 2 assumes that permit denials would be required for all facilities forecast to locate in the entire airshed in which the town potentially violating the standards is located (high impact).[2] The actual impact of the null strategy is likely to fall between these extremes because DEP assesses the need to deny permits on a case by case basis.

Under Scenario 1, 3 percent of the state's land area and 16 percent of the projected 1985 population is potentially affected. Under Scenario 2, about 11 percent of the state's land area and 35 percent of the projected 1985 population is potentially affected.

Both direct and indirect costs and benefits of the null strategy have been evaluated either quantitatively or qualitatively. Results of this analysis are summarized below and in Exhibits 37 and 38.

1. **Direct Costs**

- Opportunity costs may be incurred as a result of the null strategy when (if) a firm subject to permit denial is operating so close to the margin that expansion is economically feasible only at the preferred site (where permit denial would prohibit such expansion).

- Costs may also be incurred as a result of dislocation, including such components as additional site selection expenditures, possible land holding and resale expenses, and, in some cases, loss of economies of scale.

- Costs resulting from location at a less than optimal site involve the net cost increase resulting from changes in the price of the following locational requirements: land, labor, transportation, customer contact, and business services.

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[1] Facility forecasts in Chapter II were allocated by town according to an employment distribution function (manufacturing) and a population distribution function (commercial).

[2] The DEP specified airshed towns.

EXHIBIT 37
DIRECT IMPACT SUMMARY: THE NULL STRATEGY

Economic Sectors	AQMA Emissions*				Direct Impact	
	TSP		SO_2		Cost	Benefit
	% of 1975	% of Gross Increase 1975 - 1985	% of 1975	% of Gross Increase 1975 - 1985	Forecast Growth	Health and Welfare
All Manufacturing	24.6	40.2	16.1	37.7	I	S
20 Food	0.4	0.5	0.3	0.6	(6)	(3)
22 Textiles	0.7	0.4	0.7	reduction	(6)	(2)
23 Apparel	0.1	0.1	0.06	0.1	(6)	(1)
24, 25 Lumber, Furniture	0.03	0.1	0.06	0.2	(4)	(1)
26 Paper	1.6	1.0	1.1	1.4	(6)	(5)
27 Printing, Publishing	0.1	0.2	0.1	0.5	(2)	(2)
28 Chemicals 30 Rubber, Plastics	3.1	8.0	2.3	8.5	(6) (3)	(10)
29 Petroleum/Asphalt	0.2	0.9	0.2	0.8	(7)	(4)
33 Primary Metals	2.5	1.9	2.1	reduction	(1)	(5)
34 Fabricated Metals	2.5	6.8	2.0	6.9	(1)	(9)
35 Machinery	1.8	1.3	1.2	1.5	(1)	(6)
36 Electrical Machinery	1.2	3.1	1.1	5.2	(2)	(7)
37 Transportation Equip.	6.4	9.5	3.1	7.7	(1)	(11)
31 Leather 32 Stone, Clay, Glass 38 Instruments 39 Miscellaneous	4.0	6.4	1.8	4.3	(6) (5) (1) (3)	(8)
All Commercial**	6.5	34.5	8.1	54.0	I	S
50 - 59	0.6	2.0	0.7	2.5	(2)	(1)
60 - 69	1.6	8.0	1.8	11.0	(1)	(2)
70 - 89**	4.3	24.5	5.6	40.5	(1)	(3)
All Institutional**					I	S
All Municipal Waste	34.6	1.2	2.1	0.1	I	M
Sewage Sludge	0.3	1.2	0.02	0.1	(1)	(2)
Municipal – Refuse	34.3	reduction	2.1	reduction	(1)	(1)
Electric Utilities	24.7	Zero	71.4	Zero	I	I

*Emissions after control (BACT) for point sources.

**Institutional emissions aggregated with SIC 70-79 (commercial).

Source: AQMA emissions from DEP; Economic analysis and rankings by Harbridge House, Inc. (1976).

KEY

I = Insignificant impact.
M = Moderate impact.
S = Significant impact.
( ) = Relative rankings within major sectors. (1) represents least relative impact. Impact on forecast growth rankings developed in Harbridge House, Inc., analysis. Impact on health and welfare rankings based on contribution to gross emission growth.

EXHIBIT 38
INDIRECT IMPACT* SUMMARY: THE NULL STRATEGY

	Costs														Benefits	
					Other Programs**			Social Well-Being								
	Incremental Unemployment	Population Shift	Development Patterns	Local Taxes	PEP	Economic Development	Land Use	Urban/ Rural	Planning Options	Local Decision-Making Power	Income Distribution	Recreation	Mobility	Community Structure	Attractiveness	Resource Use Efficiency
All Six Regions	I	I	M	I	M+	M-	M-	I	M	M	I	I	I	I	M	M
New Britain	(3)	(2)	(2)	(2)	(3)	(3)	(2)	(1)	(6)	(6)	(1)	(1)	(1)	(1)	(2)	(3)
Hartford	(1)	(2)	(2)	(2)	(3)	(3)	(2)	(1)	(4)	(4)	(1)	(1)	(1)	(1)	(3)	(3)
Waterbury	(4)	(3)	(2)	(2)	(3)	(3)	(2)	(1)	(5)	(5)	(1)	(1)	(1)	(1)	(2)	(3)
Stamford	(1)	(2)	(2)	(2)	(2)	(3)	(2)	(1)	(3)	(3)	(1)	(1)	(1)	(1)	(3)	(2)
Ansonia	(4)	(2)	(1)	(1)	(2)	(2)	(1)	(1)	(2)	(2)	(1)	(1)	(1)	(1)	(1)	(2)
Middletown	(2)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

*Indirect impacts classified as costs or benefits according to their source in either direct costs or direct benefits.

**Indicates conflicting (-) or complementary (+).

KEY

I = Insignificant impact.
M = Moderate impact.
S = Significant impact.
( )= Relative rankings among regions based on impact analysis, number and timing of permit denials, proportion of commercial versus industrial permits denied, and population density. (1) represents least relative impact. When all rank (1), indicates no difference.

Source: Harbridge House, Inc. (1976).

- Within the manufacturing sector, 166 firms (17 percent of the forecasted AQMA expansion) are affected under Scenario 1 (low impact) and 365 firms (36 percent of forecast expansion in the AQMA) are affected under Scenario 2 (high impact).

  - Under both scenarios, SIC's 27, 34, and 35 are most impacted in terms of the number of facilities affected.

  - With regard to the forecasted AQMA growth subject to permit denials, SIC's 20, 28, and 39 are also relatively more affected.

  - The impact on the forecasted growth of these industries within the AQMA is likely to be insignificant.

- Within the commercial sector, from 154 to 297 establishments are potentially affected by the two scenarios; about half of these establishments are in the retail trade group. This represents, at most, 3 percent of forecasted AQMA expansion. No impact on the forecasted growth of these facilities is expected.

- Within the institutional sector, from zero to five nursing homes and from three to six veterinary clinics are potentially subject to permit denials. No impact on growth is expected.

- No impact on the forecasted growth of municipal waste disposal facilities is expected.

- No significant impact on the three to five apartment complexes subject to permit denials is expected.

2. Direct Benefits

The potential for violation of the standards in the six areas indicates that the health and welfare benefits of the null strategy are significant. Data and methodological constraints do not permit quantification of the order of magnitude of these benefits.

3. Indirect Costs

In terms of the number of facilities subject to permit denials, Hartford is most affected under both scenarios. New Britain, Stamford, and Waterbury also show relatively more facilities affected; Ansonia and Middletown are expected to have relatively few permit denials.

- The following impact on employment opportunities within the areas subject to permit denials was estimated as follows:

  - Scenario 1: About 4,700 jobs potentially affected.

  - Scenario 2: About 9,800 jobs potentially affected.

- At least 25 percent to 50 percent of these affected jobs will be shifted to areas within the commuting radius of the affected towns. The remainder will be relocated to other areas of the AQMA.

- On an annual basis, the transitional unemployment in the airsheds resulting from the null strategy represents, at most, from 0.1 to 0.4 percent.

- Potential shifts in population affect the Waterbury area relatively more than the other areas, representing a reduction of 2 percent (at most) of the projected 1985 population.

- Changes in development patterns are expected to primarily reinforce current trends. However, unprecedented dispersion of development in the vicinity of the six airsheds is likely.

- Temporary imbalances in the revenue and expenditures of local governments may occur. No impact on state revenues/expenditures is expected.

- The null strategy is expected to complement the goals of efficient resource use set by the Connecticut Department of Planning and Energy Policy. But in so doing, it may create adverse air quality impacts.

- Conflict with objectives of local economic development agencies and statewide land use policies is expected.

- The range of options for future planning consideration as well as the degree of authority at the local level will be reduced in areas subject to permit denial.

- No significant impact on other indicators of social well-being is expected.

4. **Indirect Benefits**

- The null strategy will effect enhanced attractiveness of airshed areas for nonpolluting industries as well as improved quality of life for residents.

- Greater efficiency in the use of resources is expected to result from the null strategy.

CHAPTER V: IMPACT ASSESSMENT – THE SULFUR STRATEGY

A. Background and Approach

A statewide regulation limiting the sulfur content in fuel to 0.5 percent has been in effect since 1973. The strategy evaluated here differs from that regulation in two respects: (i) the sulfur content limitation is reduced to 0.3 percent and (ii) application of this reduction is considered to affect only fossil fuel users in the seven towns of the Naugatuck Valley.[1] Consequently, it is the incremental impact of this strategy – over and above the impact of the existing statewide 0.5 percent sulfur limitation – that represents the focus of this evaluation.

Although both coal and oil products are subject to the limitation, use of coal in Connecticut is currently negligible (see Exhibit 39). There are, however, four Connecticut power plants on FEA's list for conversion from oil to coal firing under the Energy Supply and Environmental Coordination Act of 1974 (ESECA). Although none of these plants is located in the Naugatuck Valley, a brief examination of the potential impact of ESECA has been included at the request of Region I, EPA.

B. Direct Costs

1. Public

Since 1973, the increased public cost incurred by the 0.5 percent limitation on sulfur content of fuel has been directly related to the sampling program carried out by the Connecticut DEP. The total annual expenditures for the sulfur sampling program as it currently exists are estimated at $15,700. This represents less than 2 percent of the state's budgetary expenditures for the Air Unit of the DEP. A breakdown of the expenditures incurred from the implementation of the sulfur sampling system is shown in Exhibit 40. Approximately 200 samples are taken in each year yielding an estimated cost of $78.50 per sample.[2]

It has been assumed that the sampling program will continue to operate at the present rate into the future since the number of samples taken and the extent of the sampling program is not expected to change.[3] The total present value of the program costs over the next 10 years – determined using a 6 percent rate of interest which represents the

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[1]Waterbury, Naugatuck, Beacon Falls, Seymour, Ansonia, Shelton, and Derby. These towns comprise the entire Valley RPA and part of the Central Naugatuck Valley RPA.

[2]Robert Sargis, Department of Environmental Protection, Telephone interview 30 October 1975.

[3]One source of potential change in future costs, which cannot be evaluated quantitatively, involves litigation that may result from application of this strategy to the Naugatuck Valley, alone.

EXHIBIT 39
SOURCES AND DISPOSITION OF ENERGY IN CONNECTICUT AND THE U.S.
(1975)

Sources of Energy	Connecticut	U.S.
Petroleum Products	78%	45%
Natural Gas	9	32
Coal	0	18
Nuclear	12	1
Hydroelectric	1	4
TOTAL	100%	100%

Disposition of Energy	Connecticut	U.S.
Residential	19.5%	24% (Residential and Commercial combined)
Commercial	14.0	
Industrial	12.5	28
Transportation	26.0	25
Miscellaneous and Electric Generating	28.0	23
TOTAL	100.0%	100%

Source: Ed McDonald, Connecticut Department of Planning and Energy Policy (1975).

EXHIBIT 40
ESTIMATED CURRENT ANNUAL COSTS OF THE SAMPLING PROGRAM

Labor	Costs/Year	
1 principal engineer (part-time)	$1,500	
1 engineer (part-time)	6,300	
1 engineer intern (part-time)	900	
1 inspector (part-time)	4,500	
1 secretary (part-time)	100	
TOTAL LABOR COSTS		$13,300
Equipment (sample cleaning equipment, etc.)		400
Supplies		100
Laboratory		400
Transportation (car)		1,500
TOTAL COST OF SAMPLING PROGRAM		$15,700

Source: Robert Sargis, Department of Environmental Protection, telephone interview 30 October 1975.

current long-term lending rate for Connecticut bonds[1] – is about $115,600. This expenditure does not represent any increased costs to DEP as a result of sulfur strategy implementation.

2. **Private**

The economic implications of this strategy are related primarily to two issues: the availability of low sulfur fuel and the differential cost between 0.5 percent and 0.3 percent sulfur fuel. Residual oil has been the primary focus of this part of the study for several reasons: (i) residual oil contains more sulfur than distillate oil because of the nature of the refining process;[2] (ii) distillate is subject to availability problems not associated with sulfur content; and (iii) coal is discussed under Section E, "Impact of ESECA," below.

a. **Availability**. The issue of availability has been approached in the context of a recent study for EPA regarding the supply and demand for low sulfur oils.[3] This study evaluated the 1975 demand for residual fuel by sulfur content in the Petroleum Allocation District (PAD) I, which is comprised of the New England, Central Atlantic, and Lower Atlantic states. Because imports into PAD I are largely from U.S.-dedicated refineries in the Caribbean, the study modeled the 1975 potential Caribbean refinery output by sulfur content. Then, based on 1973 supply shares, the potential Caribbean supply was allocated among the regional markets within PAD I. The results of the market allocation are shown in Exhibit 41. It can be concluded from the data that although sufficient supplies of the lower sulfur residual are available from Caribbean sources to satisfy the aggregate demand of PAD I, the regional demand (in New England) cannot be satisfied if supplies are allocated in historical patterns.[4]

This conclusion must be tempered with consideration of the current low sulfur fuel use in Connecticut. In particular, the study estimated a 1975 potential supply shortage of less than 0.5 percent sulfur residual in New England. Yet the DEP estimates that the sulfur content of fuel currently used in Connecticut is averaging between 0.4 and 0.5 percent.[5] Some users are, in fact, currently burning 0.3 percent sulfur fuel.[6] Moreover,

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[1] A 6 percent rate was assumed based on telephone interviews, conducted in December 1975 with municipal bond officers. The First National Bank of Boston estimated a long-term lending rate for a Connecticut state bond at between 5.0 percent and 5.5 percent. First National City Bank of New York estimated a long-term lending rate for a Connecticut state bond at between 6 and 7 percent. See Appendix H.

[2] Low sulfur supply problems do not pose a threat for distillate. Only volume problems exist for this fuel, without regard to sulfur content. Source: ICF Incorporated. *Forecast and Analysis of Supply and Demand for Low Sulfur Fuels,* for EPA, May 1975, p. 12.

[3] *Ibid.*

[4] The report also points out that FEA allocation regulations are based on historical shares. *Ibid.*, p. 97.

[5] Greg Wight, *Air Compliance,* Connecticut Department of Environmental Protection, November 1975.

[6] The Federal Power Commission, *Monthly Fuel Cost and Quality Information* (November 1975) indicated that 0.3 percent has recently been received by a Connecticut utility. Without knowledge of the power plant location, no adjustment can be made to account for this in the impact assessment.

EXHIBIT 41
SUMMARY OF REGIONAL MARKET BALANCE: IMPORT REQUIREMENT/CARIBBEAN SUPPLY BALANCE

(million bbl/day)

Sulfur Content	Less than 0.5	0.51 - 1.0	Greater than 1.0	Total
New England				
Caribbean Supply*	193.9	106.9	133.3	434.1
Average Annual Import Requirement	195.0**	124.6**	39.3	358.9
Central Atlantic				
Caribbean Supply*	714.2	95.3	400.9	1,210.4
Average Annual Import Requirement	572.0	–	177.0	749.0
Lower Atlantic				
Caribbean Supply*	7.4	109.3	586.3	703.0
Average Annual Import Requirement	–	244.0**	246.0	490.0

*Based on 1973 supply shares.

**Potential supply shortage.

Source: ICF Incorporated, *Forecast and Analysis of Supply and Demand for Low Sulfur Oils,* for EPA, May 1975.

residual shortages are not evident in Connecticut.[1] Consequently, the potential supply of 0.3 percent sulfur fuel in Connecticut may not be as constrained as that study suggests.

Harbridge House conducted interviews with representatives of major oil companies and petroleum product specialists in order to assess their perspective on the future availability of 0.3 percent sulfur residual. Both the editor of *Platt's Oilgram* and the Heavy Fuel Oil Coordinator for Exxon Oil Co. foresaw sufficient availability of 0.3 percent sulfur fuel.[2] Several of the interviewees pointed out that with the construction of new desulfurizing refineries in the United States, there is a growing capacity to produce lower sulfur fuel oil. The Caribbean, which is the primary source of fuel oil for the northeast coast, also has sufficient desulfurizing refinery capacity.[3]

A shortage of low sulfur fuel oil could occur as the result of extraordinary circumstances (for example, the OPEC embargo) affecting the basic supply and demand distribution of all types of fuel oil.[4] Such an extraordinary circumstance is usually not foreseeable and when it does occur, it affects all grades of fuel oil from low to high sulfur. If such an extraordinary shortage occurs, however, the oil companies may tend to produce only high sulfur fuel because it is easier and faster to produce in greater quantities than the low sulfur fuel.[5] Nevertheless, based on a normal balance of supply and demand, there should be a general availability of the 0.3 percent sulfur fuel oil.

b. **Price**. Estimates of the price differential between 0.5 percent and 0.3 percent sulfur fuel oil vary significantly. *Platt's Oilgram* shows a $0.74 to $0.92 per barrel price differential, or a 6 to 8 percent higher price for the lower sulfur fuel, as of 3 December 1975.[6] EPA's general rule of thumb for sulfur content price differential is $0.66 per barrel more (a 5 percent increase) for the 0.3 percent sulfur fuel.[7] Recent studies for EPA indicate differentials of $0.15 per barrel[8] and $0.25 per barrel[9] (about a 1 to 2 percent increase).

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[1]The variance applied for by a Connecticut utility was not based on any difficulty in obtaining sufficient supplies of 0.5 percent sulfur residual. *Ibid.* March 1976.

[2]Mr. McClelland, editor, *Platt's Oilgram* and *Price Service,* publication of McGraw-Hill, telephone interview, 3 December 1975.

[3]Mr. LeCates, Heavy Fuel Oil Coordinator, Exxon Oil Co., Houston, Texas, telephone interview, 4 December 1975.

[4]Interviews with Mr. McClelland and Mr. LeCates.

[5]Interview with Mr. McClelland.

[6]*Platt's Oilgram Price Service,* December 4, 1975. Price differential for New York City and Philadelphia from $0.87 to $0.92; New Haven Harbor estimated at $0.74 by Mr. McClelland, editor. (Prices are for No. 6 residual.)

[7]Cheryl Wasserman, Policy Planning Division, U.S. EPA; January 1976 [Differential equals $13-3 (log % sulfur)].

[8]Energy and Environmental Analysis, Inc., *The Costs of Sulfur Oxide Controls to Oil Burning Power Plants in 1980* for U.S. EPA, September 4, 1975. (Based on the differential in direct desulfurization costs of crude Arabian light oil in 1973. Cost adjustment for 1974 is suggested at 28 percent. 10 percent increase used to adjust to 1975.)

[9]Environmental Protection Agency, *Implications of Alternative Policies for the Use of Permanent Controls and Supplemental Control Systems,* Office of Planning and Evaluation, July 7, 1975. (Estimates are for delivered price of residual fuel by state and sulfur content in 1980. Converted from cents per million Btu to cents per barrel using factor of 6.3×10^6 Btu per barrel.)

These differences probably result from variations in the source of the crude petroleum, in the type of refining and desulfurization used, and in the grade of oil produced. For example, No. 4 grade oil (classified as a residual by the DEP) is a blend of the lighter No. 2 grade (distillate) and the heavier No. 5 (residual). Distillates do not usually require desulfurization because the refining process removes most of the sulfur impurities. However, residuals do require the extra cost of desulfurization in order to be classified as low sulfur fuels. Moreover, higher sulfur crude has higher refining costs.

Because of these considerations, it appeared most reasonable to assume a cost differential based on the prices quoted for New Haven Harbor by *Platt's Oilgram*. Presumably, these costs would reflect the composition of crudes, processes, and fuels used in Connecticut. However, because the $0.74 per barrel (6 percent) price differential between 0.3 percent and 0.5 percent sulfur oil is higher than most other estimates, it should probably be considered to bracket the high-impact case.

(1) **Impact on Manufacturing.** Exhibit 42 shows residual oil intensity-of-use ratios for the Connecticut manufacturing sector. The ratios represent the barrels of oil used in 1971 to produce $1,000 in value added (1967 $). Ratios are also shown which indicate the cost of residual oil in 1971 (1967 $) per $1,000 in value added. Industries with relatively greater intensity-of-use ratios can be assumed to be relatively more sensitive to increases in residual oil prices.

As shown in Exhibit 42, SIC 26 (paper) is most sensitive to increased fuel prices. In 1971, fuel costs represented about 0.03 percent of value added in that industry. Assuming that the ratios remain constant over time, a 6 percent (or high range) increase in fuel oil prices would, at most, increase the cost of operations by 0.2 percent.[1]

Fuel price increases that have occurred since 1973 provide an indication of the impact of these increased costs. In 1972, the delivered price of residual oil to industrial users was about $4.30 per barrel.[2] The 1975 price of $11.76 per barrel (*Platt's Oilgram*) indicates a 273 percent price increase. Again, based on the 1971 intensity-of-use ratio this residual fuel price increase can be estimated to have increased the cost of operations in SIC 26 by 7.9 percent.

An evaluation conducted by the First National Bank of Boston during the spring and fall of 1974 provides some insight into how New England manufacturers responded to these drastic price increases.[3] A brief summary of relevant data and conclusions is shown below:

- From September 1973 to March 1974 the median increase in energy costs to manufacturers was 34 percent. For the one-year period through September

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[1]This is calculated by multiplying the fuel cost as a percent of value added (28.95×10^3) times 6 percent.

[2]*Connecticut's Energy Outlook*, p. A-29. Adjusted to 1972 $.

[3]First National Bank of Boston. *A Special Evaluation of Energy Cost Impacts on New England Economic Development* (undated). (Of the 255 and 275 firms surveyed in the spring and fall of 1974, 49 and 52 firms, respectively, were in Connecticut.)

