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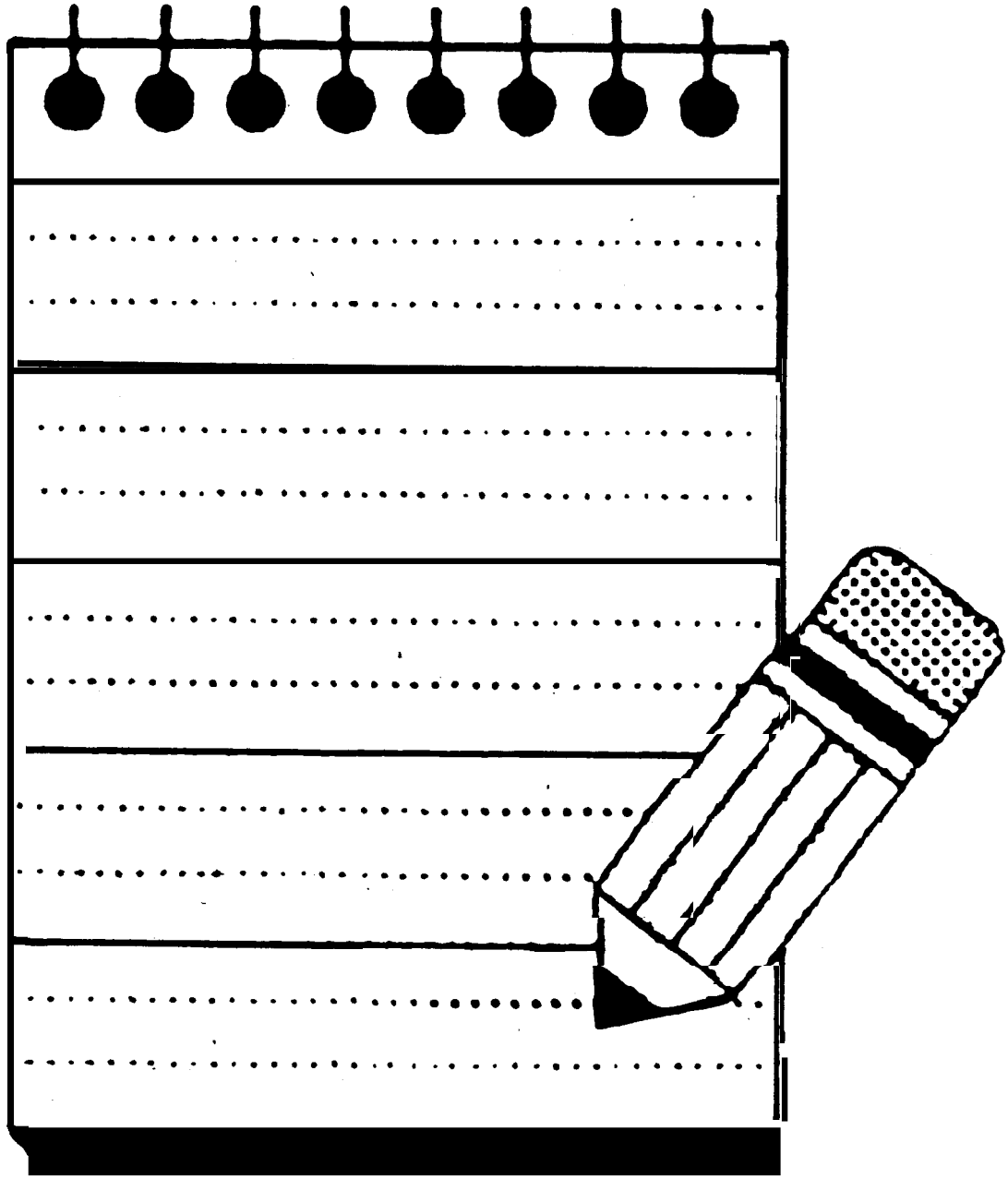

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THE U.S. ENVIRONMENTAL PROTECTION INDUSTRY:

The Technical Document

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1. EXECUTIVE SUMMARY

This study identifies the production and service activities that constitute environmental protection (EP) activities in the U.S. economy. The identification of these activities is accomplished through the use of an input-output (I-O) accounting framework. The U.S. I-O table, published by the Bureau of Economic Analysis (BEA, U.S. Department of Commerce), is adjusted to isolate EP activities from other economic activities. The resulting EP I-O tables characterize the sectors whose output is used to comply with environmental regulations as well as the sectors that demand EP goods and services. This study does not attempt to measure or draw conclusions about the net economic impacts of environmental regulation. Rather, it focuses on defining and measuring the amount of resources devoted to EP activities.

In Chapter 2, "Definition of the Environmental Protection Industry," starts by reviewing previous attempts at developing an EP industry definition. In this study, the EP industry is defined by tracing the costs of complying with environmental regulation through the U.S. economy. An attempt to maintain consistency with the types of costs defined as EP costs by the EPA in *Environmental Investments: The Cost of a Clean Environment* has been made. This is accomplished by applying the input-output accounting framework. This framework is consistent with the United Nations' (U.N.) proposed System for Integrated Environmental and Economic Accounting (SEEA).

Chapter 3, "The Environmental Protection Input-Output Tables," generates the data needed to fill the cells of EP input-output (I-O) matrices and documents all data sources and data construction techniques. Attention has been focused upon 1977 and 1982 since these are the two most recent economic census years for which benchmark I-O tables had been compiled at the time this report was written. The BEA I-O table, "The Use of Commodities by Industries" forms the basis of this report.