EXHIBIT 42
1971 RESIDUAL OIL INTENSITY-OF-USE RATIOS FOR CONNECTICUT

SIC	Barrels/10^3 \$ Value Added	\$ Fuel/10^3 \$ Value Added
26	7.66	28.95
22	4.23	15.99
28	4.04	15.27
32	3.05	11.53
24	2.69	10.17
33	2.53	8.88
39	2.05	7.75
31	1.38	5.22
25	0.99	3.74
34	0.94	3.55
30	0.88	3.33
37	0.81	3.06
20	0.59	2.23
38	0.58	2.19
35	0.40	1.51
29	0.38	1.44
23	0.35	1.32
36	0.22	0.83
27	0.12	0.45

Source: Based on residual fuel use data in *Connecticut's Energy Outlook 1975-1994* and *Energy Emergency Plan for Connecticut* and *Census of Manufactures* value added (deflated to 1967 constant dollars). Distribution based on DEP listing of major residual fuel burners in the Naugatuck Valley. 1971 delivered price of residual to industrial users in Connecticut was \$3.78 per barrel (1967 \$) *(Connecticut Energy Outlook).*

1974, the median increase was 50 percent. In both surveys the range was from 0 to over 400 percent.

- In the spring survey, the percentage increase in total manufacturing costs because of higher energy costs averaged 2.2 percent, with a range from 0.1 percent to 8.7 percent. In the fall survey, the average was 3.2 percent while the range was from 0.9 percent to 5.9 percent. (Ranges given by SIC.)

- Of the firms surveyed, 84.3 percent (spring) and 82.9 percent (fall) indicated that increased energy prices had not affected capital spending plans; 5.1 percent (spring and fall) indicated an increase in capital spending; 4.7 percent (spring) and 7.3 percent (fall) indicated a decrease in capital spending as a result of increased energy prices.

Based on the limited change in capital spending plans resulting from significant increases in energy costs experienced by the firms surveyed, it appears very unlikely that the minimal price increase caused by the sulfur strategy will have any substantial effect on the forecasted industrial growth in the Naugatuck Valley.

The greatest growth in the Valley RPA was projected in SIC's 30, 33, 34, and 35, while the Central Naugatuck Valley RPA was forecasted to experience substantial growth in SIC's 28 and 38. Exhibit 43 summarizes the spring and fall survey results regarding increased manufacturing costs for these industries as a result of the 1973-74 price increases. Also shown are the calculated percentage increases in operating costs for the 6 percent price increase resulting from the sulfur strategy. It is not presumed that the 1973-74 price increases were easily absorbed or that they did not, of themselves, precipitate a long-term impact on the competitive advantage of the firms most heavily affected. Nevertheless, in the context of such recent significant price changes, the incremental impact of a 6 percent increase (at most) in residual fuel prices is not expected to have any substantial effect on the competitive position of the industries in the Naugatuck Valley.

(2) **Impact on the Commercial Sector.**[1] The commercial sector is the other major user of residual oil in Connecticut (about 30 percent of residual oil use). Within this sector, residual oil users are generally large energy users – thus, they are also likely to be sensitive to increased fuel prices.[2] However, the proportion of fuel costs to total operating costs within the commercial sector is usually significantly smaller than in the manufacturing sector.[3]

SIC's 23, 36, 27 are at bottom of the residual oil intensity-of-use ratios calculated for manufacturing. In estimating space heating and lighting requirements versus production requirements for fossil fuels, the Connecticut Energy Agency used these industries as

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[1] As opposed to earlier analysis, the commercial sector in this part of the study is considered to include educational and health services (institutional) because of the aggregation of fuel use data.

[2] *Connecticut's Energy Outlook*, p. c-68.

[3] In manufacturing fuel is required in production processes as well as for comfort purposes.

EXHIBIT 43
PERCENTAGE INCREASE IN MANUFACTURING COSTS AS A RESULT OF HIGHER ENERGY COST

SIC	Survey Results		Estimated % Result from Sulfur Strategy
	Spring 1974	Fall 1974	
28	1.3%	3.5%	.09%
30	4.2	4.1	.02
33	2.4	5.7	.05
34	2.7	2.5	.02
35	2.1	2.3	.009
38	2.9	3.4	.01

Source: Survey Results from *A Special Evaluation of Energy Cost Impacts on New England Economic Development.* Estimated impact from sulfur strategy described in text.

representative of 100 percent heating and lighting. From this, the Agency estimated the energy use components in other manufacturing industries.[1]

It appears to be reasonable to approximate the impact of increased fuel oil costs in the commercial sector on the basis of the lowest use ratios in Exhibit 42. Assuming again that a 6 percent increase in residual oil costs represents the upper impact level of sulfur strategy implementation, the resulting incremental increase in costs of operation to the commercial sector ranges from .003 to .008 percent. No impact on the growth or competitive advantage of industry groups within the sector is expected to result from this minimal cost increase.

(3) **Impact on Electricity Generation.** A 6 percent increase in price of residual oil may have a significant impact on the cost of electricity in Connecticut because of the fuel adjustment clauses which allow utilities to pass increased fuel costs on to consumers. In a state where about 40 percent of the electricity generated is from nuclear sources, the cost of fossil fuels currently represents 36.2 percent of each dollar of utility revenue.[2] Consequently, a 6 percent increase in price of fuel oil would result in a 2.2 percent increase in the cost of electricity to households served by utilities in the Naugatuck Valley.

C. Direct Benefits

Implementation of the sulfur strategy would result in as much as a 2 percent decrease in the sulfur available for emission to the ambient air during fuel combustion in the Naugatuck Valley. Over time, the reduced amount of sulfur in fuel would decrease the rate of air quality degradation. The populations of the seven towns in the Naugatuck Valley as well as in some adjacent communities will experience a reduction (absolute and relative) in the costs associated with air pollution damage. As described in Appendices L and M and in Chapter III, these benefits are likely to be substantial.

Within the seven towns in the Naugatuck Valley, 11 percent of the population is over 65 years of age, compared with a statewide average of 9.5 percent.[3] Since older persons are more affected by the health dangers of air pollution, benefits from decreasing sulfur oxide emissions and stemming future growth in emissions will probably be comparatively greater in the Naugatuck Valley than in the state as a whole.

D. Indirect Costs

Because of the limited direct cost impact, as discussed above, there is little basis for assessing the indirect cost implications of the sulfur strategy. Socioeconomic variables such as employment, population, distribution, development patterns, taxes, and social well-being were considered and no evidence of adverse impact was found. There is one aspect of implementation, however, that may indirectly result in increased costs: fuel dealers will have to store the 0.3 percent sulfur fuel oil for Naugatuck Valley users

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[1]*Energy Emergency Plan for Connecticut,* p. A-81.

[2]Fred Sutton, Senior Rate Research Analyst, Northeast Utilities, March 1975.

[3]*Connecticut Market Data Book*, based on 1970 census figures.

separately from the 0.5 percent sulfur oil distributed to other areas of Connecticut. This may require construction of additional facilities as well as underutilization of existing facilities. If so, there will be a situation of inefficient resource utilization and increased costs for the dealers.

E. Indirect Benefits

As described in Chapter III and Appendix L, there is evidence of a demand for locations away from air pollution. Because of this, the improved air quality in the Naugatuck Valley that results from implementation of the sulfur strategy will provide residents with an improved quality of life and may incrementally improve the area's attractiveness for business location (see discussion of attractiveness in Chapter III). Moreover, by decreasing the sulfur oxides emitted into the atmosphere, more development can be accommodated within the air quality standards (see the orderly growth discussion in Chapter III). As with the permit program, then, the sulfur strategy mediates local government's pollution concerns and the desire for economic development.

Increased energy conservation may also result from the sulfur strategy. As prices rise, users may become more sensitive to unnecessary consumption of both electricity and fuel oil. The First National Bank of Boston study on the 1973-74 energy crunch provides a parallel for this consideration. The study noted that private discussions with several of New England's large utilities indicated reductions in the use of electricity of up to 15 percent. Results of the fall survey of manufacturers showed that all industry groups were responding to increased energy prices by decreasing consumption. The mean percentage decrease among the industry groups ranged from 4 to 10 percent. Within industry groups, however, as many as two thirds of the respondents reported no decrease in energy consumption. Consequently, from the point of view of only a 6 percent increase in the price of fuel oil, it appears that minimal (if any) increased conservation could be expected for the industrial sector.

F. Impact of ESECA

The Energy Supply and Environmental Coordination Act of 1974 directs the Federal Energy Administration (FEA) to order conversion to coal of any oil or gas-fired electric power plant (or other major fuel-burning installation) provided that the plant (i) has equipment to burn coal; (ii) has access to adequate coal supplies; and (iii) can meet other criteria, most of which are environmental. The Act represents a compromise designed to postpone conflict over pressures to ease air quality standards until sulfur removal technology is perfected. It is intended as a stopgap measure to deal with foreign oil embargoes.[1] All plants ordered to convert must be able to meet primary air quality standards at the time of conversion, but could receive a variance from secondary standards provided EPA certified that the converting utility had a compliance plan that would enable it to meet all clean air requirements by 1 January 1977.[2]

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[1] Easing air quality standards would stimulate the use of the nation's vast deposits of high sulfur coal, which cannot be burned under current federal air quality standards.

[2] James G. Phillips, *Energy Report: Unexpected Obstacles Hinder Ford Plan for Coal Conversion.* National Journal Reports, May 31, 1975, p. 816.

FEA developed a list of 80 plants for potential conversion, four of which are in Connecticut. Of the 80 plants, however, EPA has estimated that the Act's environmental criteria would permit only about 23 to convert.[1] Implementation problems encompass two major controversies: the availability and cost of low sulfur coal, and the cost of pollution control equipment where cleaner burning coal is not available.[2] In addition to these key problems, there are others that may also present substantial obstacles to implementation. These are summarized below:

- Manpower requirements for engineering, design, and water quality control to convert plants scheduled to go on line before 1980.
- Financial liabilities under contracts for oil supplies.
- Electrical reliability while units are removed from service for conversion to coal firing. Includes lead time to provide the replacement generating capacity to assure continued reliability of service.
- Interface with Federal Power Commission gas curtailment orders which directed plants to switch from gas to oil. (Some consumers may have to bear the costs of yet another switch, this time from oil to coal.)
- Installation of new equipment in plants that may otherwise have relatively short economic life remaining – indicating a potential for economic waste.
- Availability of the quantity of new boilers required for conversion under the Act's requirements.
- Adequacy of the transportation system for coal delivery.
- Long-term effectiveness of an oil conservation effort aimed at coal conversion versus nuclear energy and at electric generation as opposed to transportation (gasoline consumption).

The low sulfur-coal/scrubber controversy is based on the contention that the costs of acquiring low sulfur coal or scrubbers on the one hand, and the environmental cost of not acquiring either on the other hand, do not outweigh the benefits of oil savings resulting from conversion to coal. FEA has contended that there will be considerable economic savings from the conversions in addition to national security benefits. Arguing that savings of $2.19 per barrel of oil will result, FEA assumes continuation of $12 per barrel price for oil and $40 per ton for coal, a $60 per kilowatt cost for scrubbers installed in new plants, and an $80 per kilowatt cost for modifications of existing plants to accommodate scrubbers.[3]

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[1] Phillips, *op. cit.*, p. 816.

[2] One EPA study estimated that 26 of the 80 conversion candidates would need stack gas scrubbers if EPA's estimates of low sulfur coal availability were accurate. *Ibid.*, p. 817.

[3] *Ibid.*, p. 818.

On the utility side, it is argued that the price of coal will eventually escalate to the level of oil prices, with the net result that excessive costs will be imposed upon utilities at a time when they are experiencing a capital crunch. It has also been suggested that because of the utilities' relative insensitivity to fuel prices (the result of fuel adjustment clauses), there is a disincentive to undertake capital spending (which takes much longer to recoup) as an alternative to high fuel oil costs.

The foregoing arguments represent only the tip of the iceberg in a drawn out and very cost-specific controversy. In order to assess the potential impact of ESECA on the four Connecticut plants[1] on FEA's list of conversion candidates, data are summarized below concerning the cost of scrubbers and the availability and cost of low sulfur coal.

1. Availability and Cost of Low Sulfur Coal

ESECA provides for issuance of variances from secondary standard compliance. However, it also imposes a "regional limitation," whereby secondary standards must be met in air quality regions where the primary standard is violated (although not by the converted plant itself). [Since *Guidance for Regional Limitation Determinations Under ESECA* recommends that air quality data be treated literally (in most cases), it is likely that regional limitation would apply to the Connecticut Utilities.[2]] Consequently, substantial pressure is being placed on the already tight supply of low sulfur coal, particularly in the East where air quality standards are relatively stiff and much of the low sulfur coal is committed to steel making.

FEA has estimated that the nation's annual demand for coal will increase by about 41 million tons by 1980 as a result of conversion of the 80 potential candidate facilities.[3] To meet this demand new mines will have to be opened. Yet the coal industry is demanding that utilities put up the tremendous advance investment capital for them and, in some cases, contract for the mine's entire output. Moreover, the lead time required (from two to five years) to bring new mines to production necessitates quick action.

Both FEA and EPA have estimated the extent of a clean fuels (coal) deficit over time. Taking into account increased supplies of low sulfur coal and the use of stack gas scrubbers, the 1975 deficit was estimated at about 225 million tons by both agencies. In

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[1]The four plants on FEA's list are:

Company	Plant	Unit Numbers	Capacity
Connecticut Light and Power	Montville	5	75
	Devon	3, 7, 8	273
	Norwalk Harbor	1, 2	326
Hartford Electric Light	Middletown	1, 2, 3	422

The Montville plant would need a new precipitator; EPA would require the other three plants to install scrubbers. (Source: Phillips, *op. cit.*, p. 821.)

[2]U.S. EPA *Guidance for Regional Limitation Determinations Under ESECA*. OAQPS No. 1.2-033. (July 1975).

[3]*National Journal Reports*. May 31, 1975.

1977 EPA estimated a deficit of 100 million tons, while FEA estimated 175 million tons. By 1980 EPA's estimate is only 25 million tons, FEA's, 100 million tons.[1] Overall, EPA expects that in the post-1980 period there will be more than adequate supplies of low sulfur coal.[2]

Clearly, though, through 1980 there will be a premium on low sulfur coal. In 1973, the differential price between high and low sulfur coal was $3 per ton; it is expected to rise to $4 per ton (1974 $) in the future.[3] Moreover, the rapid increase in coal prices over the last few years coupled with the pressure for increased production requiring large capital outlays suggests price increases for all types of coal.

2. **Cost of Scrubbers**

The scrubber debate is closely linked to the availability and cost of low sulfur coal, as shown by the inclusion of scrubbers in calculation of clean fuels deficits by EPA and FEA. However, the question of scrubber availability and reliability has declined in significance, compared to the issues of installation costs and their relationship to the economic practicality guideline written into ESECA. A sample of the pollution control estimates originating from different sources is shown in Exhibit 44. Totaled over one plant or several plants of one company, these costs can reach large proportions. For example, Bertram D. Moll, vice president for inter-utility operations of New York City's Consolidated Edison Company has said that the cost of scrubbers alone would run $278 million for three Con Ed plants regarded by FEA as leading candidates for conversion.[4]

Using the FEA cost estimates and applying them to the capacities of the four Connecticut plants, the following pollution control costs are estimated:

- Montville plant: $300,000 (precipitator).
- Devon plant: $21,840,000 (scrubber retrofit).
- Middletown plant: $33,760,000 (scrubber retrofit).
- Norwalk Harbor plant: $26,080,000 (scrubber retrofit).

Total costs for pollution control equipment alone would be nearly $82 million. Assuming that all of the increased cost is passed on to the consumers, electricity rates in Connecticut

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[1] "How the Clean Air Act Clogs Clean Fuels Development," in *Mining Engineering*. May 1975.

[2] Letter to Senator Robert Morgan from Roger Strelow, Assistant Administrator for Air and Waste Management, EPA, December 1975.

[3] EPA. *Implications of Alternative Policies for the Use of Permanent Controls and Supplemental Control Systems (SCS)*, July 7, 1975, p. A-15.

[4] As reported in *National Journal Reports*. December 14, 1975, p. 1867.

EXHIBIT 44
ALTERNATE ESTIMATES OF POLLUTION CONTROL COSTS REQUIRED UNDER ESECA
($ per kilowatt of plant capacity)

	Upgrading TSP Control Equipment	New Scrubber Installation	Scrubber Retrofit
FEA*	$4	$60	$80
Utility Officials**	$13 - $22		$100 (minimum)
EPA Panel***			$50 - $65
CACC†		$60 (1974 $)	$80 (1974 $)
PEDCO†		$60	$65

*"Unexpected Obstacles Hinder Plan for Coal Conversion," *National Journal Reports,* 31 May 1975, p. 818.

**"Utility Executives Attack Ford Coal Conversion Proposal," *National Journal Reports,* 14 December 1974, p. 1867.

***"Great Scrubber Debate Pits Utilities Against Electric Utilities," *National Journal Reports,* 27 July 1974, p. 1107.

†Clean Air Coordinating Committee and Redco, Inc. (for EPA), surveys as cited in *The Costs of Reducing SO_2 Emissions from Generating Plants* by NERA, Inc., for Electric Utility Industry Clean Air Coordinating Committee, June 1975.

will increase about $27 per household.[1] This represents about an 8 percent increase over the average household's 1975 electricity bill.[2]

With regard to benefits, consideration may be given to the stimulation in demand for air pollution control equipment. Based on 1975 nationwide control equipment market estimates of $310 million to $850 million (see Chapter III), the ESECA expenditures in Connecticut represent from 10 to 26 percent of current national air pollution control equipment demand. Manufacturers will clearly benefit from this increased demand.

G. Summary

Evaluation of the sulfur strategy focused on the impacts of reducing the sulfur content limitation in fuel from 0.5 percent to 0.3 percent and applying this reduction to the seven towns in the Naugatuck Valley. Emphasis was placed on residual oil fuel users because (i) currently, use of coal in Connecticut is negligible, and (ii) distillate oil is generally not subject to availability and cost constraints related to sulfur content. At the request of Region I, EPA, the impact of the Energy Supply and Environmental Coordination Act of 1974 (ESECA) was evaluated separately. The results of this analysis are summarized below and in Exhibits 45 and 46.

Direct Costs

- The economic implications of the sulfur strategy are primarily related to the price and availability of low sulfur fuel.
- Analysis indicates that sufficient quantities of 0.3 percent sulfur residual oil will be available for users in the Naugatuck Valley.
- At most, a 6 percent increase in the price of residual oil is estimated to result from strategy implementation.
- For major manufacturing users of residual oil in the Naugatuck Valley, the percentage increase in manufacturing costs as a result of the sulfur strategy ranges from 0.01 to 0.09 percent. In light of the 2.0 to 6.0 percent increases in manufacturing costs for these industries that resulted from the energy price increases of 1973 to 1974, no significant impact on the forecast growth or competitive advantage within this sector is expected.

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[1] A recent report for the electric utility industry by NERA, Inc. *An Analysis of the Costs to the Electric Utility Industry of House and Senate Significant Deterioration Proposals* (December 12, 1975), also assumed that all costs (including capital costs) would be passed on to households. Note that no amortization, energy, labor, etc., costs have been estimated. Households in Connecticut in 1974 from Homer Siler and George Associates, *Connecticut Housing Market Analysis.*

[2] Average household bill in June 1975 was $25.75; in December 1975, it was $31.46. Using the average of these two monthly bills, the annual 1975 electricity bill was $343.26. Source: Fred Sutton, Senior Rate Research Analyst, Northeast Utilities, March 15, 1976.

EXHIBIT 45
DIRECT IMPACT SUMMARY: THE SULFUR STRATEGY AND ESECA

	SO_2 Emissions*		Direct Impact		
			Costs	Benefits	
Economic Sectors • Sulfur Strategy	Percent of 1975	Percent of Gross Increase 1975-1985	Economic Growth	Health and Welfare	Demand Stimulation
All Manufacturing (SIC)	14.50	38.4	I	M	NA
20 Food	0.20	0.6	(2)	(1)	
22 Textiles	0.70	1.2	(7)	(2)	
23 Apparel	0.06	0.1	(1)	(1)	
24 Wood	0.07	0.3	(6)	(1)	
25 Furniture			(4)		
26 Paper	0.70	2.7	(8)	(2)	
27 Printing, Publishing	0.08	0.6	(1)	(1)	
28 Chemicals	3.40	12.2	(7)	(5)	
30 Rubber, Plastics			(3)		
29 Petroleum/Asphalt	0.20	1.1	(1)	(2)	
33 Primary Metals	3.40	Reduction	(6)	(2)	
34 Fabricated Metals	1.70	6.7	(4)	(4)	
35 Machinery	0.40	0.60	(2)	(1)	
36 Electrical Machinery	0.10	2.2	(1)	(2)	
37 Transportation Equipment	1.20	3.5	(3)	(3)	
38 Instruments	2.30	6.6	(2)	(4)	
31 Leather			(5)		
32 Stone, Clay, Glass			(6)		
39 Miscellaneous			(5)		
All Commercial/Institutional	7.10	56.4	I	M	NA
Electric Utilities	76.00	0.0	I	M	NA
(price of electricity)			M		
• ESECA					
Electric Utilities			I	I	S
(price of electricity)			S		

*Emissions represent SO_2 emissions from point source fuel combustion in New Haven County, which includes the Naugatuck Valley.

KEY

NA = Not Applicable
M = Moderate Impact
I = Insignificant Impact
S = Significant Impact
( ) = Relative rankings within major sectors. (1) represents least relative impact. Impact on growth based on intensity-of-use ratios. Impact on health and welfare based on emissions.

Source: Emissions from the DEP; Economic Analysis by Harbridge House, Inc. (1976).

EXHIBIT 46
INDIRECT IMPACT SUMMARY:
THE SULFUR STRATEGY AND ESECA

Region (strategy)	Costs		Benefits		
	Fuel Dealers	Other	Attractiveness	Orderly Growth	Efficient Use of Resources
Naugatuck Valley (sulfur strategy)	M	I	M	M	I
Connecticut (ESECA)	NA	NA	NA	NA	M

KEY
I = Insignificant Impact
M = Moderate Impact
S = Significant Impact
NA = Not Applicable

Source: Harbridge House, Inc. (1976).

- Increased costs to the commercial sectors range from 0.003 to 0.008 percent. No significant impact is expected.

- The cost of electricity to households in the Naugatuck Valley is likely to increase by 2.2 percent as a result of the sulfur strategy.

Direct Benefits

- Both absolute and relative reductions in damage from air pollution are expected in the Naugatuck Valley. Health benefits may be particularly great because of the higher than average (for the state) proportion of elderly persons in the Naugatuck Valley.

Indirect Costs

- Fuel oil dealers will bear increased costs in storing 0.3 percent sulfur fuel in addition to the 0.5 percent sulfur fuel.

Indirect Benefits

- Naugatuck Valley residents will experience improved quality of life. There is potential for increased attractiveness of the towns for business locations.

- More development will be accommodated within the limits of NAAQS, thereby promoting orderly growth.

- Minimal increases in energy conservation practices are expected.

Impact of ESECA

- Four Connecticut power plants are on FEA's list of potential candidates for conversion from oil to coal.

- Major costs likely to be incurred by these plants include costs relating to obtaining low sulfur coal and/or scrubbers.

- Increased costs of pollution control equipment associated with conversion are estimated to increase the average household's annual electricity bill by about 8 percent.

- The required air pollution control equipment expenditures represent from 10 to 26 percent of the 1975 market for control devices.

APPENDIX A
THE OBERS PROJECTIONS

THE OBERS PROJECTIONS

The 1972 OBERS Series E economic activity projections were used as a basis for the AQMA designation and subsequent AQMP tasks, including this study. These projections have been developed by the Bureau of Economic Analysis of the U.S. Department of Commerce and the Economic Research Service of the U.S. Department of Agriculture. The OBERS Series E projections at this time constitute the most complete econometric data analysis available for the state of Connecticut. OBERS-E economic activity projections are available for the state as a whole, SMSA's, and BEA economic areas from 1970 to 2020.

Population projections cited in the 1972 OBERS Series E are derived from 1972 U.S. Bureau of the Census Series E population estimates and a cohort fertility rate of 2.1. These projections also assume some migration into the state following the historical pattern developed in the 1950's and 1960's. Recent population estimates indicate that the OBERS Series E population projections are high, and the state's population has not grown as anticipated. Thus, current population estimates indicate that Connecticut's fertility rate is less than the established 2.1 rate and that some out-migration of population from the state has occurred.

OBERS Series E economic projections are based upon a shift-sharing technique between the region and the nation. National projections of employment and earnings have been based upon the assumption of a fixed 4 percent unemployment rate and do not take into consideration cyclical changes in the economy. The OBERS-E forecasts only total employment, projecting a 21.5 percent increase in Connecticut's total employment between 1970 and 1980. Industry earnings are projected on a two-digit SIC level. Increases in earnings are attributable to increases in employment and productivity (output per man-hour). A 2.9 percent annual rate of increase in productivity has been assumed in the projections. Based on forecasted national earnings and shift-share analysis, the OBERS projects a 2.7 percent annual growth in manufacturing earnings for Connecticut.

An in-house document prepared by the Connecticut Department of Environmental Protection compared the OBERS Series E projections to other estimates of individual demographic and economic components, concluding that OBERS can reasonably be considered with a ±10 percent margin of error for the year 1977, with the degree of error likely to increase beyond that point. Without attempting to refute this carefully prepared comparison, Harbridge House would like to note that in development of basic data for this study there were considerable indications that the OBERS Series E is skewed toward optimistic projections, particularly over relatively short time periods (such as 10 years). In particular, the deliberate ignorance of cyclical relationships within the economy does not appear to reflect economic constraints over the period from 1975 to 1985. It is believed, nevertheless, that consideration of cyclical phenomena should be appropriately tempered with a longer term (contingency type) outlook. As a result, it is suggested that interim updating of a reliable data base be used in conjunction with, or in place of, long-term statistically derived forecasts. The sensitivity of the AQMP procedure to the growth assumptions utilized indicates that a fairly detailed-and-current-data base should be developed.

APPENDIX B
PERMIT EXEMPTION CRITERIA

PERMIT EXEMPTION CRITERIA

A. Permits are not required for:

(i) Mobile sources.

(ii) Equipment used in a manufacturing process involving surface coating (including, but not limited to, spray and dip painting, roller coating, electrostatic depositing, or spray cleaning) and in which the total quantity of coating material and solvents used is less than 30 pounds in any one hour.

(iii) Equipment used in a manufacturing process involving metal cleaning and/or surface preparation, and which is connected to a ventilation system controlling escape of air pollutants or contaminants to the workroom air, such manufacturing process including, but not limited to, etching, pickling, or plating when the total capacity of such equipment is 1,000 gallons or less; or any solvent degreasing units with a total capacity of 1,000 gallons or less.

(iv) Equipment used in a manufacturing process, other than as set forth in subsections (A) (i), (ii), (iii), (v), (vi), or (vii) herein, in which the combined weight of all materials introduced, excluding air and water, does not exceed either 2,000 pounds in any one hour or 16,000 pounds in any one day.

(v) Any liquid storage tank, reservoir, or container, used for the storage of acids, volatile organic compounds, solvents, dilutants or thinners, inks, colorants, lacquers, enamels, varnishes, liquid resins, and having a capacity less than 40,000 gallons.

(vi) Fuel-burning equipment in which the maximum rated fuel-burning capacity is less than five million Btu per hour, unless the source is burning coal or residual oil.

(vii) Sources used as incinerators in dwellings containing six or fewer family units.

(viii) Any other process, operation, equipment, or activity, except those types specified in subsection (A) (i) through (vii) herein, which emits or causes to be emitted a total of eight tons per year or less of any air pollutant or combination of air pollutants.

B. Notwithstanding any provision of subsection (A) above, permits shall be required for all new stationary industrial pneumatic solid material handling or conveying systems and all industrial flares for the disposal of waste or excess process gases.

Source: Connecticut Department of Environmental Protection, *Administrative Regulations, Abatement of Air Pollution*, p. D-3.

APPENDIX C
SUMMARY OF DATA BASE AND RATIONALE FOR ASSUMED MANUFACTURING PROJECTIONS BY SIC

SUMMARY OF DATA BASE AND RATIONALE
FOR ASSUMED MANUFACTURING PROJECTIONS BY SIC

A. Introduction

As described in Chapter II, supplementary data were used to refine and modify the manufacturing forecasts calculated on the basis of linear regressions. This information is described below along with the limitation which should be recognized in its use. The description is followed by SIC summary sheets indicating the rationale for any forecast modifications.

- *Actual Number of Expansions (1963-1972):* These data concern only new construction whether it takes place at an existing plant or at a new location. It appears that the addition of a warehouse or office space to a manufacturing establishment is classified as a new facility although no increase in output may result.[1]

- *Actual Number of Expansions (1973, 1974):* These data have the same limitations as the 1963-1972 figure above. In addition, there may be some overlap between the two years as a result of facilities planned in 1973 and then completed in 1974.[2]

- *Expansions from Press Releases (1974, 1975):* This must be considered a nonrepresentative sample, since the press releases issued by Connecticut Development Authority refer only to those firms which obtained financing through the Authority.

- *Location Quotient (1972, Two-Digit SIC):* The use and limitations of location quotients are described in detail in Appendix K. Aggregation at the two-digit SIC level can substantially distort the expression of growth indicated for the component parts of the industry.

- *Employment Size Class of Greatest Number of Firms (1972):*[3] The employment size class is indicated in this category along with the percentage of total Connecticut firms (in the industry) which falls into that size class. Consequently, these data represent a frequency distribution, rather than an average firm size.

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[1]Connecticut Department of Commerce, *Statistical Survey of New Manufacturing Firms, 1963-1972.*

[2]Connecticut Department of Commerce, *Major Industrial and Corporate Office Construction in Connecticut, 1973, 1974.*

[3]U.S. Department of Commerce, *County Business Patterns,* 1972. (The 1973 *County Business Patterns* did not become available until December 1975 – after completion of the forecasts.)

- *Phone Interviews:* The criteria for selecting interviewees were based on the following: location quotient ranking at the four-digit level; lists of current and planned construction from the Connecticut Department of Commerce; recurrence of the SIC code in the permit system history; and lists of the five largest manufacturing employers for towns in the AQMA. Efforts to obtain a representative sample of responses by size of facility and SIC breakdown were limited by time constraints.

- *Dodge Bulletins:*[1] Limited data were obtained from Dodge Bulletin notification of construction plans and are included along with telephone interview data. Substantially greater reliance would have been placed on this source had time permitted.

[1] McGraw-Hill Information Systems, Dodge Bulletins.

B. Manufacturing Forecasts by SIC

SIC 20: FOOD AND KINDRED PRODUCTS

Data Base

• Average Annual Growth Rate (Calculated)	3.34%
• Calculated Number of New and Expanded Facilities (1972-1985)	59
• Actual Number of Expansions (1963-1972)	34
• Actual Number of Expansions (1973)	8
• Actual Number of Expansions (1974)	11
• Expansion Plans from Press Releases (1974-1975)	7
• Location Quotient (1972, two-digit SIC)	0.45
• Employment Size Class with Greatest Number of Firms (1972)	8-19 (24%)
• Phone Interviews: Neither of the two large companies contacted planned any expansion through 1985. Both indicated excess capacity in current operations.	

Conclusion

It is believed that the projected number of new and expanded facilities between 1972 and 1985 may reasonably be expected to occur in light of historical trends in the number of new and expanded facilities which have located in Connecticut from 1963 to the present as well as the predominance of small firms in this industry group. Consequently, it has been assumed that four facilities will be constructed per year from 1975 to 1985.

SIC 22: TEXTILE MILL PRODUCTS

Data Base

• Average Annual Growth Rate (Calculated)	2.34%
• Calculated Number of New and Expanded Facilities (1972-1985)	9
• Actual Number of Expansions (1963-1972)	27
• Actual Number of Expansions (1973)	6
• Actual Number of Expansions (1974)	7
• Expansion Plans from Press Releases (1974-1975)	5
• Location Quotient (1972, two-digit SIC)	0.80
• Employment Size Class with Greatest Number of Firms (1972)	20-49 (25%)

- Phone Interviews: Of the three firms contacted, none was planning either short- or long-term expansion.

Conclusion

Based solely on historical trends (that is, new and expanded facility construction from 1963 to the present), the number of facilities projected to locate in Connecticut between 1972 and 1985 appears low. Therefore, expansions were recalculated assuming 90 percent capacity utilization in 1972 (instead of 80 percent). This yielded an estimate of 25 new or expanded firms over the 13-year period. Taking into account the phone interview results and the clustering of the frequency distribution of employment size classes in the middle range for Connecticut industry, it is believed that this projection represents a reasonable estimate. Consequently, it has been assumed that two firms per year will locate or expand in Connecticut from 1975 to 1985.

SIC 23: APPAREL AND OTHER FINISHED PRODUCTS

Data Base

• Average Annual Growth Rate (Calculated)	1.39%
• Calculated Number of New and Expanded Facilities (1972-1985)	(10)
• Actual Number of Expansions (1963-1972)	42
• Actual Number of Expansions (1973)	1
• Actual Number of Expansions (1974)	0
• Expansion Plans from Press Releases (1974-1975)	2
• Location Quotient (1972, two-digit SIC)	0.55
• Employment Size Class with Greatest Number of Firms (1972)	20-49 (31%)

- Phone Interviews: No firms in this industry were interviewed.

Conclusion

The reduction in the number of establishments calculated from 1972 to 1985 despite a positive (but low) average annual growth rate can, perhaps, be attributed to a higher capacity utilization ratio than the 80 percent assumed in the majority of the manufacturing forecasts. Using a ratio of 90 percent, 18 firms are calculated to locate or expand in Connecticut over the 13-year period. Recent expansion plans (from 1973 to 1975) corroborate this low annual growth in the number of establishments. In the absence of more detailed data, it has been assumed that one firm per year will locate or expand in Connecticut from 1975 to 1985.

SIC 24: LUMBER AND WOOD PRODUCTS

Data Base

•	Average Annual Growth Rate (Calculated)	(1.54%)
•	Calculated Number of New and Expanded Facilities (1972-1985)	neg.
•	Actual Number of Expansions (1963-1972)	39
•	Actual Number of Expansions (1973)	0
•	Actual Number of Expansions (1974)	2
•	Expansion Plans from Press Releases (1974-1975)	1
•	Location Quotient (1972, two-digit SIC)	0.18
•	Employment Size Class with Greatest Number of Firms (1972)	1-3 (34%)

• Phone Interviews: No firms in this industry were interviewed.

Conclusion

A negative annual average growth rate was calculated for this industry. However, 39 firms were expanded or constructed between 1963 and 1972. In view of the low location quotient, it appears reasonable to assume that not more than two firms per year will be constructed between 1975 and 1985.

SIC 25: FURNITURE AND FIXTURES

Data Base

• Average Annual Growth Rate (Calculated)	4.59%
• Calculated Number of New and Expanded Facilities (1972-1985)	46
• Actual Number of Expansions (1963-1972)	47
• Actual Number of Expansions (1973)	7
• Actual Number of Expansions (1974)	4
• Expansion Plans from Press Releases (1974-1975)	1
• Location Quotient (1972, two-digit SIC)	0.59
• Employment Size Class with Greatest Number of Firms (1972)	20-49 (23%)

- Phone Interviews: No firms in this industry were interviewed.

Conclusion

The calculated number of new or expanded facilities represents an average of about four facilities per year over the 13-year period. This appears to be reasonable, despite the industry's relatively high growth rate – in light of the size distribution of firms, past expansion and recent plans, and the low location quotient. In the absence of additional data, it has been assumed that four establishments per year will locate or expand in Connecticut between 1975 and 1985.

SIC 26: PAPER AND ALLIED PRODUCTS

Data Base

• Average Annual Growth Rate (Calculated)	4.15%
• Calculated Number of New and Expanded Facilities (1972-1985)	35
• Actual Number of Expansions (1963-1972)	21
• Actual Number of Expansions (1973)	2
• Actual Number of Expansions (1974)	6
• Expansion Plans from Press Releases (1974-1975)	4
• Location Quotient (1972, two-digit SIC)	0.68
• Employment Size Class with Greatest Number of Firms (1972)	50-99 (23%)

- Phone Interviews: No firms in this industry were interviewed.

Conclusion

The calculated number of new or expanded facilities represents an average of three facilities per year over the next 13 years. This appears to be a reasonable estimate of future expansion. In the absence of additional data, it has been assumed that three establishments will locate or expand in Connecticut per year from 1975 to 1985.

SIC 27: PRINTING AND PUBLISHING

Data Base

• Average Annual Growth Rate (Calculated)	2.48%
• Calculated Number of New and Expanded Facilities (1972-1985)	59
• Actual Number of Expansions (1963-1972)	201
• Actual Number of Expansions (1973)	16
• Actual Number of Expansions (1974)	13
• Expansion Plans from Press Releases (1974-1975)	5
• Location Quotient (1972, two-digit SIC)	1.06
• Employment Size Class with Greatest Number of Firms (1972)	1-3 31%

- Phone Interviews: No firms in this industry were interviewed.

Conclusion

The large number of expansions from 1963 to 1972 as compared to the relatively small number of calculated new or expanded facilities indicates that the method of conversion from value added to number of establishments is in error for this manufacturing group. Assuming that the capacity utilization ratio in 1972 was 90 percent (instead of 80 percent), expanded facilities would number 139. Since the distribution of 1972 establishments is markedly skewed toward small facilities and the location quotient was calculated to be greater than one, it appears reasonable that this larger number of expansions may occur. Consequently, it has been assumed that 11 firms per year will locate or expand in Connecticut between 1975 and 1985.

SIC 28: CHEMICALS AND ALLIED PRODUCTS

Data Base

• Average Annual Growth Rate (Calculated)	4.59%
• Calculated Number of New and Expanded Facilities (1972-1985)	66
• Actual Number of Expansions (1963-1972)	45
• Actual Number of Expansions (1973)	11
• Actual Number of Expansions (1974)	19
• Expansion Plans from Press Releases (1974-1975)	7
• Location Quotient (1972, two-digit SIC)	0.85
• Employment Size Class with Greatest Number of Firms (1972)	8-19 (23%)
• Phone Interviews: Of the three large firms responding, two plan to expand prior to 1985.	

Conclusion

The calculated number of new or expanded facilities averages five per year over the 13-year period. Based on the actual number of expansions between 1963 and 1972 and the location quotient of less than one, the calculated number appears to represent a reasonable estimate. It should be noted, however, that the distribution of establishments by employment size is skewed toward small-sized facilities and that recent (1973 to 1975) indications of expansion in the industry are higher than during the pre-1972 period. In the absence of additional data, it has been assumed that five establishments per year will expand or locate in Connecticut between 1975 and 1985.

SIC 29: PETROLEUM AND COAL PRODUCTS

Data Base

• Average Annual Growth Rate (Calculated)	8.83%
• Calculated Number of New and Expanded Facilities (1972-1985)	41
• Actual Number of Expansions (1963-1972)	4
• Actual Number of Expansions (1973)	1
• Actual Number of Expansions (1974)	0
• Expansion Plans from Press Releases (1974-1975)	0
• Location Quotient (1972, two-digit SIC)	.13
• Employment Size Class with Greatest Number of Firms (1972)	8-19 (35%)

- Phone Interviews: No firms in this industry were interviewed.

Conclusion

There were only 17 firms in this industry in Connecticut in 1972, most of which were manufacturers of paving and roofing material. The location quotient is quite low and only four facilities were constructed between 1963 and 1972. Consequently, it is expected that the calculated number of new or expanded facilities, which averages three per year, is extremely high. It has been assumed that one plant every two years goes on line between 1975 and 1985. This estimate is considered reasonable, especially in light of this sector's expansion trend since 1963.

SIC 30: RUBBER AND MISCELLANEOUS PLASTIC PRODUCTS

Data Base

• Average Annual Growth Rate (Calculated)	4.59%
• Calculated Number of New and Expanded Facilities (1972-1985)	77
• Actual Number of Expansions (1963-1972)	80
• Actual Number of Expansions (1973)	5
• Actual Number of Expansions (1974)	8
• Expansion Plans from Press Releases (1974-1975)	7
• Location Quotient (1972, two-digit SIC)	1.60
• Employment Size Class with Greatest Number of Firms (1972)	8-19 (23%)
• Phone Interviews: The single large firm responding did not anticipate expansion before 1985.	

Conclusion

The projected number of expansions per year through 1985 represents a lower rate of growth than that of the 1963 to 1972 period. This divergence indicates that the methodology for conversion of projected value added to the number of establishments is not appropriate for this manufacturing group. In view of the high location quotient, it appeared reasonable to assume that the industry averaged 90 percent capacity utilization in 1972. Calculated on this basis, a total of 108 firms can be expected to expand in Connecticut from 1972 to 1985. Consequently, it was assumed that eight firms per year would locate or expand in Connecticut between 1975 and 1985.

SIC 31: LEATHER AND LEATHER PRODUCTS

Data Base

• Average Annual Growth Rate (Calculated)	(0.83%)
• Calculated Number of New and Expanded Facilities (1972-1985)	neg.
• Actual Number of Expansions (1963-1972)	4
• Actual Number of Expansions (1973)	0
• Actual Number of Expansions (1974)	0
• Expansion Plans from Press Releases (1974-1975)	0
• Location Quotient (1972, two-digit SIC)	0.36
• Employment Size Class with Greatest Number of Firms (1972)	20-49 (23%)

- Phone Interviews: No firms in this industry were interviewed.

Conclusion

A negative growth rate was calculated. Expansion in this industry has been minimal since 1963. It has been assumed that not more than one firm every other year is expanded or built in Connecticut.

SIC 32: STONE, CLAY, AND GLASS PRODUCTS

Data Base

• Average Annual Growth Rate (Calculated)	1.47%
• Calculated Number of New and Expanded Facilities (1972-1985)	(6)
• Actual Number of Expansions (1963-1972)	29
• Actual Number of Expansions (1973)	7
• Actual Number of Expansions (1974)	6
• Expansion Plans from Press Releases (1974-1975)	0
• Location Quotient (1972, two-digit SIC)	0.73
• Employment Size Class with Greatest Number of Firms (1972).	8-19 (29%)

- Phone Interviews: No firms in this industry were interviewed.

Conclusion

Based on 80 percent capacity utilization, the number of firms in this industry was calculated to decrease between 1972 and 1985 despite a positive (although low) growth rate. However, the actual number of expansions of the past 11 years indicates that the number of firms could be expected to increase gradually over the next 10 years. Assuming a 90 percent capacity utilization rate in 1972, 16 new firms could be expected to come on line over the next 13 years, or an average of one firm per year. Again, this figure seems low, particularly in light of the relatively small size of establishments in the industry. Overall, it is believed that the growth rate, which was calculated on the basis of value added in the absence of a more appropriate indicator, does not reasonably reflect significant future growth in the industry. It has been assumed that three establishments per year will locate or expand in Connecticut betwen 1975 and 1978, based on the average between 1963 and 1972.

SIC 33: PRIMARY METAL INDUSTRIES

Data Base

• Average Annual Growth Rate (Calculated)	3.73%
• Calculated Number of New and Expanded Facilities (1972-1985)	59
• Actual Number of Expansions (1963-1972)	32
• Actual Number of Expansions (1973)	7
• Actual Number of Expansions (1974)	12
• Expansion Plans from Press Releases (1974-1975)	5
• Location Quotient (1972, two-digit SIC)	1.12
• Employment Size Class with Greatest Number of Firms (1972)	20-49 (20%)

- Phone Interviews: Of the eight firms responding, two planned to expand between 1975 and 1978, and two between 1978 and 1985. One firm, however, specifically indicated that Connecticut was not attractive for expansion because of high labor costs, high taxes, and a high unemployment compensation rate. Four of the firms (all large ones) noted that the metal business is currently in a depressed state and that efforts were geared toward regaining profitability.

Conclusion

The calculated number of new or expanded firms appears to be somewhat optimistic in light of the interview responses and the growth in establishments from 1963 to 1972. However, no reasonable alternative pattern for future expansion and construction can be ascertained from available data. Consequently, it has been assumed that an average of four establishments per year will come on line between 1975 and 1985.

SIC 34: FABRICATED METAL PRODUCTS

Data Base

• Average Annual Growth Rate (Calculated)	3.73%
• Calculated Number of New and Expanded Facilities (1972-1985)	205
• Actual Number of Expansions (1963-1972)	232
• Actual Number of Expansions (1973)	44
• Actual Number of Expansions (1974)	33
• Expansion Plans from Press Releases (1974-1975)	21
• Location Quotient (1972, two-digit SIC)	1.86
• Employment Size Class with Greatest Number of Firms (1972)	8-19 (26%)

- Phone Interviews: Of the seven relatively large firms responding, two indicated expansion plans between 1975 and 1985. However, three firms expressed uncertainty about expansion in Connecticut even if the economy takes a turn for the better. They cited taxes, labor rates, and market saturation as reasons.

Conclusion

The calculated number of new and expanded facilities appears low in light of the high location quotient, past growth trends, and the relatively small size of most firms. Consequently, it has been assumed that a 90 percent capacity utilization rate would be more representative of industry operating characteristics during 1972. The new calculation yields an average of 18 establishments per year (total of 240 over 13 years), which is considered a reasonable estimate of facility increases from 1975 to 1978. In light of the telephone interview responses, it is likely that small firms will compose the major portion of these expansions.

SIC 35: MACHINERY, EXCEPT ELECTRICAL

Data Base

• Average Annual Growth Rate (Calculated)	3.73%
• Calculated Number of New and Expanded Facilities (1972-1985)	334
• Actual Number of Expansions (1963-1972)	422
• Actual Number of Expansions (1973)	15
• Actual Number of Expansions (1974)	18
• Expansion Plans from Press Releases (1974-1975)	14
• Location Quotient (1972, two-digit SIC)	1.82
• Employment Size Class with Greatest Number of Firms (1972)	8-19 (27%)

- Phone Interviews: Of the seven firms responding, three anticipate expansion between 1978 and 1985. Most of the other respondents cited current economic conditions and Connecticut's tax structure as deterrents to expansion.

Conclusion

The calculated number of new and expanded firms averages about 26 establishments per year. Although this is significantly lower than the 1963 to 1972 average, it does represent an increase over the number of establishments expanding during the 1973 to 1975 period. Because of the economic downturn in the last few years and the indications that health may be slowly returning to the national economy, the calculated increases are expected to be representative of future growth in this capital investment-oriented industry. Consequently, it has been assumed that 26 new or expanded establishments per year will come on line between 1975 and 1985.

SIC 36: ELECTRICAL MACHINERY

Data Base

• Average Annual Growth Rate (Calculated)	3.73%
• Calculated Number of New and Expanded Facilities (1972-1985)	104
• Actual Number of Expansions (1963-1972)	169
• Actual Number of Expansions (1973)	10
• Actual Number of Expansions (1974)	13
• Expansion Plans from Press Releases (1974-1975)	5
• Location Quotient (1972, two-digit SIC)	1.36
• Employment Size Class with Greatest Number of Firms (1972)	20-49 (19%)
• Phone Interviews: Of the eight large firms responding, only one anticipated expansion prior to 1985.	

Conclusion

The calculated number of new and expanded establishments represents an average of eight per year for the 13-year period. This estimate appears to be reasonable. Consequently, it has been assumed that eight establishments will come on line per year between 1975 and 1985.

SIC 37: TRANSPORTATION EQUIPMENT

Data Base

• Average Annual Growth Rate (Calculated)	3.31%
• Calculated Number of New and Expanded Facilities (1972-1985)	29
• Actual Number of Expansions (1963-1972)	69
• Actual Number of Expansions (1973)	3
• Actual Number of Expansions (1974)	4
• Expansion Plans from Press Releases (1974-1975)	4
• Location Quotient (1972, two-digit SIC)	2.49
• Employment Size Class with Greatest Number of Firms (1972)	8-19 (19%)

- Phone Interviews: Of the five large firms responding, none had plans for expansion prior to 1985, although one firm had a $10 million plant under construction.

Conclusion

Although the calculated number of new or expanded firms represents a significant decrease from the 1963 to 1972 level of facility expansion, the estimate is considered reasonable in light of the post-Vietnam economy and the responses of firms interviewed. Consequently, an average of two new or expanded facilities per year has been assumed to come on line between 1975 and 1985.

SIC 38: INSTRUMENTS AND RELATED PRODUCTS

Data Base

• Average Annual Growth Rate (Calculated)	3.38%
• Calculated Number of New and Expanded Facilities (1972-1985)	34
• Actual Number of Expansions (1963-1972)	25
• Actual Number of Expansions (1973)	6
• Actual Number of Expansions (1974)	11
• Expansion Plans from Press Releases (1974-1975)	8
• Location Quotient (1972, two-digit SIC)	2.63
• Employment Size Class with Greatest Number of Firms (1972)	20-49 (19%)
• Phone Interviews: Of the three large firms responding, only one anticipates expansion (between 1978 and 1985).	

Conclusion

The calculated number of new and expanded facilities represents about three establishments per year over the 13-year period. This estimate is considered to be somewhat low in light of the high location quotient and the active solicitation of firms in this industry by at least one economic development agency. It has been assumed that four establishments per year between 1975 and 1985 is a more representative estimate.

SIC 39: MISCELLANEOUS MANUFACTURING INDUSTRIES

Data Base

• Average Annual Growth Rate (Calculated)	4.59%
• Calculated Number of New and Expanded Facilities (1972-1985)	93
• Actual Number of Expansions (1963-1972)	98
• Actual Number of Expansions (1973)	6
• Actual Number of Expansions (1974)	6
• Expansion Plans from Press Releases (1974-1975)	2
• Location Quotient (1972, two-digit SIC)	1.83
• Employment Size Class with Greatest Number of Firms (1972)	1-3 & 8-19 (14% each)
• Phone Interviews: Of the three large firms responding, none had plans for expansion through 1985.	

Conclusion

The calculated number of new and expanded establishments is considered to be a reasonable estimate of future growth in the number of firms. Consequently, it has been assumed that an average of seven facilities come on line per year between 1975 and 1985.

APPENDIX D
HOSPITAL, MENTAL HEALTH FACILITY, AND MENTAL RETARDATION FACILITY FORECASTS

HOSPITAL, MENTAL HEALTH FACILITY, AND MENTAL RETARDATION FACILITY FORECASTS

As indicated in Chapter II, telephone interviews indicated that no source growth in hospitals, mental health facilities, or mental retardation facilities would occur during the study period. Background data providing the basis for this conclusion are provided here.

I. Hospitals

Connecticut currently has a surplus of hospital beds, according to state Department of Health sources. Further, two basic health care trends are expected to contribute to a reduced need for hospital beds in the future. First, doctors are tending to increasingly rely on out-patient care rather than inpatient confinement. Second, increased patient turnover rates have caused greater utilization of existing bed capacity. Consequently, construction of additional hospital capacity is highly unlikely during the period 1975 to 1985. This conclusion is corroborated by the Chief of Health Facility Construction, Department of Health.[1] Replacement construction over the next 10 years is expected to occur in roughly the same areas where current facilities exist, neither increasing or decreasing the size of individual facilities.

II. Mental Health Facilities

Projected growth of mental health care facilities in the state from 1975 to 1985 may differ substantially in character from traditional growth patterns. Future expansion is expected to be non-space related. Space needs will, in fact, probably be reduced.[2]

Currently, 85 percent of the total volume served by state mental health care facilities is represented by hospital in-patient care. If present plans are met, by 1978 in-patient and out-patient care would be equally divided.

Mental health care replacement facilities will reflect the current trend in treatment away from patient confinement toward assimilation into society. As a result, expected construction of new facilities is minimal. Maximum use of existing structures will be made as follows:

(i) Local hospitals will provide partial (less than 24-hour) hospitalization.

(ii) Church basements will provide less intensive day treatment programs.

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[1]Thomas Redding, Chief of Health Facility Construction, Hospital and Medical Care Division, Department of Health, State of Connecticut. Telephone interview 21 November 1975.

[2]Dr. Mark, Department of Mental Health, State of Connecticut. Telephone interviews, November 1975.

(iii) Existing structures will provide halfway houses where patients will experience sheltered living and work environments.

(iv) 24-hour emergency phone services will be implemented locally.

Presently, the state provides mental health care to 2 percent of the total population. However, it is anticipated that the trends toward diversification and dispersion of services will result in care being extended to 6 to 7 percent of the total population by 1985. In summary, the long-term consequence of these mental health care trends will probably yield an overall reduction of space, minimal construction, and increased efficiency of service.

III. Mental Retardation Facilities

Telephone interviews and correspondence with officials at the Connecticut Department of Mental Retardation indicate that no new construction of either public or private mental retardation facilities will take place through 1985.[1] At present, there is a regional center under construction in Norwalk. In addition, 16 new cottages in Mansfield Depot are being constructed to replace antiquated facilities. However, ground has already been broken on both of these projects.

Growth in facility requirements is expected to be accommodated through the purchase or lease of community-based residences. It is anticipated that 25 such facilities may be opened over the next 10 years, with a total bed capacity of approximately 300.[2] This type of expansion, however, is not relevant to evaluation of the strategies under consideration. Consequently, no growth in mental retardation facilities has been assumed.

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[1] Arthur, L. DuBrow, Director of Administrative Services, Department of Mental Retardation, State of Connecticut, letter dated 28 October 1975.

[2] *Ibid.*

APPENDIX E
EDUCATIONAL FACILITIES

EDUCATIONAL FACILITIES

The short-term forecast in Chapter II was based on the planned public school construction projects shown in Exhibit E-1.

The long-term forecast of school facilities was based on the indices of school needs, as follows:[1]

$$\text{Index}_{\text{Lower Schools}} = \frac{\text{Population Age 0-5}}{\text{Population Age 6-11}}$$

$$\text{Index}_{\text{Upper Schools}} = \frac{\text{Population Age 6-11}}{\text{Population Age 12-17}}$$

Based on some simplifying assumptions, the index measures the degree to which changes will occur in the demand for school facilities over the next five to six years. To the extent that the younger age group is larger than the older, future need for school facilities will increase. Similarly, if the younger group is smaller than the older, school facility needs will decrease. A measure of .85 or lower on the index is an indication that classroom space will be freed over the next five to six years, while a measure of 1.20 or higher indicates the need for additional classroom space.[2]

The required assumptions are:

- That mortality rates among the population under age 18 remain constant.
- That the net migration rates of the population under age 18 remain constant.
- That the "dropout" rate remains low among those students who are not compelled by law to attend school (16 and 17 years old).
- That during the time periods under consideration, school facilities and school policies remain unchanged.

In utilizing the index, regional differences in population age groups were not taken into account because the data required for such specificity were not available. Consequently, it is implicitly assumed that the age distribution of the Connecticut population is uniform throughout the regions.

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[1]Hadden, Kenneth; William Groff; Rosemary Campiformio; and Lakshmi Murty, *School Enrollment in Connecticut: Past Trends and Future Prospects*, Bulletin 427, College of Agriculture and Natural Resources, the University of Connecticut, Storrs, March 1974.
[2]*Ibid.*

EXHIBIT E-1
SELECTED PUBLIC SCHOOL PROJECTS*

Town	Level	Type	Cost (millions $)	Description
Bridgeport	Elem.	New	6	
	Elem.	New	6	
	Elem.	New	6	
	Elem.	New	6	
	Elem.	New	6	
	Elem.	New	6	
Easton	Middle	Ext.-Alt.	N.A.	
Ellington	H.S.	Ext.-Alt.	2.9	Additional core facilities.
	J.H.S.	Ext.	0.7	
	Elem.	Ext.	0.8	Alleviation of overcrowding.
	Elem.	Ext.	0.2	
Fairfield	J.-S.H.S.	Ext.-Alt.	3.8	Satisfaction of long-term need.
	Elem.	Ext.	0.6	
	Elem.	Ext.	0.7	Libraries, gymnasiums, cafeterias.
	Elem.	Ext.	0.6	Satisfaction of future needs of community.
	Elem.	Ext.	0.6	
Wolcott	H.S.	Ext.-Alt.	5.8	Alleviation of overcrowding.
Shelton	Elem.	Ext.	0.1	Portable structures; alleviation of overcrowding.
Avon	Elem.	Ext.	0.4	Gymnasium to meet present needs.
New Haven	Middle	New	8.4	Part of New Haven middle school concept.

*New facilities, extensions (Ext.) and extension-alterations (Ext.-Alt.) within the AQMA selected from *Project Resume,* Connecticut School Building Unit, September 1975.

EXHIBIT E-1 (Cont'd)

Town	Level	Type	Cost (millions $)	Description
Hartford		New	3.2	Part of Hartford Redevelopment Area; community educational facilities scattered throughout.
Darien	J.H.S.	Ext.-Alt.	1.4	Consistent with code and growing need.
	Elem.	Ext.-Alt.	0.6	
	Elem.	Ext.-Alt.	0.4	
	Elem.	Ext. Alt.	0.3	
	Elem.	Ext.-Alt.	0.3	
	Elem.	Ext.-Alt.	0.1	
Marlborough	Elem.	New	3.0	
Norwalk	Middle	Ext.-Alt.	1.8	Core facilities: labs, classrooms, music and art rooms.
Ridgefield	H.S.	Ext.	0.1	Power mechanisms building.
Tolland	H.S.	Ext.	0.1	Music facilities.
Waterbury	Middle & H.S.	New	22.8	
Wethersfield	Elem.	Ext.-Alt.	2.1	Demolition of one wing; addition to existing wing.
Windsor	H.S.	Ext.	0.9	Industrial arts and office facilities.
	J.H.S.	Ext.-Alt.	0.5	
	Elem.	Ext.-Alt.	2.5	Replacement of existing structure.
West Hartford	Elem.	Ext.-Alt.	1.3	Media center and additional core facilities.
	Elem.	Ext.-Alt.	1.3	
	H.S.	Ext.-Alt.	1.3	Swimming pool.
	H.S.	Ext.-Alt.	1.3	

The calculated indices of school needs are shown in Exhibit E-2. According to the criteria previously established, it may be concluded that no additions to school capacity are required through 1985. There may, however, be some replacement construction. Although such construction would be subject to permit approval, the extent of such activity could not be assessed within the scope of this study. Moreover, the net change in emissions from replacement construction would be negligible. For this analysis, then, it has been assumed that no new school construction is undertaken from 1978 through 1985.

As noted in Chapter II no forecast was made of growth in private and post-high school educational facilities. A list of the existing schools is shown in Exhibit E-3 in order to give an indication of the extent of the omission.

EXHIBIT E-2
INDICES OF SCHOOL NEED

Index for:	1975-1976	1980-1981	1985-1986
Based on Data for:	1970	1975	1980
Upper School	1.04	.89	.82
Lower School	.86	.82	.71

Source: Harbridge House, Inc. Indices for 1975-1976 from *School Enrollment in Connecticut: Past Trends and Future Prospects.*

EXHIBIT E-3
PRIVATE AND POST-HIGH SCHOOL EDUCATIONAL FACILITIES IN CONNECTICUT
1975

Type of School	Number of Schools
Elementary and Middle	200
Secondary and Preparatory	88
Post-Secondary	59
Vocational Training (Secondary Level)	16
Technical Colleges	4
Colleges and Universities:	
– Public	22
– Private	25

Source: Connecticut Department of Commerce. *Connecticut Educational Systems,* 1975.

APPENDIX F
RESOURCE RECOVERY PLAN

RESOURCE RECOVERY PLAN

There are currently 22 municipal incinerators operating in Connecticut. Several of them appear to be out of compliance with air quality regulations, and substantial expenditures will be required to bring them into compliance. In addition, several municipalities use landfills to dispose of solid wastes. Many of these landfills represent water quality hazards, and land available for extension and upgrading of landfills is quite limited in certain areas of the state.

To implement a statewide plan for managing solid waste, Connecticut has organized a Resource Recovery Authority. A solid waste management plan, developed in 1973, has been established to maximize resource recovery from solid waste, to minimize adverse environmental impacts, and to provide maximum benefits at least user cost. The plan calls for construction of 10 plants, using advanced methods of resource recovery from solid wastes. These plants will be capable of processing all wastes except hazardous chemicals and demolition wastes.

It is estimated that by 1985 or 1986, the system will be processing approximately 84 percent of the state's waste from 133 of the 169 towns. The remaining 36 towns, which are mainly in the lightly populated northeast, northwest, and estuary regions generally, are expected to join the system during the 1986 to 1994 period using the existing resource recovery plants. By 1994, the entire state is expected to be participating in resource recovery.

The relative cost advantages of such widespread participation are documented in the Plan Summary.[1] Installation of a new municipal incinerator meeting air quality standards is estimated to cost about $17 to $25 per ton, and new properly engineered landfills cost about $5 to $7 per ton. The estimated net total costs of the new Resource Recovery Plan will be about $10 per ton, with the actual cost varying somewhat by region. When the municipalities are confronted with the extremely high cost of installing a new municipal incinerator or of upgrading their present facility to meet air quality standards, it is expected that they will choose to participate in the less costly Resource Recovery Plan.

The proposed schedule for plant construction is shown in Exhibit F-1. The years indicated on the chart as the earliest dates on line are under reassement. Currently, it appears that plans are six months to a year behind schedule.[2] However, it is expected that the municipalities will be able to extend the use of their present disposal facilities during this delay.[3] It is anticipated that as the Plan progresses, changes may be made in facility

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[1] *A Proposed Plan for Solid Waste Management for Connecticut – Summary*. Prepared by General Electric Corporate Research and Development, and Connecticut Department of Environmental Protection, 1973.

[2] Richard Chase, President, Resource Recovery Authority, telephone interview 25 November 1975.

[3] *Ibid.*

EXHIBIT F-1
CONSTRUCTION SCHEDULE FOR RESOURCE RECOVERY PLANTS

Location	Earliest Date on Line	Type of Plant	1985 Tonnage (tons/day)
Greater Bridgeport	Mid 1976	Dry Fuel	1,814
New Haven Area	1977	Gas Pyrolysis	1,694
Hartford Area	1978	Oil Pyrolysis	2,185
New Britain-Berlin	Mid 1979 to 1980	Dry Fuel or Gas Pyrolysis	1,915
Southwestern Region	1980	Gas Pyrolysis or Dry Fuel	1,821
Montville*	1981	Pyrolysis	1,325
Waterbury	1981	Pyrolysis	1,621
Valley Region	1982	Dry Fuel or Pyrolysis	785
Danbury	1983	Pyrolysis	953
East Windsor	1984	Pyrolysis	1,806

*Montville plant is not in the AQMA.

Source: *A Proposed Plan for Solid Waste Management for Connecticut.*

siting and scheduling. For example, a few of the 10 orginally planned plants may be combined, resulting in construction of only seven plants. Depending on how the system functions in operation and the level of demand placed on individual facilities, the Greater Bridgeport and Southwestern plants may be combined and the New Haven, Hartford, and New Britain facilities may be integrated into one structure.[1]

In order to provide a check on individual and combined plant capacities, Harbridge House estimated solid waste generation for each of the 133 towns in the state which are expected to be participating in the Resource Recovery System by 1980 and by 1985. The projections were based upon DEP estimates of waste per capita per day for each town and disaggregation of the 1980 and 1985 population projections by town. It was assumed that the 1973 town population, as a proportion of Regional Planning Agency population, would remain constant. The DEP waste estimates represent the amount of solid waste ultimately disposed of at municipal facilities, including the following categories: residential, commercial, non-problem industrial, bulky combustible, bulky non-combustible, and non-urban renewal demolition wastes. The total solid waste to be processed at each plant was a summation of the wastes of the towns serviced by the respective resource recovery plants.

These calculations indicated that more than sufficient capacity would be available at each of the 10 planned regional plants. However, it appeared that combining the plants into seven facilities instead of 10 would require greater than the 1,800 tons per day of planned capacity at the combined plants.

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[1] *Ibid.*, 11 November, 1975.

APPENDIX G
PLANNED SEWAGE SLUDGE INCINERATOR CAPACITY

PLANNED SEWAGE SLUDGE INCINERATOR CAPACITY

Start-Up Date	Plant/Location	Start-Up Capacity*	Final Capacity	(Year)
1976	New Haven Boulevard	78,800	226,000	(2010)
1976	New Milford**	N.A.	17,100	(1996)
1976	Windsor Locks	N.A.	N.A.	(1996)
1976	Middletown	N.A.	44,000	(1996)
1977	Vernon	N.A.	65,350	(1997)
1978	New Haven East Shore	N.A.	308,500	(2010)

*Capacity in terms of equivalent population served.

**Not in AQMA.

N.A. = Not available.

Note: These facilities were used as the basis of the DEP emission projections.

Source: Air Compliance Section, Department of Environmental Protection. (Based on estimate received from Water Compliance.)

APPENDIX H
DISCOUNTING TO PRESENT VALUE

DISCOUNTING TO PRESENT VALUE

A. Background

In some cases the interest rate used in discounting dollars to present value can have substantial effect on the valuation of net benefits or costs.[1] The interest rates used in this analysis were based on interviews with banking officials in which information was requested regarding the long-term rate for Connecticut bonds (public discounting) and the current prime lending rate (private sector).[2] The rationale for using these interest rates in discounting was based on a pragmatic view of the role of present value, assuming that such a calculation should consider rates for loans should they be required.

Alternatively, the Office of Management and Budget (OMB) requests that any study done for them include discounting at 10 percent (although other rates may also be used). This rate, according to a source at OMB,[3] theoretically represents the real rate of return earned in the private sector and is supposed to reflect opportunity cost. As such, it is contended the rate does not fluctuate over time.

No attempt has been made to reconcile these alternate views of discounting. Instead, a sample problem illustrative of the use of two alternative rates (7 percent and 10 percent) is shown below.[4]

B. Example of Present Value Calculations

Suppose the local planning agency of Anytown, U.S.A., is comparing two different air quality maintenance strategies. The time period will be 20 years, and the planners have decided to consider the possibilities of 7 percent and 10 percent interest. All costs are assumed to occur on 31 December of the year in which they are incurred. (If a cost will occur in January or February, the Anytown planners assume that it will have occurred the preceding year.) The data for the alternatives are:

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[1]Note that in this study the net impact cannot be evaluated solely on a quantitative basis because of the nature of certain costs and benefits.

[2]For the public sector, a 6 percent rate was used based on telephone interviews 1 December 1975 with municipal bond officers. First National Bank of Boston estimated long-term rate for Connecticut bonds at between 5.0 and 5.5 percent, while First National City Bank of New York estimated the rate at between 6.0 and 7.0 percent. For the private sector, a prime rate of 7.25 percent was estimated by the Commercial Loan Department, First National Bank of Boston.

[3]Telephone interview with Mr. Jerry Shipley, 4 March 1976.

[4]EPA *Guidelines for Air Quality Maintenance Planning and Analysis, Volume 2: Plan Preparation* (EPA-450/4-74-002), July 1974.

Alternative I

Capital Costs:	$1 million in years 1, 5, 20
Operating Costs:	$10,000 per year

Alternative II

Capital Costs:	$0.5 million in year 1 1.0 million in year 10 2.0 million in year 20
Operating Costs:	$50,000 per year

The total undiscounted costs for the alternatives are $3.2 million and $4.5 million, respectively. However, the present value of these costs is shown in Exhibit H-1. At an interest rate of 7 percent, there is little economic advantage in either alternative. However, at a rate of 10 percent, Alternative II is more acceptable.

APPENDIX I
POLLUTION CONTROL COST ESTIMATES

POLLUTION CONTROL COST ESTIMATES

A. Background and Approach

Several problems were encountered in the effort to obtain approximations of control costs attributable to permit program implementation. The first difficulty resulted from the level of source aggregation – both by size of facility and by SIC – for which estimates were required. Within a two-digit SIC group, the variation among processes and even products is considerable. Consequently, emissions – and thus the level and type of control required – can also vary significantly. The size of each facility similarly affects the components of a control cost estimate. Moreover increases in product throughput (as an indication of size) are not directly related to increases in abatement costs; rather, it is the level of gas throughput which serves as the size criterion to which abatement costs are (or should be) pegged.

Another problem in the pollution control estimates involved determination of the current level of control implied by BACT as well as consideration of future changes in BACT. For some establishments, for example, BACT may require a change in production methods, rather than the application of end-of-pipe control equipment (see Appendix O). Moreover, BACT may change over the study period such that the permit related-control costs could increase or even decrease.

In addition, there was a problem in determining the reliability and accuracy of data. Published studies regarding pollution control costs often fail to enumerate relevant assumptions such as interest rates used in annualized cost figures; some, in fact, do not even give the year for which data were representative. Often, costs attributable to retrofitting versus new installations could not be discerned. Compounding the problem was the nearly universal reticence of pollution control manufacturers to quote equipment and/or installation prices. In fact, sources considered most reliable in the search for representative pollution control costs, stressed the necessity of a case-by-case evaluation.

The raw data developed from several sources are shown in Section B, below. As is evident there were not sufficient data to estimate average or overall costs on a statistical basis. However, in view of the above limitations, the usefulness of a statistical estimate is questionable. Accordingly, a rough factoring out process was initiated, using the permit history to indicate the distribution of the types of control problems. For example, in the commercial sector, 83 percent of the retail trade establishments applied for incinerator permits in the past; thus, it was assumed that this same percentage of retail trade permit applicants in the future would need control equipment for incinerators. The remaining applicants (17 percent) were assumed to incur control costs for fuel-burning equipment.

A reasonable breakdown of type of permit applied for could not be obtained within the manufacturing sector. Consequently, a control cost estimate was made directly from the raw data. Examination of the data and consideration of the lows and highs served as the procedure.

For the sources subject to New Source Performance Standards (NSPS) (see Exhibit I-1), it was assumed that the expenditures required for compliance with the nationwide program could not be attributed to permit program implementation by the

EXHIBIT I-1
NEW SOURCE PERFORMANCE STANDARDS: PROMULGATED AND PROPOSED

Industry	Affected Facilities	Pollutants	Date
Steam Generators	Fossil-fuel fired, steam-generating units with a capacity greater than 250 mm Btu per hour heat input.	Particulates Sulfur Dioxide Nitrogen Oxides	Promulgated 23 December 1971
Municipal Incinerators	Municipal incinerators of capacity greater than 50 tons per day.	Particulates	Promulgated 23 December 1971
Portland Cement Plants	Kilns, clinker coolers, raw mill system, finish mill system, raw mill dryer, raw material storage, finished product storage, conveyor transfer points, bagging and bulk loading and unloading systems.	Particulates	Promulgated 23 December 1971
Nitric Acid Plants	"Weak nitric acid" (30 to 70 percent in strength) production facilities.	Nitrogen Oxides	Promulgated 23 December 1971
Sulfuric Acid Plants	Contact-process sulfuric acid and oleum facilities.	Sulfur Dioxide Acid Mist	Promulgated 23 December 1971
Asphalt Concrete Plants	Dryers; hot aggregate elevators; screening equipment; hot aggregate storage equipment; hot aggregate weighing equipment; asphalt concrete mixing equipment; mineral filler loading, transfer, and storage equipment; loading, transfer, and storage equipment that handles dust collected by emission control system.	Particulates	Promulgated 8 May 1974
Petroleum Refineries	Fluid catalytic cracking unit catalyst regenerator.	Particulates and Carbon Monoxide	Promulgated 8 May 1974
	Fluid catalytic cracking unit incinerator-waste heat boiler.	Particulates	
	Fuel gas combustion device.	Sulfur Dioxide	
Storage Vessels for Petroleum Liquids	Storage vessels that have capacities $>$ 40,000 gal.	Hydrocarbons	Promulgated 8 May 1974
Secondary Lead Smelters and Refineries	Blast (cupola) and reverberatory furnaces, pot furnaces of more than 550 lb. charging capacity.	Particulates	Promulgated 8 May 1974
Secondary Brass or Bronze Ingot Production Plants	Reverberatory and electric furnaces ($>$2205 pounds production capacity), blast (continuous) furnaces ($>$550 lbs. capacity).	Particulates	Promulgated 8 May 1974
Iron and Steel Plants	Basic oxygen process furnaces.	Particulates	Promulgated 8 May 1974
Sewage Treatment Plants	Incinerators used to burn sludge generated in the plant.	Particulates	Promulgated 8 May 1974

EXHIBIT I-1 (Cont'd)

Industry	Affected Facilities	Pollutants	Date
Primary Copper Smelters	Dryer, roaster, smelting furnace, copper converter.	Particulates Carbon Monoxide	Proposed 16 October 1975 Promulgated January 15 1976
Primary Zinc Smelters	Roasters, sintering machine.	Particulates Sulfur Dioxide	Proposed 16 October 1974 Promulgated 15 January 1976
Primary Lead Smelters	Sintering machine discharge end, blast furnace, dross reverberatory furnace.	Particulates	Proposed 16 October 1974 Promulgated
	Sintering machine, electric smelting furnace, converter.	Sulfur Dioxide	15 January 1976
Steel Plants: Electric Arc Furnaces	Electric arc furnaces and dust-handling equipment.	Particulates	Proposed 21 October 1974 Promulgated 23 September 1974
Ferroalloy Production Facilities	Electric submerged arc furnaces which produce silicon metal, ferrosilicon, calcium silicon, silicomanganese zirconium, ferrochrome silicon, silvery iron, high-carbon ferrochrome, charge chrome, standard ferromanganese, silicomanganese, ferromanganese-silicon, or calcium carbide; and dust-handling equipment.	Particulates Carbon Monoxide	Proposed 21 October 1974
Phosphate Fertilizer Industry			Proposed 22 October 1974
Wet-Process Phosphoric Acid Plants	Reactors, filters, evaporators, and hotwells.	Fluorides	
Superphosphoric Acid Plants	Evaporators, hotwells, acid sumps, and cooling tanks.	Fluorides	
Diammonium Phosphate Plants	Reactors, granulators, dryers, coolers, screens, and mills.	Fluorides	
Triple Super-Phosphate Plants	Mixers, curing belts, reactors, granulators, dryers, coolers, screens, mills, and storage facilities.	Fluorides	
Granular Triple Super-phosphate Storage Facilities	Storage or curing piles, conveyors, elevators, screens, and mills.	Fluorides	
Primary Aluminum Plants	Potrooms, anode bake plants in reduction plant.	Particulates and Fluorides	Proposed 23 October 1974
Coal Preparation Plants	Thermal dryers, pneumatic coal-cleaning equipment, coal processing and conveying equipment, screening equipment, coal storage and coal transfer points, and coal loading facilities.	Particulates	Proposed 24 October 1974

Connecticut DEP. Upon determination that BACT required expenditures over and above NSPS, however, the incremental costs were attributed to the permit program. In the case of electric utilities, installation of flue gas desulfurization equipment would be required under BACT, but not NSPS.[1] Consequently, the cost of scrubbers was attributed to the permit program.[2] With regard to sewage sludge incineration and asphalt batching, no clear-cut evidence of the need for control expenditures beyond NSPS was found. In both cases, however, a minimal expenditure of $1,000 to $3,000 was attributed to the permit program to provide some margin of safety to accommodate advances in technology. The other sources subject to NSPS are aggregated with sources not subject to NSPS so that an industry-wide, permit-related control cost was assumed to apply.

Because of the problems in estimating control costs for compliance with permit requirements, the cost ranges cannot be considered representative of any individual establishment. Instead, they should be considered a "best guess" as to the order of magnitude of costs likely to be incurred by each of the source groupings.

B. Raw Data Pertaining to Pollution Control Cost Estimates

The data used in developing estimates of pollution control costs by SIC are shown below under their respective sources. For each source, applicable material is paraphrased and tables and charts are included. In presenting these sources, no attempt has been made to reconcile conflicts or to interpret the raw data.

1. J. Booth. "Control of Industrial Boiler Emissions," in *POWER*, August 1975.

   - For a given gas throughput, a wet scrubber will cost 25 percent more than a two-stage cyclonic separation system, while fabric filters and precipitators will cost five times that of cyclones. With regard to operating costs, precipitators are cheaper by a factor of five than scrubbers and by a factor of 10 than industrial fabric filters (pp. 55-58).

2. *The Economics of Clean Air.* Annual Report of the Administrator of the Environmental Protection Agency to the Congress of the United States, March 1972.

   - Small incinerators, such as in an apartment building, require about $1,115 per ton of daily capacity in capital investment and $295 per ton of daily capacity for annual operating costs (pp. 4-6).

   - The range of control costs incurred by small, medium, and large asphalt batching plants is from $23,000 in capital investment and $7,000 in annual operating costs

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[1] EPA and FEA, *An Analysis of the Impact on the Electric Utility Industry of Alternative Approaches to Significant Deterioration,* October 1975.

[2] EPA is currently considering more stringent provisions of the NSPS for electric utilities. (Interview with Barbara Brown, Office of Air and Waste Management, U.S. Environmental Protection Agency, January 1976.) In the future, therefore, scrubbers may be required under NSPS.

to $94,000 in capital investment and $18,000 in annual operating costs (pp. 4-33).

- Very small iron foundries (with a value of shipments less than $500,000) would incur control costs of $14.60 per ton, while very large iron foundries (with value of shipments over $10 million) would incur control costs of $2.60 per ton (pp. 4-67).

- A steel plant with total annual capacity of nine million tons and production of 6.4 million tons of finished steel per year in 1970 (one third from basic oxygen furnaces and two thirds from open hearth furnaces) would incur estimated costs as follows: total investment, $30 million; total annual cost, $9.8 million; annual cost per ton of raw steel, $1.30; and annual cost per ton of finished steel, $1.53. Estimated costs for a small firm having an annual capacity of 2.24 million tons and production of 1.58 million tons of finished steel, entirely from open hearth furnaces, involve an investment requirement of $8.4 million and a total annual cost of $2.9 million, or $1.83 per ton of finished steel. Similarly, a small firm producing 1.7 million tons of finished steel in 1967 with a capacity of 2.3 million tons, using only basic oxygen and electric arc furnaces, would have an estimated investment of $7.0 million and an annual cost of $3.5 million, or $2.03 per ton of finished steel. For this firm, the high cost per ton of finished steel results from the use of 19 small electric furnaces (pp. 4-76).

- Control costs for secondary nonferrous metals range from $0.21 per short ton for lead to $0.59 per short ton for zinc (pp. 4-156).

3. Bill Judge, Air Equipment Company (subsidiary of Duall Industries). 3 December 1975. Telephone Interview.

   - On a very rough basis, estimated foundry control costs are about $100,000 and estimated metal working control costs are about $50,000 for New England manufacturers.

   - Metal working firms are going to several small package collector systems, each of which covers two or three machines. This provides flexibility for relocation of production lines and so forth. At about 50,000 CFM (cubic foot per meter), economics usually dictate use of a single collector.

4. Beinkerhoff, Ronald J., "Inventory of Intermediate-Size Incinerators in the United States – 1972." *Pollution Engineering*, November 1973, pp. 33-38.

   - The average incinerator unit size in EPA, Region I is 207 lb/hr. The average unit size by class of purchaser is as follows:

Commercial	267 lb/hr
Industrial	297 lb/hr
Medical	242 lb/hr
High Rise	126 lb/hr
Schools	183 lb/hr

5. Leung, Kenneth Ch'uan-k'ai, and Jeffrey A. Klein, *The Environmental Control Industry. An Analysis of Conditions and Prospects for the Pollution Control Equipment Industry.* Submitted to the Council on Environmental Quality, December 1975.

- *Selected Characteristics of Particulate Removal Devices (p. 33)*

Device	Particle Size (microns)	Rate (%)	Cost per CFM*
Electrostatic Precipitators	0.005	96 - 99	$4.00 - $4.50
Fabric Filters	0.005	98 - 99	$1.25 - $2.00
Wet Scrubbers	.010 - 1.000	70 - 99	$5.00 - $7.00
Mechanical Collectors	5.000	50 - 90	$2.50

*CFM equals cubic foot per meter of gas flow.

- *Selected Sulfur Removal Systems (p. 48)*

		Costs per	
Process Throwaway	Size (Kw)	Investment Kw	Operating Kwh
Limestone Scrubbing	115,000	$57 - Retro	2.2 mills
	820,000	$43 - New	N.A.
Lime Scrubbing	410,000	$84 - Retro	5.8 mills
	65,000	$57 - Retro	2.5 mills
Recovery			
Magnesium Oxide Scrubbing	100,000	$70 - Retro	N.A.
Catalytic Oxidation	110,000	$73 - Retro	4.0 mills
Wellman Lord	115,000	N.A. - Retro	N.A.

6. *Control Techniques for Particulate Air Pollutants.* U.S. Department of Health, Education, and Welfare; Public Health Service; Consumer Protection and Environmental Health Service, January 1969.

- For computing costs for a given system, one should consider (i) raw materials and fuels used in the process, (ii) alterations in process equipment, (iii) control hardware and auxiliary equipment, and (iv) disposal of collected emissions (p. 6-5).

- Efficiency of control equipment will vary with particle characteristics (wetability, density, shape, size distribution, etc.) (p. 6-9).

- Maintenance and operation costs are difficult to assess as individual firms may not break out these costs but rather include them in total operating costs.

- *Conditions Affecting Installed Cost of Control Devices (p. 6-17)*

Cost Category	Low Cost	High Cost
Equipment Transportation	Minimum distance; simple loading and unloading procedures	Long distance; complex procedure for loading and unloading
Plant Age	Hardware designed as an integral part of new plant	Hardware installed into confines of old plant requiring structural or process modification or alteration
Available Space	Vacant area for location of control system	Little vacant space requires extensive steel support construction and site preparation
Corrosiveness of Gas	Noncorrosive gas	Acidic emissions requiring high alloy accessory equipment using special handling and construction techniques
Complexity of Startup	Simple startup, no extensive adjustment required	Requires extensive adjustments; testing; considerable downtime
Instrumentation	Little required	Complex instrumentation required to assure reliability of control or constant monitoring of gas stream
Guarantee on Performance	None needed	Required to assure designed control efficiency
Degree of Assembly	Control hardware shipped completely assembled	Control hardware to be assembled and erected in the field
Degree of Engineering Design	Autonomous "package" control system	Control system requiring extensive integration into process, insulation to correct temperature problem, noise abatement
Utilities	Electricity, water, waste disposal facilities readily available	Electrical and waste treatment facilities must be expanded, water supply must be developed or expanded
Collected Waste Material Handling	No special treatment facilities or handling required	Special treatment facilities and/or handling required
Labor	Low wages in geographical area	Overtime and/or high wages in geographical area

- *Total Installation Cost for Various Types of Control Devices Expressed as a Percentage of Purchase Costs (p. 6-16)*

Equipment Type	Cost, Percent			
	Low	Typical	High	Extreme High
Gravitational	33	67	100	–
Dry Centrifugal	35	50	100	400
Wet Collector:				
Low, Medium Energy	50	100	200	400
High Energy*	100	200	400	500
Electrostatic Precipitators	40	70	100	400
Fabric Filters	50	75	100	400
Afterburners	10	25	100	400

*High-energy wet collectors usually require more expensive fans and motors.

7. *Background Information for Proposed New-Source Performance Standards.* EPA No. APTD-0711.

- Control of particulate matter in steam generating plants may increase capital investment requirements by 6 percent and operating costs by 4 percent (p. 15).

- Control of sulfur dioxide by steam generating plants may increase capital investment by 10 percent and operating costs by 7 percent to 30 percent (p. 16).

- Nitrogen oxide control will cause increase of up to 7 percent in capital investment and increases near 4 percent in operating costs (p. 16).

- Capital investment required for control of particulate, SO_2 and NO_x emissions of steam-electric generating plants will generally be less than 25 percent of the total installed cost of the plant. Plants burning gaseous fuels (requiring control of NO_x only) will experience only a 5 percent increase in installed cost (p. 15).

- Operating costs for solid- and liquid-fuel generating units will increase by 15 percent to 40 percent with emission controls, while plants using gaseous fuels will increase their operating costs by only 4 percent.

- Installed costs for a 100 ton-per-day refractory furnace are about $1 million for the incinerator, including about $150,000 for high-efficiency control equipment. Installed costs of control equipment are therefore about 15 percent of the entire plant costs. For plants with a capacity of 300 tons per day, costs decrease to 13 percent of the incinerator cost (p. 24).

- For a 100-ton-per-day water wall furnace, incinerator costs are about $1.5 million installed, including about $105,000 for the cost of high-efficiency control equipment. Control equipment costs are therefore about 9 percent of installed costs for the 100-ton-per-day plant. This decreases to about 5 percent for a 300-ton-per-day plant (p. 24).

8. *Background Information for Proposed New Source Performance Standards,* Volume 1, Main Text. EPA No. APTD-1352a.

- *Control Costs for Typical Asphalt Concrete Plants**

Plant Size, Tons/Hour (acfm)	Emission Standard	Required Control Equipment	Control Investment ($)	Annual Cost ($/year)	Annual Cost per Unit of Production ($/ton)
150 (25,000)	Proposed performance standard = 0.031 gr/dscf	Fabric filter	63,000	18,000	0.16
		Venturi scrubber	56,000	21,000	0.19
	Reference process weight standard = 0.30 gr/dscf	Low-energy scrubber	44,000	16,000	0.14
300 (50,000)	Proposed performance standard = 0.031 gr/dscf	Fabric filter	92,000	26,000	0.12
		Venturi scrubber	95,000	36,000	0.16
	Reference process weight standard = 0.18 gr/dscf	Low-energy scrubber	75,000	27,000	0.12

*Model plant assumptions: (1) 1500 hours on-stream annually, (2) production averages 50 percent of capacity, (3) 10-year straight-line depreciation, (4) 50 percent of retained fines, valued at $9/ton, recycled, and (5) average product price of $6/ton.

- *Control Costs of Meeting Performance Standard (0.022 gr/dscf) for Typical Secondary Lead Plants* (p. 42)*

Plant Type	Required Control Equipment	Control Investment (S)	Annual Cost (S/year)	Annual Cost per Unit of Production (S/ton)
Blast furnace, 50 tons/ day	Afterburner, U-tube cooler, fabric filter	157,000	51,000	4.05
	Afterburner, water quench, venturi scrubber	123,000	80,000	6.40
Reverberatory Furnace, 50 tons/day	U-tube cooler, fabric filter	188,000	21,000	1.65
	Water quench, venturi scrubber	125,000	36,000	2.86

*Major assumptions: (1) production rate, 4,000 lb/hr; (2) annual production, 12,500 tons; (3) recoverable dust is recycled at a value of 2.25 cents/lb. except for reverberatory dust recovered from fabric filters at value of 4.5 cents/lb; (4) fabric filter systems depreciated straight-line, 15-year life; (5) venturi scrubber systems depreciated straight-line, 10-year life; and (6) estimated average product price $320/ton.

- *Control Costs of Meeting Performance Standard (0.022 gr/dscf) for Reverberatory Furnaces (p. 48)*

Furnace Capacity, Tons/Day	Investment (S)	Annual Cost (S)	Annual Cost per Ton of Product (S)
20	74,000	13,000	6.52
50	110,000	20,070	4.01
75	130,000	34,300	3.24

- *Control Costs of Meeting Performance Standard (0.022 gr/dscf) for Typical New Two-Vessel Basic Oxygen Process Furnaces* (p. 55)*

Plant Size (tons/melt)	Required Control Equipment	Control Investment ($)	Annual Cost ($/yr)	Annual Cost per Unit of Production ($/ton)
140	Open hood, scrubber	5,700,000	1,950,000	1.52
	Open hood, ESP**	5,900,000	1,500,000	1.17
	Closed hood, scrubber	6,800,000	2,140,000	1.67
250	Open hood, scrubber	7,400,000	2,750,000	1.20
	Open hood, ESP	8,000,000	2,000,000	0.89
	Closed hood, scrubber	8,400,000	2,800,000	1.22

*Major assumptions: (1) production of 140 tons/melt = 2,300,000 tons/yr; (2) 18-year straight-line depreciation.

**ESP-electrostatic precipitator.

- *Control Costs of Typical Sewage Sludge Incinerator* (p. 61)*

Plant Size, Tons/Day (cfm)	Emission Standard	Required Control Equipment	Control Investment ($)	Annual Cost ($/year)	Annual Cost per Person ($)
10 (10,000)	Performance standard = 0.031 gr/dscf	Low-energy venturi scrubber	60,000	11,700	0.12
	Typical local standard = 0.10 gr/dscf	Low-energy impingement scrubber	55,000	8,400	0.08
100 (17,800)	Performance standard = 0.031 gr/dscf	Low-energy venturi scrubber	132,000	34,200	0.03
	Typical local standard = 0.10 gr/dscf	Low-energy impingement scrubber	120,000	21,100	0.02

*Model plant assumptions: (1) 10 tons/day – 3640 hours of operation per year, 100 tons/day – 8736 hours of operation per year; (2) sinking fund depreciation over 12.5 years; and (3) interest at 6 percent.

9. *Implications of Alternative Policies for the Use of Permanent Controls and Supplemental Control Systems (SCS).* EPA Office of Planning and Evaluation, 7 July 1975.

   - Capital cost for adding a scrubber to existing plants is $90 per KW; operating and maintenance cost on existing plants will increase by $.18 per million Btu with the addition of a scrubber (p. 8).

   - Addition of a scrubber to plans for a new plant will increase the capital cost by $65 per KW; addition of a scrubber will increase operating and maintenance costs in a new plant by $.11 per million Btu (p. 8).

10. Perl, Lewis J., and Joe D. Pace, *The Costs of Reducing SO_2 Emissions from Electric Generating Plants,* a report to Electric Utility Industry Clean Air Coordinating Committee by National Economic Research Associates, Inc., June 1975.

    - Clean Air Coordinating Committee (CACC) survey of utilities indicated that estimated capital costs of scrubbers for new electric generating plants averaged $60 per kilowatt in 1974 dollars. A Pedco, Inc., study reported similar estimates (p. 24).

    - CACC survey indicated an estimated cost averaging $80 per kilowatt for installing scrubbers in existing plants. This estimate is $15 per kilowatt higher than reported by the Pedco, Inc., survey which, admittedly, may not represent "a 'typical' retrofit situation" (p. 24).

    - Both of these surveys exclude the cost of precipitators. Both assume that 100 percent of the flue gas is to be scrubbed whereas in some cases partial scrubbing may be adequate.

    - Energy required to operate scrubbing equipment would average 2 percent of the electricity generated by unit being scrubbed (p. 24).

    - Two percent of the fuel otherwise used to generate electricity would be consumed in reheat (necessary in order to achieve appropriate plume height). If less than half the gas is scrubbed, scrubbed and unscrubbed gases may be mixed, eliminating the need for reheat (p. 25).

    - Labor and materials costs for scrubbers average about 1.4 mills per kilowatt-hour scrubbed in 1974 dollars.

APPENDIX J
LIST OF INTERVIEWS

TELEPHONE INTERVIEWS WITH MANUFACTURING FIRMS

Sterling Alexiadis, Comptroller and Treasurer, Bic Pen Corporation, Milford, 203/878-6861, 31 October 1975.

Charles B. Allen, Manager of Financial Analysis, Anaconda American Brass Co., Waterbury, 203/757-2021, 30 October 1975.

Fred Anderson, Plant Engineer, Nash Engineering Co., South Norwalk, 203/853-3900, 18 November 1975.

J. Paul Beliveau, Plant Manager, Bridgeport Brass Co., Bridgeport, 203/366-6182, 19 November 1975.

Roy Bergstrom, President, Commercial Foundry Co., New Britain, 203/224-1794, 31 October 1975.

Helen Bolinger, Public Relations Department, American Can Corp., Greenwich, 203/552-2000, 19 November 1975.

James Brown, Corporate Purchasing Agent, Armstrong Rubber Co., New Haven, 203/562-1161, 18 November 1975.

Mr. Brunyansky, Manager of Plant Engineering, Avco Corporation, Bridgeport, 203/378-8211, 18 November 1975.

Don Buska, Plant Manager, Hitchiner Manufacturing Co., Inc., Wallingford, 203/265-2331, 30 October 1975.

Doug Button, Environmental Engineer, Scoville Manufacturing Co., Waterbury, 203/757-6061, 17 November 1975.

J. W. Caldwell, Manager of Industrial Engineering, Dresser Industries, Inc., Stratford, 203/378-8281, 31 October 1975.

Mr. Calmyca, Plant Superintendent, Napier Co., Meriden, 203/237-5522, 30 October 1975.

Richard Cannon, Public Relations, Olin Mathieson-Winchester Division, New Haven, 203/777-7911, 20 November 1975.

Charles Dayton, Director of Public Relations, Perkin-Elmer Corporation, Norwalk, 203/762-1000, 18 November 1975.

Mr. DeMaria, Plant Engineer and Real Estate Coordinator, Superior Electric Co., Bristol, 203/582-9561, 21 November 1975.

Chester J. Deutsch, Senior Vice President of Finance, Arnold Bakers, Inc., Greenwich, 203/661-2770, 20 November 1975.

Frank Donovan, Connecticut Relations, General Electric Co., Fairfield, 203/373-2211, 28 October 1975.

Thomas Edwards, Manager of Communications, General Electric Co., Bridgeport, 203/334-1012, 31 October 1975.

John Erickson, Plant Engineer, Electrolux Corporation, Old Greenwich, 203/637-1761, 20 November 1975.

Mr. Favro, Director of Employee Relations, Gedney Electric Co., Inc., Bristol, 203/584-0571, 20 November 1975.

Mr. Fletcher, Engineer, Textron, Inc., Fafnir Bearing Division, New Britain, 203/225-5151, 21 November 1975.

Florian Galdau, Manager of Manufacturing and Engineering, Ferite Co., Seymour, 203/888-2591, 17 November 1975.

Mr. Gerky, Personnel Manager, Bunker-Ramo Corporation, Amphenol R.F. Division, Danbury, 203/743-9272, 20 November 1975.

Robert M. Gordon, President, Raybestos-Manhattan, Inc., Bridgeport, 203/371-0101, 11 November 1975.

Frank Gosselin, Plant Controller, Ferro Corporation, Norwalk, 203/853-2123, 30 October 1975.

Harland Graime, Chief Engineer, Acme Screw and Fastenings Co., Bristol, 203/583-0200, 28 October 1975.

Alfred B. Gunthel, President, Dossert Manufacturing Corporation, Waterbury, 203/757-8761, 28 October 1975.

Mr. Hagstrom, Plant Manager, New Departure Co., Bristol, 203/582-6371, 20 November 1975.

Carl Hamberg, Head of Industrial Engineering, Marlin-Rockwell, Division of Thompson-Ramo-Wooldridge, Inc., New Britain, 203/747-2771, 19 November 1975.

Arnold Haydn, Chief Engineer, Carpenter Technology Corporation, Bridgeport, 203/335-0121, 28 October 1975.

Michael J. Hutnik, Chief Plant Engineer, International Silver, Meriden, 203/634-2500, 28 October 1975.

Arnold Keppell, Plant Manager, Automotive Controls Corporation, Branford, 203/481-0341, 20 November 1975.

Mr. Klein, Manager of Environmental Programs, Combustion Engineering, Inc., Hartford, 203/688-1911, 17 November 1975.

Mr. Kochman, Comptroller, Acme Screw and Fastenings Co., Richfield, New Jersey, 201/941-1050, 28 October 1975.

George Krize, Plant Engineer, Burndy Corporation, Norwalk, 203/838-4444, 20 November 1975.

Tom Latham, Supervisor, Wallingford Steel Co., Wallingford, 203/269-3361, 11 November 1975.

Mr. Lemar, Director of Communications and Services, Avco Corporation, Bridgeport, 203/378-8211, 18 November 1975.

Jack Martin, Plant Facilities Engineer, Sargent and Co., New Haven, 203/562-2151.

Ed McDonough, Assistant Secretary, Electrolux Corporation, Stamford, 203/359-3600, 20 November 1975.

Thomas McGary, Public Relations, Pitney-Bowes, Inc., Stamford, 203/356-5000, 20 November 1975.

Robert McLalland, Manager of Employee-Community Relations, General Electric Co., Plainville, 203/747-1671, 28 October 1975.

Mr. Meoni, Vice President of Finance, Napier Co., Meriden, 203/237-5522, 30 October 1975.

Malcolm Millar, Manager of Manufacturing Services, Colt Industries, Inc., Firearms Division, Hartford, 203/278-8550, 17 November 1975.

Neil Morrison, Vice President and General Manager, Farrell Co., Ansonia, 203/734-3331, 17 November 1975.

Mr. O'Dell, Vice President of Manufacturing, Standard-Knapp Division of Emhart Corporation, Middletown, 203/342-1100, 18 November 1975.

Mr. Ottavio, Plant Manager, Barden Corporation, Danbury, 203/744-2211, 20 November 1975.

Mr. Pelton, Purchasing Agent, Kimberly-Clark Corporation, Danbury, 203/354-4481, 20 November 1975.

Mr. Pfeffer, Comptroller, National Plastics and Plating Supply Co., Inc., Plymouth, 203/589-7800, 28 October 1975.

T.H. Rosfelder, Regional Engineer, Sun Oil Co., Bridgeport, 203/239-4441, 31 October 1975.

Richard Rubenstein, Vice President, Wiltshire Industries, Waterville, 203/756-7877, 30 October 1975.

Mr. Rupinski, Manager of Planning, Combustion Engineering, Inc., Hartford, 203/688-1911, 17 November 1975.

Dick Ryan, Plant Engineer, Hamilton Standard Division of United Aircraft Corporation, Hartford, 203/623-1621, 21 November 1975.

Ken Ryder, Plant Engineer, Eyelet Specialty Co., Division of Insilco Corporation, Wallingford, 203/269-3381, 18 November 1975.

Mr. Schiffer, North American Director of Industrial Relations, Timex Industries, Waterbury, 203/758-1911.

David Sidney, Comptroller, American Fabrics Co., Bridgeport, 203/335-2151, 30 October 1975.

William Stieg, Engineer, Pfizer, Inc., Chemical Division, Groton, 203/445-5611, 3 November 1975.

Mr. Stoloff, Plant Manager, Veeder-Root Co., Division of Veeder Industries, Inc., Hartford, 203/527-7201, 30 October 1975.

Eric Storch, Environmental Engineer, Uniroyal, Inc., Naugatuck Chemical Division, Naugatuck, 203/723-3419, 31 October 1975.

Allan Swift, President, M. Swift & Sons, Inc., Hartford, 203/522-1181, 30 October 1975.

Robert Tolles, Director of Plant Engineering Services, Stanley Works, New Britain, 203/225-5111, 28 October 1975.

Wayne Tyson, Manager of Community Relations, Clairol, Inc., Stamford, 203/357-5000, 18 November 1975.

Mr. Wagner, Manager of Facilities, General Electric Credit Corporation, Stamford, 203/357-4000, 31 October 1975.

Thomas Walk, Purchasing Agent, Hull Dyer and Print Works, Inc., Ansonia, 203/734-1654, 17 November 1975.

Mr. Walker, Environmental Engineer, Wallingford Steel Co., Wallingford, 203/269-3361, 11 November 1975.

Mr. Wegner, Director of Operations, United Technology, East Hartford, 203/728-7000.

H.R. Werley, Director of Engineering, Pepperidge Farms, Inc., Norwalk, 203/847-0456, 20 November 1975.

TELEPHONE INTERVIEWS WITH PUBLIC AND PRIVATE AGENCIES AND GROUPS

Harold Ames, Dept. of Planning and Energy Policy, Hartford, Personal Interview, 4 November 1975.

Mr. Andrews, Director, South Central RPA, New Haven, 203/777-4795, 24 November 1975.

Jerome Barr, McDave Oil Burner Company, New York City, 212/384-0270, 4 November 1975.

Mrs. Bernt, Fairfield School Board, 203/255-0421, 19 November 1975.

Peggy Brown, Southwestern RPA, 203/866-5543, 21 November 1975.

George W. Bruno, Senior Market Analyst, Dept. of Commerce, Hartford, 203/566-4587, Personal Interview, 5 November 1975.

Ed Butler, Economist, Office of Planning and Energy Policy, Hartford, 203/566-5803, 18 November 1975, Personal Interview, 4 November 1975.

Mr. Cashman, Bureau of Grants Management and Information, Dept. of Education, Hartford, 203/566-4897, 22 October 1975.

Mr. Cerelle, Waterbury School Board, 203/757-1191, 19 November 1975.

Richard Chase, President, Resource Recovery Authority, 203/549-6390, 12 November 1975, 25 November 1975.

Connecticut Development Authority, 203/566-4320, 27 October 1975.

Tom Cooney, Regional Planner, Central Connecticut RPA, Bristol, 203/224-9888, 21 November 1975.

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Mr. Tippin, Technical Emission Advisor, New York City, EPA, 212/566-2717, 3 November 1975.

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APPENDIX K
LOCATION QUOTIENTS

APPLICATION AND LIMITATIONS OF LOCATION QUOTIENTS

Location quotients (LQ's) have been used as an indication of Connecticut's relative attractiveness to and growth potential for specific industry sectors (both manufacturing and non-manufacturing). The LQ calculation involves dividing the proportion of earnings or employment attributable to an industry within the region by the proportion of national earnings or employment accounted for by that industry.[1] A result greater than 1.0 represents relatively greater activity of the industry within the region. This, in turn, can be deemed an indication of two factors: the region's relative locational advantages for the industry and, if demand can be assumed to be uniform throughout the nation, the degree of the industry's regional export specialization. Export industries are generally considered to have greater growth potential in that they can expand faster than the overall regional economy. Consequently, the LQ can aid in differentiation between industries which are relatively "footloose" with respect to location and those which are more strongly tied to location in a region and can roughly indicate industry's growth potential within a region.

It is important to note the assumptions implicit in application of the LQ for these purposes. In addition to the assumption that demand for an industry's product or services is evenly distributed, the LQ approach also:

- Assumes no major differences in productivity throughout the nation.
- Assumes no factors such as brand loyalty affect demand for generic products.
- Assumes a single nationwide production function for the industry at whatever level of detail (that is, SIC) is used.

As a result of these assumptions, the numerical LQ can be quite sensitive to the level of specificity used in industry and product categorization. Furthermore, as statistical technique it is more reliable in evaluation of large economic areas. In general, LQ's are considered to yield a low estimate of export specialization.

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[1] $$\text{Location Quotient} = \frac{\text{Area industry as a \% of total area earnings or employment}}{\text{U.S. industry as a \% of total U.S. earnings or employment}}$$

This is equivalent to the following formula:

$$\text{Location Quotient} = \frac{X_{ij}}{X_{oj}} \bullet \frac{X_{oo}}{X_{io}}$$

where X = measure of economic activity usually earnings or employment
i = ith industry
j = jth region
o = summation. In the left position, it is an industrial summation; in the right position, it is an area summation.

In determining LQ's for Connecticut industries, employment was used as a measure of economic activity. Comparable employment estimates by two-, three-, and in some cases, four-digit SIC's for the U.S. and Connecticut, were obtained from *County Business Patterns, 1972.* The results are summarized in Exhibit K-1 for those industries with LQ's greater than or equal to 1.0.

EXHIBIT K-1
CONNECTICUT LOCATION QUOTIENTS
GREATER THAN ONE

SIC		LQ
176	Roofing and Sheet Metal Work	1.05
179	Miscellaneous Special Trade Contractors	1.02
1799	Special Trade Contractors, n.e.c.	1.12
19	Ordnance and Accessories	2.00
205	Bakery Products	1.27
226	Dyeing and Finishing Textiles, Except Wool and Knit Goods	1.77
228	Yarn and Thread Mills	1.34
229	Miscellaneous Textile Goods	2.84
265	Paperboard Containers and Boxes	1.11
27	Printing, Publishing, and Allied Industries	1.06
271	Newspapers: Publishing, Publishing and Printing	1.12
275	Commercial Printing	1.04
283	Drugs	1.55
284	Soap, Detergents, and Cleaning Preparations; Perfumes, Cosmetics and Other Toilet Preparations	1.90
30	Rubber and Miscellaneous Plastics Products	1.60
306	Fabricated Rubber Products, n.e.c.	1.93
307	Miscellaneous Plastics Products	1.27
329	Abrasive, Asbestos, and Miscellaneous Nonmetallic Mineral Products	1.57
33	Primary Metal Industries	1.13
335	Rolling, Drawing, and Extruding of Nonferrous Metals	4.37
3357	Drawing and Insulating of Nonferrous Wire	3.83
34	Fabricated Metal Products	1.87
342	Cutlery, Hand Tools, and General Hardware	5.08
345	Screw Machine Products and Bolts, Nuts, Screws, Rivets, and Washers	3.64
3451	Screw Machine Products	4.72
346	Metal Forgings and Stampings	1.39
347	Coating, Engraving, and Allied Services	1.94
348	Ordnance and Accessories, Except Vehicles and Guided Missiles	2.98
349	Miscellaneous Fabricated Metal Products	1.77

EXHIBIT K-1 (Cont'd)

SIC		LQ
35	Machinery, Except Electrical	1.82
354	Metalworking Machinery and Equipment	3.16
355	Special Industry Machinery, Except Metalworking Machinery	1.47
3559	Special Industry Machinery, n.e.c.	2.90
356	General Industrial Machinery and Equipment	4.53
3561	Pumps and Pumping Equipment	1.88
3562	Ball and Roller Bearings	13.87
357	Office, Computing, and Accounting Machines	2.27
3579	Office Machines, n.e.c.	12.06
359	Miscellaneous Machinery, Except Electrical	1.64
36	Electrical and Electronic Machinery, Equipment and Supplies	1.36
361	Electric Transmission and Distribution Equipment	1.61
3613	Switchgear and Switchboard Apparatus	2.93
363	Household Appliances	1.78
364	Electric Lighting and Wiring Equipment	2.77
366	Communications Equipment	1.19
3662	Radio and Television Transmitting, Signalling and Detection Equipment and Apparatus	1.59
367	Electronic Components and Accessories	1.49
3679	Electronic Components, n.e.c.	2.05
37	Transportation Equipment	2.49
372	Aircraft and Parts	6.72
3722	Aircraft Engines and Engine Parts	18.9
38	Measuring, Analyzing, and Controlling Instruments; Photographic, Medical, and Optical Goods; Watches and Clocks	2.63
382	Measuring and Controlling Instruments	2.97
383	Optical Instruments and Lenses	8.86
384	Surgical, Medical, and Dental Instruments and Supplies	2.62
387	Watches, Clocks, Clockwork-Operated Devices and Parts	9.16
3871	Watches and Clocks	10.18
39	Miscellaneous Manufacturing Industries	1.83
391	Jewelry, Silverware, and Plated Wire	3.24
3914	Silverware, Plated Ware, and Stainless Steel Ware	12.84
395	Pens, Pencils, and Other Office and Artist's Materials	3.93
396	Costume Jewelry, Costume Novelties, Buttons, and Miscellaneous Notions, Except Precious Metal	5.22
3964	Needles, Pins, Hooks and Eyes, and Similar Notions	9.42
41	Local and Suburban Transit and Interurban Highway Passenger Transportation	1.12
415	School Buses	3.34

EXHIBIT K-1 (Cont'd)

SIC		LQ
493	Combination Electric and Gas; Other Utility Services	1.62
5029	Chemicals and Allied Products, n.e.c.	1.05
5047	Meats and Meat Products	1.13
506	Wholesale Trade-Electrical Goods	1.03
5063	Wholesale Trade-Electrical Apparatus and Equipment; Wiring Supplies and Construction Materials	1.35
5095	Beer, Wine, and Distilled Beverages	1.15
5096	Paper and Its Products	1.00
533	Retail Trade-General Merchandise	1.04
54	Retail Trade-Food Stores	1.06
541	Grocery Stores	1.03
546	Retail Bakeries	1.41
56	Retail Trade-Apparel and Accessory Stores	1.03
565	Retail Trade-Family Clothing Stores	1.10
592	Liquor Stores	1.04
598	Fuel and Ice Dealers	2.09
5983	Fuel Oil Dealers	3.58
603	Mutual Savings Banks	6.04
63	Insurance	2.11
631	Life Insurance	2.17
633	Fire, Marine, and Casualty Insurance	2.54
66	Combinations of Real Estate	1.40
702	Rooming and Boarding Houses	1.04
734	Services to Dwellings and Other Buildings	1.08
7349	Cleaning and Maintenance Services to Dwellings and Other Buildings, n.e.c.	1.24
739	Miscellaneous Business Services	1.02
7392	Management Consulting and Public Relations Services	1.11
7393	Detective Agencies and Protective Services	1.21
7398	Temporary Help Supply Service	1.32
81	Legal Services	1.08
82	Educational Services	1.50
84	Museums, Art Galleries, Botanical and Zoological Gardens	1.74

Source: Harbridge House, Inc. (Based on *County Business Patterns, 1972.*)

APPENDIX L
BENEFITS OF IMPROVED AIR QUALITY

BENEFITS OF IMPROVED AIR QUALITY

Particulate matter and sulfur oxides have numerous effects on human health and behavior, property, and the environment as summarized in Exhibit L-1. Normally, these effects have some economic values or costs which represent beneficial gains from reducing or stemming growth in pollution. Nevertheless, quantification of such benefits associated with the strategies under consideration is constrained primarily by three factors. First, there is substantial difficulty in estimating the incremental benefits accruing to the individual strategies in the context of the wide range of pollution abatement measures and technological innovations. Second, valuation of qualitative attributes of reduced pollution levels, such as improved aesthetics and health, are subject to only rough estimates based on those aspects of the benefits that have measurable monetary values (for example, salaries foregone as a result of illness or premature death). Finally, the interaction of pollutants, individually and synergistically, in the environment can significantly affect the degree of impact that is experienced. Despite these limitations, several efforts have been aimed at determining the order of magnitude of the benefits associated with reductions in air pollution (or conversely the costs of incremental pollution of the air). These studies are summarized below.

A. Human Health

There are two major published studies on the health costs associated with air pollution.[1] Both use the same general method of estimating costs: first, estimating the total dollar value associated with health losses in diseases linked to air pollution and second, multiplying by a coefficient determined to represent the share of this value attributable to air pollution. Different estimates of the costs result from consideration of different diseases, inclusion of different types of costs associated with morbidity and mortality, alternate valuations of the costs, and different estimates of coefficients relating air pollution to health costs. However, the major drawback of these and other studies is that they assume a linear relationship between air pollution and health even though it is not possible to relate health costs to levels of pollution or to sources of pollution.[2]

A comparison of the two studies is shown in Exhibit L-2. Based on evaluation of diseases of the respiratory system Ridker estimated that the damage to health from air pollution in 1958 had an economic value of $360 to $400 million, or 18 to 20 percent of the costs of respiratory diseases associated with air pollution. The Lave-Seskin study included heart disease and several types of cancer in its 1963 estimates of $2.08 million in savings that would result from a 50 percent reduction in pollution. Neither study approached the cost estimates by pollutant.

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[1]Ridker, Ronald G.; *Economic Costs of Air Pollution;* New York, Frederick A. Praeger, 1967; and L.B. Lave and E.P. Seskin, "Air Pollution and Human Health," *Science* 169 (3947) August 21, 1970, as reported in *Cost of Air Pollution Damage: A Status Report,* U.S. Environmental Protection Agency. (AP-85), February 1973.

[2]Barrett, Larry B., and Thomas E. Waddell, National Environmental Research Center, *Cost of Air Pollution Damage: A Status Report,* for U.S. Environmental Protection Agency, Publication AP-85 (February 1973).

EXHIBIT L-1
EFFECTS OF PARTICULATE MATTER AND SULFUR OXIDES

Particulate Matter: Particulate matter can be either solid or liquid aerosols suspended in the atmosphere, including substances such as smoke, dusts, fumes, and mists. Atmospheric particles can affect the climate, damage and soil materials, and endanger human health.

- By scattering and absorbing sunlight as well as by attenuating the light from objects and illuminating the air (thereby reducing visual contrast) particulate matter cuts visibility. Reduced visibility is not only aesthetically undesirable, it is also dangerous for aircraft and motor vehicles.

- Reduction of sunlight in cities is strongly correlated with particulate emissions. In general, cities receive 15 to 20 percent less solar radiation than rural areas; the reduction in sunlight can be as high as one third in the summer and two thirds in the winter. Also, particles, with their affinity for water vapor, have caused increased rainfall in some industrial cities.

- The effects of particulate matter on materials include corrosion of metals when the air is humid; corrosion and damage of electrical equipment; erosion and soiling of buildings, sculpture, and painted surfaces; and soiling of clothing and draperies.

- Toxic effects of particulates on the respiratory system of animals and humans result from the particles' intrinsic toxicity caused by its chemical or physical properties. Many studies have been carried out which show increased mortality and illness accompanying higher levels of particulate matter.

Sulfur Oxides: in the atmosphere sulfur oxides go through a series of complicated chemical reactions. One of the most common reactions is conversion to sulfuric acid in the presence of moisture. If there are hydrocarbons and nitrogen oxides in the atmosphere, an aerosol made of sulfur particles will be formed. Numerous other reactions are possible depending on the type of sulfur oxide and the constituents of the atmosphere.

- Damage from sulfur oxide emissions affects materials, vegetation, and health. The effect on materials and property is largely a result of the conversion to sulfuric acid. Discoloration and physical deterioration are produced in building materials and sculpture. The corrosion of most metals is accelerated by atmospheres polluted with SO_2; particulate matter, humidity, and elevated temperatures play important synergistic roles. Deterioration and fading are also produced in fabrics, leather, and paper. The drying time, brittleness, gloss, and even color of paints may also be affected.

- Even at very low concentrations, SO_2 has been found to adversely affect vegetation. High concentrations over short periods can produce acute leaf injury; while chronic leaf injury, such as gradual yellowing, results from low concentrations over long periods.

- Respiratory irritation has been linked with sulfur oxide levels, although the concentrations needed to produce pathological lung change or mortality in animals are much greater than the levels encountered in urban atmospheres. Nevertheless, a rise in SO_2 levels has been linked with increased mortality and morbidity in several cities. In all cases, elderly people with heart or lung disorders have been affected most severely.

EXHIBIT L-2
COMPARISON OF RESULTS OF TWO STUDIES ON THE HEALTH COSTS OF AIR POLLUTION

Study / Diseases	Types of Costs	Share of Disease Costs Attributable to Air Pollution
Ridker Study*		
• Cancer of Respiratory System • Chronic Bronchitis • Acute Bronchitis • Common Cold • Pneumonia • Emphysema • Asthma	Premature Death Treatment Absenteeism	18 to 20%
Lane & Seskin Study**		
• Respiratory Diseases (bronchitis, other) • Cancer (lung, other) • Cardiovascular	Premature Death Treatment Absenteeism	10 to 25%

*Ridker, Ronald G., *op. cit.*
**Lave, L.B. and E.P. Seskin, *op. cit.*

Source: Barrett and Waddell, *op. cit.*

In both studies the authors consider their results to be conservative. For example, no attempt was made to value the mental costs of death or illness. Nor were more indirect costs, such as costs of moving to cleaner areas for health reasons, taken into account. Certainly, the focus on future earnings foregone places emphasis on the people in the working force, thereby attributing a lower value or none at all to the lives of homemakers, unemployed, and retired persons.

Using the criteria of reasonableness, a subsequent evaluation of the two studies yielded a figure of $2.08 billion savings for a 50 percent reduction in air pollution, or a $4.16 billion total cost of air pollution.[1] This estimate includes the discounted 1963 value of future earnings lost because of mortality as well as the costs of treatment, prevention, and morbidity. If it can be assumed that the relationship of the economic loss in 1963 to the 1963 GNP (7 percent of GNP) is constant, then the 1974 loss associated with health effects of air pollution would be about $9.8 billion.[2]

B. Materials

Several studies have evaluated the costs of air pollution damage to materials. Two early attempts focused on estimating the national cost of corrosion of metals, implicating air pollution as a causal factor but not specifying the relationship between cost and air pollution. The total corrosion bill in the United States in 1950 was estimated in one study[3] to be $5.4 billion, and in the other to be $7.5 billion in 1958.[4]

Another study on materials damage, this one concerned with painted surfaces, is of similarly minimal applicability because of the speculative nature of the assumptions used.[5] The 1967 estimate of increased costs of painting resulting from air pollution damage in New York was undertaken by Hudson Painting and Decorating Company based on the sum grossed by paint and other products sales in New York and New Jersey. Assuming, among other things, that one third of the cost of painting is attributable to air pollution damage, $150 million in damages was calculated for New York in 1967.

A more sophisticated approach was taken by Stanford Research Institute in its evaluation of the damage caused to electrical contacts by air pollution.[6] In this study it was estimated that $20 million is spent on plating contacts with precious metals to prevent air

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[1] 1974 GNP: $1397.4 billion, as reported in *Survey of Current Business*, Volume 55, Number 11, November 1975.

[2] Barrett and Waddell, *op. cit.*

[3,4] *Ibid.*, p. 13.

[5] *Ibid.*, p. 14.

[6] Stanford Research Institute, *Inquiry into the Economic Effects of Air Pollution on Electrical Contacts*, U.S. Department of Health, Education, and Welfare, Public Health Service, National Air Pollution Control Administration; April 1970.

pollution corrosion. The study also estimated that $25 million is spent annually on air conditioning and purification systems, with additional annual expenditures of $4 million for washing insulators, $5 million for research and development, and $10 million for equipment failures.[1] The total annual expenditure is about $65 million. However, the study concluded that the $65 million was unnecessarily high because two or more individually effective countermeasures were often applied simultaneously to minimize losses. Similarly, losses will decrease (over time) as less expensive and more air pollution-resistant materials are used in electrical contacts.

The most comprehensive survey of the economic effects of air pollution on materials was undertaken at Midwest Research Institute.[2] The total value of materials exposed to air pollution and the values of interaction between the various materials and pollutants were calculated and then combined to yield a figure representing the extent of economic damage attributable to air pollutants. These rank orderings are shown in Exhibit L-3. Although the individual material loss estimates were made to determine relative importance rather than actual value, the total figure of $3.8 billion in 1968 is thought to be reasonable.[3]

On the basis of work done by Midwest Research Institute on zinc, the annual cost of corrosion of galvanized steel, including prevention costs, has been estimated at $4.5 billion.[4] Calculation of the extreme values yielded a low of $1.4 billion and a high of $13 billion. It is suggested that the minimum value of $1.4 billion reflects the most defensible estimate in light of data limitations.[5]

Essentially, consideration of cost savings from reduced air pollution damage of materials as a benefit only views half of the situation. Since the air pollution damage results in the need for more replacement, repair, and maintenance of materials (all usually considered in the costs of air pollution damage), it also stimulates the market for firms that provide these products and services. Consequently, reduction in air pollution results in a benefit to the consumer (industrial, household, or government) but represents a loss, or cost, to the firms profiting from air pollution damage. In this case the factor which is likely to tip the scales in favor of air pollution reduction – the efficient use of resources – cannot be reasonably quantified.

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[1] Barrett and Waddell, *op. cit.*, p. 15.

[2] Salmon, R.; Midwest Research Institute; *Systems Analysis of the Effect of Air Pollution on Materials;* U.S. Department of Health, Education, and Welfare; Public Health Service; National Air Pollution Control Administration, January 1970.

[3] Barrett and Waddell, *op. cit.*, p. 17.

[4] Haynie, F.H.; *Estimation of Cost of Air Pollution as the Result of Corrosion of Galvanized Steel;* National Environmental Research Center, Research Triangle Park, N.C.; unpublished report.

[5] Barrett and Waddell, *op. cit.*, p. 21.

EXHIBIT L-3
SUMMARY AND RANKINGS OF DAMAGE FACTORS

Rank	Material	Value of Interaction ($/year)	In-Place Value of Materials Exposed ($ billion)	Economic Loss ($ million)
1	Paint	0.50×10^{-1}	23.90	1,195.0
2	Zinc	0.29×10^{-1}	26.83	778.0
3	Cement and concrete materials	0.10×10^{-2}	316.21	316.0
4	Nickel	0.25×10^{-1}	10.40	260.0
5	Cotton (fiber)	0.40×10^{-1}	3.80	152.0
6	Tin	0.26×10^{-1}	5.53	144.0
7	Synthetic rubber	0.10×10^{0}	14.00	140.0
8	Aluminum	0.21×10^{-2}	54.08	114.0
9	Copper	0.20×10^{-2}	54.88	110.0
10	Wool (fiber)	0.40×10^{-1}	2.48	99.2
11	Natural rubber	0.10×10^{0}	0.54	54.0
12	Carbon Steel	0.50×10^{-2}	10.76	53.8
13	Nylon (fiber)	0.40×10^{-1}	0.95	38.0
14	Cellulose ester (fiber)	0.40×10^{-1}	0.82	32.8
15	Building brick	0.10×10^{-2}	24.15	24.2
16	Urea and melamine (plastic)	0.10×10^{-1}	2.27	22.7
17	Paper	0.30×10^{-2}	7.53	22.6
18	Leather	0.40×10^{-2}	5.15	20.6
19	Phenolics (plastic)	0.10×10^{-1}	1.98	19.8
20	Wood	0.10×10^{-2}	17.61	17.6
21	Building stone	0.23×10^{-2}	7.65	17.6
22	Polyvinyl chloride (plastic)	0.10×10^{-1}	1.54	15.4
23	Brass and bronze	0.42×10^{-3}	33.12	13.9
24	Polyesters (plastic)	0.10×10^{-1}	1.37	13.7
25	Rayon (fiber)	0.40×10^{-1}	0.33	13.2
26	Magnesium	0.20×10^{-2}	6.50	13.0
27	Polyethylene (plastic)	0.10×10^{-1}	1.17	11.7
28	Acrylics (plastic)	0.10×10^{-1}	1.00	10.0
29	Alloy steel	0.40×10^{-2}	2.18	8.7
30	Polystyrene (plastic)	0.10×10^{-1}	0.85	8.5
31	Acrylics (fiber)	0.40×10^{-1}	0.19	7.6
32	Acetate (fiber)	0.40×10^{-1}	0.19	7.6
33	Polyesters (fiber)	0.40×10^{-1}	0.16	6.4
34	Polypropylene (plastic)	0.10×10^{-1}	0.64	6.4
35	Acrylonitrile-butadiene-styrene (plastic)	0.10×10^{-1}	0.61	6.1
36	Epoxies (plastic)	0.10×10^{-1}	0.47	4.7
37	Cellulosics (plastic)	0.10×10^{-1}	0.40	4.0
38	Bituminous materials	0.10×10^{-3}	22.45	2.2
39	Gray iron	0.50×10^{-3}	3.86	1.9
40	Nylon (plastic)	0.10×10^{-1}	0.17	1.7
41	Polyolefins (fiber)	0.40×10^{-1}	0.04	1.6
42	Stainless steel	0.85×10^{-4}	18.90	1.6
43	Clay pipe	0.10×10^{-2}	1.44	1.4
44	Acetate (plastic)	0.10×10^{-1}	0.12	1.2
45	Malleable iron	0.16×10^{-2}	0.58	0.9
46	Chromium	0.75×10^{-3}	1.08	0.8
47	Silver	0.12×10^{-2}	0.57	0.7
48	Gold	0.10×10^{-3}	5.80	0.6
49	Flat glass	0.10×10^{-4}	28.59	0.3
50	Lead	0.11×10^{-3}	2.18	0.2
51	Molybdenum	0.25×10^{-3}	0.51	0.1
52	Refractory ceramics	0.10×10^{-4}	1.93	0.02
53	Carbon and graphite	0.10×10^{-5}	0.30	0.00
	Total			3,800.00

Source: Midwest Research Institute. *Systems Analysis of the Effect of Air Pollution on Materials.* 1970. As reported in Barrett and Waddell. p. 20.

C. Vegetation

Production cost increases resulting from air pollution were estimated to be in excess of \$3.5 million through observations and analysis conducted in Pennsylvania in 1969.[1] Indirect losses attributable to air pollution were estimated to equal an additional \$8 million, of which \$7 million reflected profit losses, \$0.5 million represented reforestation costs, and the remainder reflected costs for grower relocation. Total costs attributable to air pollution damage of vegetation, therefore, equal about \$11 million annually. Although methods of translating physical injury into economic loss have not been standardized and several aspects of air pollution's impact on vegetation, such as reduction in aesthetic values have not been included, the Pennsylvania study is considered successful and its results defensible.[2]

D. Soiling

In recent years several attempts have been made to identify the costs of soiling from air pollution. For the most part these studies have dealt with the household as the primary unit of investigation in an attempt to measure pollution-related cleaning and maintenance costs in certain localities. Two towns in the Upper Ohio River Valley – Steubenville and Uniontown – provided a stark comparison for one study in 1966.[3] Steubenville had an annual average particulate concentration of 235 mg/m^3 while Uniontown had 115 mg/m^3. Based on the frequency of household cleaning and the local market prices for the household services, calculations showed that Steubenville residents incurred costs of \$84 (per capita) more than Unionville residents.

Validation of this study was undertaken in the Washington, D.C., area because of the lower particulate concentrations and the smaller particulate increment between the cities paired for comparison. Again a positive relationship was found between the frequency of household cleaning and the ambient particulate concentrations. Subsequently, the methodology used and cleaning frequencies determined in the Washington and Steubenville studies were applied to Connecticut to evaluate economic losses from soiling attributable to air pollution in Connecticut. However, the Connecticut results are considered highly questionable because of the failure to verify the applicability of previous study results to the state of Connecticut.[4]

Despite the differences uncovered in the household cleaning costs of Steubenville and Uniontown residents, subsequent studies have not borne out the significance of economic losses that can be associated with soiling from air pollution. In particular, a study

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[1] Lacasse, Weidensaul; Carroll; *Statewide Survey of Air Pollution Damage to Vegetation – 1969;* Center for Air Environment Studies (CAES), State College, Pa.; CAES Publication 148-70, January 1970; as reported in Barrett and Waddell.

[2] Barrett and Waddell, *op. cit.*, p. 29.

[3] Michelson and Tourin, *Comparative Method for Studying Costs of Air Pollution*, Public Health Reports, 81(6), June 1966, as reported in Barrett and Waddell.

[4] Barrett and Waddell, *op. cit.*, p. 37.

in Philadelphia found that some low-cost cleaning and maintenance operations, such as washing windows, appear to be sensitive to air particulate levels but that high-cost operations, such as painting and dry cleaning, are relatively unaffected by variations in air particulate levels.[1]

E. Residential Property Values

An interesting finding in the Philadelphia soiling study was that a higher proportion of residents of high-pollution areas believed their neighborhoods were dirtier than residents of low-pollution areas felt theirs to be. Since the value of residential property is contingent upon many factors, it is reasonable to assume that the quality of air would affect residential property values. Certainly damage through soiling and material degradation may be expected to affect property values. However, residential property value studies go further in their evaluation of the impact of air pollution by building on the market price differentials associated with demands for relocation away from pollution.

Ridker and Henning made the first serious use of the housing market estimator as an index of the effect of air pollution on property values.[2] Using the St. Louis Standard Metropolitan Statistical Area (SMSA) for the study, they estimated the mean change in property values per 0.25 mg $SO_3/100\ cm^2$-day change in sulfation at $245, or about $100 per 0.1 mg change.

Subsequently, Crocker and Anderson studied the covariation of sulfation-suspended particulates and census tract median property values in St. Louis; Washington, D.C.; and Kansas City.[3] The estimates derived ranged from $300 to $700 per 0.1 mg SO_3 and 10 mg/m^3-day change in suspended particulates. Using similar methods, Zerbe[4] reported a best estimate of $966 reduction in property values for each increase of 1.0 mg $SO_3/100\ cm^3$-day, or about $100 per 0.1 mg $SO_3/100\ cm^2$-day change. A fourth study[5] also yielded comparable estimates: $663 per 0.5 mg SO_3 or about $130 per 0.1 mg SO_3. All four studies cited above show that sulfation is inversely related to median property values and that the magnitude of the marginal capitalized sulfation damage for residential structures, for a marginal decrease of 0.1 mg $SO_3/100\ cm^2$-day, probably lies in the range of $100 to $300. The uniformity of results for the five metropolitan areas studied is noteworthy.

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[1] Barrett and Waddell, *op. cit.*, p. 42.

[2] Ridker, Ronald G., and John Henning; "The Determinants of Residential Property Values with Special Reference to Air Pollution"; *Review of Economics and Statistics,* 49: 246-257; May 1967; as reported in Barrett and Waddell.

[3] Anderson and Crocker; "Air Pollution and Housing: Some Findings," Paper No. 264; presented at Institute for Research in the Behavioral, Economic, and Management Sciences, Purdue University; Lafayette, Indiana; December 1969; as reported in Barrett and Waddell.

[4] Zerbe, R.O., Jr.; *The Economics of Air Pollution: A Cost-Benefit Approach;* Report to the Ontario Department of Public Health, Toronto, Canada; 1969.

[5] Barrett and Waddell, *op. cit.*, p. 53.

F. Other Estimates

Other types of estimates also merit consideration. For example, the National Academy of Sciences has estimated that air pollution causes 4,000 deaths and four million days of illness every year. The EPA has estimated that, as of 1970, the monetary cost of air pollution in health and material damage probably amounted to $12 billion annually.[1] Exhibit L-4 summarizes several national pollution damage estimates. The Barrett and Waddell estimate, in particular, broke down the damage estimate by pollutant, concluding that about 50 percent of total costs were attributable to sulfur oxides and 36 percent attributable to particulates.[2] Overall, it is noteworthy that a recent CEQ review of studies on the costs of air pollution damage concluded that when health and property damage are considered there appears to be an outright economic advantage to pollution control.[3]

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[1] Hill, Gladurin; "Air Pollution Drive Lags, but Some Gains Are Made"; *New York Times;* May 31, 1975; pp. 1 and 15.

[2] Barrett and Waddell, *op. cit.* The breakdown is as follows: residential property values – 54% SO_2 and 46% TSP; materials – 46% SO_2 and 15% TSP; health – 54% SO_2 and 46% TSP; vegetation – 100% SO_2 and 6% TSP. Since the estimates were based on prior studies the individual pollutants considered in those studies largely determine these allocations.

[3] Kenneth Ch'uan-k'ai Leung and Jeffrey Klein, *The Environmental Control Industry: An Analysis of Conditions and Prospects for the Pollution Control Equipment Industry*, for Council on Environmental Quality, December 1975.

EXHIBIT L-4
COMPARISON OF NATIONAL
POLLUTION DAMAGE ESTIMATES

Media		Base Year	Range (in billions of dollars)
Air	Ridker (1966)	1970	$ 7.3 - 8.9
Air	Gerhardt (1969)	1968	6.0 - 15.2 (best 8.1)
Air	Barrett and Waddell (1973)	1968	16.1*
Air	Babcock and Nagda (1973)	1968	20.2**
Air	Justice, Williams, and Clement (1973)	1970	2.0 - 8.7
Air	Waddell (1974)	1970	6.1 - 18.5 (best 12.3)
Air	National Academy of Sciences (1974)	1973	15 - 30 (best 20)
Air	Heintz and Hershaft (1975)	1973	9.5 - 35.4 (best 20.2)

*By adjusting estimate to 1975 dollars, the annual costs for 1975 air pollution damages to health, materials, residential properties, and vegetation are estimated at $10.1 billion, $7.8 billion, $8.5 billion, and $166 billion, respectively – for a total of $26.6 billion.

**An updated study projected total annual pollution damages to be $23.5 billion in 1976, of which $20.9 billion represented damage from stationary sources.

Source: *The Environmental Control Industry,* for CEQ. December 1975, pp. 24, 25.

APPENDIX M
HEALTH AND WELFARE EFFECTS OF POLLUTANTS AT CONCENTRATIONS BELOW NATIONAL AIR QUALITY STANDARDS: A SUMMARY OF FINDINGS

By

Richard Ayres
Environmental Policy Center
Washington, D.C.
January 8, 1976

HEALTH AND WELFARE EFFECTS OF POLLUTANTS AT CONCENTRATIONS BELOW NATIONAL AIR QUALITY STANDARDS: A SUMMARY OF FINDINGS

HEALTH EFFECTS

Summarizing the results of the Conference on Health Effects of Air Pollution which was conducted under the auspices of the National Academy of Sciences – Engineering, the NAS reporters concluded:[1]

> Due to the limitations of present knowledge, it is impossible at this time to establish an ambient air concentration of any pollutant – other than zero – below which it is certain that no human beings will be adversely affected.

For example, a sulfur dioxide episode in Yokkaichi, Japan, in 1972 resulted in 817 reported illnesses from sulfur dioxide inhalation when the pollution level reached 0.1 part per million (ppm). [Syrota, M., "Observations on the fight against air pollution in Japan," 15 Pollution Atmospherique 129-151 (1973).] By comparison, the maximum 24-hour concentration, which is not to be exceeded more than once per year, under the present national standards is 0.14 ppm. During the same episode in Japan, absenteeism among school children due to respiratory ailments tripled when the average weekly sulfur dioxide level exceeded 0.09 ppm. [*Ibid.*]

A recent report in this country found:[2]

> The implication of daily levels of SO_2 and particulates has been studied in particularly vulnerable groups such as patients with chronic bronchitis and emphysema. Deterioration in their respiratory well-being has resulted from daily concentrations of SO_2 of about 500 micrograms per cubic meter which is not much above the 24-hour primary standard. A few studies have even suggested that deterioration in particularly vulnerable groups may occur with daily concentrations which are below this standard.

A classic example of the adverse effects on health from sulfur oxide concentrations below the ambient standards has recently been documented by EPA itself. Ever since the national sulfur dioxide standards were promulgated, increasing attention has been given derivative forms of sulfur dioxides, namely sulfates. Sulfates are produced through complex interactions of sulfur oxides with other chemical substances in the air and with ambient moisture. In recent years, sulfates have become increasingly regarded as being more

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[1]Summary of Proceedings – Conference on Health Effects of Air Pollution, Senate Public Works Committee, 93d Cong., 1st Sess. 1 (1973).

[2]Rall, "A Review of the Health Effects of Sulfur Oxides," National Acadamy of Sciences – Engineering, Air Quality and Automobile Emission Control, Vol. 2, Senate Public Works Committee, 93d Cong., 2d Sess. 418 (1974) (Hereafter NAS Report).

dangerous to human health and more likely to be responsible for observed human health effects than sulfur dioxide itself.[1] The data tentatively suggest (1) adverse health effects could be ascribed to quite low values of suspended sulfates,[2] and (2) such values exist pervasively in the ambient air throughout the eastern United States.[3]

On September 23, 1975, EPA issued a report which, while emphasizing the need for additional studies, stated that its "best judgment estimates" tied adverse effects to sulfate concentrations at or below that found in a 24-state region of the northeastern United States, including rural areas. [EPA, Position Paper on Regulation of Atmospheric Sulfates, p. x (1975).] Furthermore, these sulfate concentrations were correlated to sulfur dioxide levels at or near the primary annual standards and at or below the primary 24-hour standard. For example, urban levels now being monitored in the northeastern United States measured a range of sulfate concentrations of 10 to 24 micrograms per cubic meter (ug/m^3); nonurban concentrations ranged from 8 to 14 ug/m^3 (annual average). [*Id.* at x, 20.] "Best judgment estimates" on levels associated with adverse health effects were as low as 10 to 15 ug/m^3 (annual average). [*Id.* at viii, 10.]

Despite this information, EPA has concluded that (*id.* at 78):

> [S]ulfate information presently available does not now permit the establishment of a new regulatory program.

Moreover (*id.* at xiv):

> development of the data and information necessary for a sulfate regulatory program would require 3 to 5 years. In this regard, if EPA were to set a National Ambient Air Quality Standard (NAAQS) for sulfates, it could not realistically be proposed before 1980 or 1981.

Sulfur dioxide emissions from relatively clean air in rural areas is a chief contributor to dangerously high urban sulfate concentrations. EPA states (*id.* at 35):[4]

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[1]See, *e.g.*, Rall, "A Review of the Health Effects of Sulfur Oxides," 8 *Environmental Health Perspective* 97-121 (1974); EPA, *Health Consequences of Sulfur Oxides* 7-18 (1974).

[2]See, *e.g.*, Chapman, *et al.*, *Power Generation: Conservation, Health and Fuel Supply*, Report to the Task Force on Conservation and Fuel Supply, FPC, 1973, National Power Survey 24-26.

[3]NAS Report, *supra*, Vol. 1, p. 60.

[4]See also *id.* at 38, 40; Klein, "St. Louis Study Indicates People Are Doing More About the Weather than Talking About It," *The Wall Street Journal*, Aug. 19, 1975, p. 34, wherein it is reported "Pollution coming out of Chicago, St. Louis, Detroit and other Midwestern centers contribute to weather patterns all over the eastern U.S."; Russell, "Smog Trail Tracked to Fredericksburg," *The Washington Star*, Oct. 3, 1975, p. 1.

> The hypothesis that long range transport of sulfates from power plants is influencing urban sulfate levels is supported by the limited data on emission and concentration trends .... [T]he NAS [National Academy of Sciences] presents estimates of the impact of large emission sources on downwind sulfate concentrations. Their analysis suggests appreciable impacts on sulfate levels at distances of 300 miles downwind ....

EPA further states (*id.* at 41):

> [O]nce applicable emission limits have been met by all sources in urban areas thus reducing locally produced sulfates, EPA believes that, based on the available evidence concerning transport, further increases in regional and urban sulfates can be expected if nonurban SO_2 emissions from power plants and other sources continue to rise. Given the general levels of sulfates, other fine particles, and sulfur oxides in the northeast, the Agency's assessment of the preliminary health data suggests that such increases should be viewed with concern.

EPA concludes that (*id.* at 60):

> protecting the most sensitive portion of the population could ultimately involve SO_2 control in excess of that required to meet current SO_2 standards.

Low-level effects of other pollutants which are not covered by EPA's significant deterioration regulations, such as nitrogen oxides, also cause adverse effects.[1] For example, nitrogen dioxide concentrations of 0.1-0.3 ppm for short periods of time may cause visual and olfactory effects.[2] It is now believed that further control of nitrogen oxide emissions could inhibit the formation of sulfates in the atmosphere.[3]

Finally, there is recent evidence regarding the possible cancer causing effects of a nitrogen dioxide derivative. The World Health Organization estimates that eighty percent of cancers are environmentally caused; the National Cancer Institute puts the figure at sixty to ninety percent. The City of Baltimore, Maryland, has the highest cancer death rate of any city in the nation.[4] Until recently dimethyl nitrosamine (DMN), one of the most potent cancer-causing substances known to man, had never been found anywhere in ambient air over the United States, because techniques to detect it were too primitive. It was, nonetheless, theorized that DMN could be formed in the atmosphere by the reaction of nitrogen oxides with industrial or natural substances called amines. Baltimore was among five eastern cities recently tested for DMN. This time the startling evidence revealed DMN to be present over two of the cities. Baltimore was one; its air registered the higher level.

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[1]Some of these have been noted in the Brief of Petitioners, Nos. 74-2063, 74-2079, pp. 18-20.

[2]NAS Report, *supra*, at 37.

[3]Oversight Hearings on the Clean Air Act Before the Subcomm. on Public Health and Environment of the House Comm. on Interstate and Foreign Commerce, 93d Cong. 1st Sess., Pt. 1, at 285 (1973).

[4]Challmes, Fairfield plant faces probe in cancer agent, The (Baltimore) Sun, September 20, 1975, at Bl., col. 8; Auerback, EPA Probes Chemical Effects, Washington Post, September 20, 1975 at A3, col. 1.

In sum, the evidence is mounting that adverse effects on health and welfare are associated with air pollution concentrations well below the present national standards. The National Academy of Sciences – Engineering recently reported to the Congress:[1]

> All of the panels on health effects addressed themselves to the question of whether there are thresholds for the adverse health effects of pollutants, that is, some safe levels below which essentially all members of the population are protected. The present standards were derived on the assumption that such thresholds do exist. . . .
>
> However, in no case is there evidence that the threshold levels have a clear physiological meaning, in the sense that there are genuine adverse health effects at and above some level of pollution, but no effects at all below that level. On the contrary, evidence indicates that the amount of health damage varies with the upward and downward variations in the concentration of the pollutant, and with no sharp lower limit. 44(a).

Moreover,[2]

> Some persons with respiratory or cardiac disease may have so little reserve that the slightest increase in pollution could aggravate their condition or precipitate death. 44(b).
>
> Thus, at any concentration, no matter how small, health effects may occur, the importance of which depends on the gravity of the effect. 44(c).

A report submitted to the Ford Foundation in September 1974 by the American Public Health Association, concluded that

> at every level of pollution and not at some defined threshold, it appears that, depending upon the adaptive reserve of the individual, someone becomes ill and someone's life is shortened.[3]

VEGETATION

Adverse effects are also caused to vegetation by low levels of pollution. Complete disappearance of certain lichens has occurred when winter sulfur dioxide averages reached two-thirds of the annual standard. [EPA, Effects of Sulfur Oxide in the Atmosphere on Vegetation: Revised Chapter 5 for Air Quality Criteria for Sulfur Oxides, p. 19 (1973).] Acute injury to spruce trees has been observed when the four-month growth season average concentration for sulfur dioxide was two-thirds the annual standard. [*Id.* at 36-37.] Other studies indicate varying adverse effects of pollutants at levels below the national standards on wheat and potato yields, spinach and apple quality, white pine tree volume and many other crops. [*Ibid.*]

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[1]NAS Report, *supra* at 17, 58.

[2]*Id.* at 18.

[3]Carnow, Wadden, Scheff & Musselman, Health Effects of Fossil Fuel Combustion: A Quantitative Approach 2 (1974), *in* American Public Health Association, Health Effects of Energy Systems: A Quantitative Assessment (1974).

ACID RAIN

Another effect of low-level pollution, which is closely associated with observed ambient levels of suspended sulfates, is the phenomenon known as acid rain. [EPA, Position Paper on Regulation of Atmospheric Sulfates, *supra*, p. 11.] EPA has found that the acidification of rainfall can raise the acidity of soils and natural waters, cause mineral leaching, and damage vegetation. [*Ibid.*] The results can have a devastating effect on forests, soils, plant, animal, and aquatic life.[1] A recent study suggests that acid precipitation may be causing depletion of fish populations in lakes in the Adirondack Mountains of New York.[2] A Swedish study pointed to the increasing acidity of Swedish and Norwegian lakes and streams, some of which have become so acidified that they can no longer support fish life.[3]

Several groups have warned about the potential effect on vegetation which a rise in acidity may have. Sweden's researchers found that a very small increase in ambient concentrations of sulfur oxides led to a drop in the growth rate of its forests. [*Id.* at 44.] The resulting acidity was projected to result in a reduction of forest growth by as much as 10 to 15 percent by the year 2000. [*Id.* at 9.] Evaluating the environmental impact of power plant development in the Southwest, a federal study group found that "the effect of acid rain . . . may be expected to be significant" on vegetation as well as water quality. [Southwest Energy Study, *Report of the Air Pollution Work Sub-group*, App. C-1, p. 29 (1972).] An EPA panel found that a Christmas tree plantation suffered significant damage from emissions from a power plant, even through the maximum one-hour average of ambient sulfur oxides did not exceed .36 ppm during the study period, in contrast to the secondary 3-hour standard of .5 ppm.[4]

In its comments to EPA on the 1973 proposed regulations, the Forest Service expressed particular concern over reports of "substantial reduction in timber volume caused by chronic low levels of SO_2 or acid rains." The comments pointed out that, "although acute damage episodes are diminishing, we are now faced with a more serious problem – chronic exposure to low levels of various air pollutants." To avoid such damage, the Forest Service urged "a cautious approach to allowing any deterioration of air quality . . . "[5]

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[1] Air Pollution Across National Boundaries, *Sweden's Case Study for the United Nations Conference on the Human Environment* 9, 56 (1971); Likens & Bormann, Acid Rain: A Serious Regional Environmental Problem, *Science* 11, 76 (June 14, 1974); EPA, *Summary Report on Suspended Sulfates and Sulfuric Acid Aerosols* (197); EPA, *Comments on the Study Management Team's Draft Report, Southwest Energy Study* 12 (1972).

[2] Schofield, *Lake Acidification in the Adirondack Mountains of New York*, presented at the 1st International Symposium on Acid Precipitation, and the Forest Ecosystem, Columbus, Ohio, 1975.

[3] Air Pollution Across National Boundaries, *supra*, p. 56.

[4] EPA, *Recommendations and Summary of Mt. Storm, West Virginia – Gorman, Maryland and Luke, Maryland – Keyser, West Virginia, Interstate Air Pollution Abatement Conference*, Washington, D.C., October 1971.

[5] Forest Service Comments on Environmental Protection Agency "Proposed Rules for the Prevention of Significant Air Quality Deterioration," October 19, 1973, Attachment to Record No. E-3.

Rainfall ten times more acidic than normal has been reported over the eastern United States. In some remote rural areas of New England, the rains have been described to be "as acid as pure lemon juice."[1]

One especially difficult aspect of acid rain is that its quantity and concentration depend upon the total amount of pollution in the air over a wide region rather than the concentration in any particular place. Any increase in pollutants, even at very low levels and even in an area which enjoys air quality better than required by the standards, nevertheless will contribute to the overall atmospheric loading of pollution which can result in acid rainfall.

VISIBILITY

Any amount of air pollution, even at low levels, will have an impact on visibility. If sulfur oxides are present at a level well below the annual standard (60 micrograms as opposed to the standard of 80), visibility will be reduced to about 15 miles. [EPA, *Air Quality Criteria for Sulfur Oxides,* p. 14.] If humidity is fairly high, visibility will be reduced even more. For example, if humidity is at 98 percent, with sulfur dioxide at 60 micrograms, visibility decreases to 3 or 4 miles. [*Ibid.*] A visual range of five miles or less requires that aircraft operations be slowed and restrictions imposed. [EPA, *Air Quality Criteria for Particulate Matter,* p. 52.] By contrast, in large areas of the country and in particular in those areas prized for their natural and scenic treasures, present visibility may extend for 50 to 100 miles.[2]

The presence of particulates also reduces visibility sharply. At what EPA terms a "typical rural concentration" of 30 micrograms of particulates per cubic meter, visibility is about 25 miles. [EPA, *Air Quality Criteria for Particulate Matter,* p. 60.] At the level of the secondary annual standard, 60 micrograms, the range is reduced about 12 miles. [*Id.* at 57.] If particulates are at the level of the primary standard, 75 micrograms, that concentration "might produce a visibility of 5 miles in some instances." [*Id.* at 61.] And if nitrogen oxides are present with particulates, visibility is reduced even further. [EPA, *Air Quality Criteria for Nitrogen Oxides,* pp. 2-4, 2-6.]

SYNERGISTIC EFFECTS

These specific examples demonstrate that many adverse effects are present at pollution levels below those set by the ambient standards. In addition, however, atmospheric pollutants seldom, if ever, occur in isolation. It is clearly established that pollutants combined together may have a greater total effect than the sum of their individual effects. This phenomenon, called synergism, can result in adverse effects produced by two or more pollutants acting in combination, even though each pollutant is present in quantities below its corresponding national standard. As the National Academy of Sciences-Engineering has stated, the implication is that (NAS Report, *supra,* p. 19):

> Air quality standards that regulate individual pollutants independently can never fully reflect ambient pollutant concentrations and their effects on human health.

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[1] Likens & Bormann, *supra;* Council on Municipal Performance, "City Air," *Municipal Performamce Report* 1:15, pp. 7-8 (1974).

[2] Southwest Energy Study, Report of the Air Pollution Work Sub-group, *supra,* p. 37;

Research has increasingly documented synergistic effects. For example, particulate matter in concentrations below the secondary 24-hour standard will produce, in conjunction with small amounts of sulfates, a decrease in the lung function of children both at rest and after exercise. [NAS Report, *supra*, p. 76.] The evidence of synergism between sulfur dioxide and particulates is well established.[1] EPA has concluded that the harm from sulfur dioxide is increased three to four times by the presence of particulates, which oxidize sulfur dioxide to acid aerosols. [EPA, *Air Quality Criteria for Sulfur Oxides*, p. 111.] A number of other studies have also demonstrated the synergistic effect of relatively low levels of sulfur oxides in combination with particulates.[2]

Synergistic adverse effects upon vegetation are also well documented. For example, researchers "found that a mixture of ozone and sulfur dioxide injured tobacco leaves at concentrations that had no effects when the two chemicals were present separately." [Marx, "Air Pollution: Effects on Plants," *Science* 731, 733 (February 28, 1975).] Damage to plants has been found at sulfur dioxide levels of only .001 ppm, compared with the annual standard of .03 ppm, when combined with ozone.[3] A later study considered the combined effects of sulfur dioxide and nitrogen dioxide which "often occur together because they are both formed during the combustion of fossil fuels, especially coal."[4] The study found that "the synergistic effect was most "marked at the lower concentrations used . . . ."[5] The concentrations ranged from .15 to .5 ppm compared with the secondary standard for sulfur dioxide of .5 ppm.[6]

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[1]NAS Report, *supra*, p. 73; Hodgson, "Short Term Effects of Air Pollution on Mortality in New York City," 4 *Environmental Science and Technology* 589, 590 (1970).

[2]See, *e.g.*, Novakov, Chang, and Harker, "Sulfates as Pollution Particulates: Catalytic Formation on Carbon (Soot) Particles," *Science* 259 (October 18, 1974); Marx, "Air Pollution: Effects on Plants," *Science* 731 (February 28, 1975).

[3]Applegate & Durrant, *Synergistic Action of Ozone-Sulfur Dioxide on Peanuts*, 3 Environmental Science and Technology 759 (1969).

[4]Marx, "Air Pollution: Effects on Plants," *supra*, p. 733.

[5]White, Hill and Bennett, "Synergistic Inhibition of Apparent Photosynthesis Rate of Alfalfa by Combinations of Sulfur Dioxide and Nitrogen Dioxide," 8 *Environmental Science & Technology*, 574, 575 (1974).

[6]See also Heck, "Discussion of O.C. Taylor's Paper: Effects of Oxidant Air Pollutants," 10 *Journal of Occupational Medicine* 485-499 (1968).

APPENDIX N
MULTIPLIER EFFECTS

MULTIPLIER EFFECTS

A. Background

The following discussion of the multiplier is excerpted from *Environmental Impact Assessment Guidelines for New Sources* by EPA under the Federal Water Pollution Control Act (August 25, 1975):

> An estimate induced investment in non-basic industries which will occur as consequence of the direct investment in basic industries is made on the basis of the *multiplier concept.*
>
> "The familiar multiplier concept states, in brief, that an increase in the exports of a region will lead to an increase in regional employment and, therefore, to an increase in regional income. This increased income will, in turn, be spent and induce a second round of increased regional employment and income which will also be spent to induce more income, and so on, to a finite limit. The calculated regional multiplier is an estimate of that finite limit. It is an estimate of the total amount of income generated by an injection of one dollar of new income into the region." (Schenker, 1970).
>
> A measure of the multiplier effect is the ratio of total employment in the affected region *to the total employment for all basic industries . . .*
>
> Care must be exercised in indiscriminately applying *the multiplier so calculated because it assumes that the proposed industry will behave indentically to those basic industries already there.* This assumption is not valid for industries where the product being manufactured will be rapidly exported out of the region . . . that is, not permitted to stimulate growth in "finishing" industries, transportation, warehousing, etc.
>
> By examination of the way in which the proposed industry will be linked with the proposed economic setting in comparison to the linkages between existing basic industries and the economic setting, a qualitative judgment can be made as to whether the calculated multiplier may be high or low, by what approximate amount; adjustments can then be made accordingly.
>
> Moreover, rapid technological changes in industry manufacturing process will alter traditional industry interdependencies and affect the validity of the results. The impact assessor should consider such variables before applying the technique.

B. Derivation for Connecticut

In this study, an export employment multiplier was calculated for Connecticut based on 1972 employment. All two-digit SIC's with location quotients (L.Q's) greater than one were considered as export industries. Total employment then represents 4.1 times the export employment. Although the two-digit level of aggregation probably masked some portion of the export employment, the multiplier of 4.1 does fall within the normal range of 1.5 to 4.5 for employment multipliers.

In essence, what the multiplier indicates is that one job lost or gained in an export industry represents a total of about four jobs lost or gained in the region. Since in this study the region for which the multiplier was calculated encompasses the entire state of Connecticut, any indirect employment losses are not necessarily limited to the specific area wherein the export job losses occur. Moreover, because the study addresses the future employment situation based on a comparison of a forecasted level of growth and the alteration in that forecast induced by alternative strategies, jobs are not really lost – instead they are foregone.

APPENDIX O
PRODUCTIVE POLLUTION CONTROL INVESTMENTS

PRODUCTIVE POLLUTION CONTROL INVESTMENTS

The following excerpt from a recent Council on Environmental Quality (CEQ) report has been included to introduce an aspect of control expenditures which may increasingly merit attention in evaluating the costs and benefits of control strategies.[1]

Some Productive Pollution-Control Investments

The perception of a pollution control investment as a nonproductive expenditure (output cost), however, may lead to a more crucial examination of the production process (input cost). Thus the real challenge of pollution control is to improve resource allocation or make it more efficient. A forced focus on inefficient use of materials or energy may result in modification of existing processes or substitution of new ones that not only reduce pollution, but effect other cost savings as well. The following are a few illustrations:

1. Dow Chemical Company installed twenty-eight cooling towers at one plant for a cost of $7.2 million to reuse cooling water; a 10 percent return on investment is estimated as a result of better efficiencies and lower water costs. Seven pollution control projects installed in Dow's latex plants around the world at a capital cost of about $2 million are expected to cut operating costs by almost a similar amount per year. Over a three-year period, another Dow division has saved $6 million in materials that previously had been disposed of in sewers.
2. Studies undertaken by the CEQ indicate that changes in the production process for the typical Kraft paper mill could have substantial cost and energy advantages. Substitution of oxygen bleaching for chlorine bleaching may have the advantage of increasing pulp yields and reducing chlorine effluents (which in turn reduces the need for end-of-pipe effluent treatment by the lime process). (Source: CEQ Tradeoff Analysis EG 4AC032.)
3. A new closed-cycle system for Kraft pulp mills being installed by the Great Lakes Paper Company uses a patented salt recovery process to separate, recover, and recycle water and chemicals; without end-of-pipe wastewater treatment facilities, the system will not discharge contaminated effluents and is estimated to use less energy, less water, and cost less to operate than a conventional Kraft pulp mill. The estimated $8 million cost to implement the closed-cycle system on a 250,000-ton-a-year mill is expected to save approximately $4 million per year in lower costs for chemicals, water, and energy and in higher pulp yields (resulting from recovery of fibers coupled with a more efficient bleaching technique).

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[1] Excerpted from Kenneth Ch'uan-k'ai Leung and Jeffrey Klein, *The Environmental Control Industry: An Analysis of Conditions and Prospects for the Pollution Control Equipment Industry,* for the Council on Environmental Quality, December 1975.

4. In Kraft Paper Mills, electrostatic precipitators are an integral part of the recovery boiler. The cost to install per 1,000 tons of daily capacity is about $4.5 million. The product recovery value per year is $3.5 million in salt cake at current market prices. While a precipitator is an air pollution abatement device, it is also a required piece of equipment in the process production stage.
5. Ford Motor Company has recently announced that expanded use of catalysts on their 1976 models has enabled an average fuel mileage improvement of 25 percent over their 1975 models. If Ford achieved the industry's average improvement of 14 percent on their 1975 models over their 1974 models, it would appear that Ford has already achieved a 42.5 percent improvement on 1974 model mileage – 2.5 percent better than the Administration requested by 1980.
6. In the early years of electrical precipitation, the smelting industry was the total market for precipitators – payout from recovered materials of 2 to 3 years was considered common. In petroleum refining, cost of a cyclone is about $300,000 for recovery of $3.5 million per day of catalyst material.

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As part of the State of Connecticut's Air Quality Maintenance Planning (AQMP) procedure, this study assesses the socioeconomic impact of three strategies for attainment and short-term maintenance of sulfur oxide and particulate standards.

The three strategies are as follows: (i) an emission limitation (specified as BACT) incorporated in the Connecticut new source review procedure; (ii) an air quality impact criterion incorporated in the Connecticut new source review procedure; and (iii) a proposed reduction in the allowable sulfur content of fuel burned. The analysis has included evaluation of direct and indirect costs and benefits using quantitative as well as qualitative methods. Assessment has focused on incremental "order of magnitude" impacts of strategy implementation over a 10-year time frame.

17. KEY WORDS AND DOCUMENT ANALYSIS

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