Chapter 4, "Employment Associated with the Environmental Protection Industry," describes how the 1977 and 1982 EP I-O tables are used to estimate employment attributable to EP. Also included is a discussion of data sources and limitations.

Chapter 5, "Updating the Environmental Protection I-O Tables," describes the procedures and data sources used to update the 1982 EP I-O tables to 1985, 1988, and 1991.

Chapter 6, "Applications," demonstrates how the EP I-O tables can be used to derive measures of the size of the EP "industry" and a modified Leontief multiplier for calculating indirect EP employment. These measures and indirect employment are computed for the U.S. for 1977, 1982, 1985, 1988, and 1991. Table 1.1 summarizes the results of this study.

The detailed concordance of the 41 EP I-O table to the 540 sector "The Use of Commodities by Industries" table is presented in Appendix A. Appendix B provides details of

the procedures used to derive patterns for assigning the "materials" component of EP operation and maintenance and capital expenditures to specific I-O categories. Appendix C provides the original total I-O tables for 1977 and 1982, and Appendix D derives the total requirements matrix from the "use" and "make" tables. Appendix E documents the peer review process.

Table 1.1

Summary of Study Results

	1977	1982	1985	1988	1991
Direct Employment (Number of Individuals)	682,778	642,467	657,243	697,326	744,322
As a Percent of Total Employment	0.80	0.69	0.65	0.64	0.67
Direct + Indirect Employment (Number of Individuals)	1,312,582	1,437,290	1,489,669	1,384,464	1,619,497
As a Percent of Total Employment	1.63	1.60	1.61	1.66	1.77
Direct Value-Added (Millions of Dollars)	14,490.3	20,843.5	27,872.4	36,811.2	46,222.8
As a Percent of GNP	0.73	0.65	0.66	0.72	0.79
Direct + Indirect Value-Added (Millions of Dollars)	32,453.1	51,221.4	66,979.2	83,143.3	101,870.1
As a Percent of GNP	1.63	1.60	1.61	1.66	1.77

2. DEFINITION OF THE "ENVIRONMENTAL PROTECTION INDUSTRY"

A primary barrier to measuring the size of the environmental protection (EP) industry is the lack of a precise industry definition. Thus, the first task of this study is to define, as specifically as published data sources permit, which production and service activities constitute the EP industry. The definition for the EP industry developed in this study is driven by existing sources of data. However, the definition is flexible and can be easily modified to incorporate additional sources of information.

Previous attempts at developing an industry definition have viewed the EP industry from two distinct perspectives. First, the EP industry can be defined in terms of who bears the cost of regulation. This is the approach taken by EPA, *Environmental Investments: The Cost of a Clean Environment* (EPA, 1990). Alternatively, the EP industry can be defined as the companies that manufacture capital goods or supply raw materials and services for purposes of pollution abatement. From this perspective, the EP industry is defined as companies receiving the revenue associated with expenditures to comply with regulation. The second approach has been taken by the *World Environmental Directory*, which disaggregates the EP industry into 19 "product manufactures" categories and 24 "professional services" categories. According to the *Environmental Business Journal* (Environmental Publishing, Inc. 1994), which also takes the second approach to defining the EP industry, the EP industry consists of 13 separate categories.

The two approaches to defining the environmental industry will generate different estimates for several reasons. First, not all environmental costs involve company to company transactions. Some pollution abatement activities are performed within the polluting industry and costs associated with these activities do not become revenues for companies providing EP goods and services. Also, some environmental control costs do not involve out-of-the pocket expenditures (e.g., depreciation).[1] Second, the costs of pollution abatement include expenditures for items that are not part of the "EP" market (e.g., electricity required for the operation of pollution control equipment). Again, expenditures on these items do not become revenues for companies providing EP goods and services.[2] Finally, companies like engineering firms provide services besides EP. While these companies receive the revenues associated with EP expenditures, the total revenues of these companies overstates the amount received for EP goods and services.[3]

In this study, the EP industry is defined by tracing the costs of complying with environmental regulation through the U.S. economy. An attempt to maintain consistency with the types of costs defined as EP costs by the EPA in *Environmental Investments: The Cost of a Clean Environment* has been made. Further, the input-output accounting framework is applied. This framework is consistent with the United Nations' (U.N.) proposed System for Integrated Environmental and Economic Accounting (SEEA).

This chapter is organized as follows. In Section 2.1, the U.N.'s proposed SEEA and important I-O concepts are reviewed. Section 2.2 discusses the U.N.'s scheme for classifying EP activities. The U.N. provides guidance for classifying the various types of environmental costs in the U.S. economy. The U.N. scheme is slightly modified to classify environmental costs in the U.S. The classification scheme is key since it determines the manner in which the cells of the I-O table are adjusted to account for environmental control costs. Section 2.3 relates the classification of the costs of environmental regulations to particular adjustments in the published U.S. I-O tables. These adjustments to the I-O tables serve as the basis for defining the EP industry. In Section 2.4, the precise economic activities in the U.S. economy counted as EP activities are detailed. Finally, Section 2.5 provides a summary.

2.1. THE SEEA AND INPUT-OUTPUT TABLES

2.1.1. *Overview of the United Nations' System for Integrated Environmental and Economic Accounting*

The United Nations has proposed the System for Integrated Environmental and Economic Accounting (SEEA) as a special satellite system that is closely related to the core System of National Accounts (SNA). Figure 2.1 provides a schematic representation of the SEEA, and illustrates its relationship with the core SNA and the development of methods to measure environmental impacts.[4] The SEEA are comprised of four parts, labelled I, II, III, and IV in the diagram. Part I describes production and consumption activities and the accounts of nonfinancial assets. This includes the I-O table from which EP activities are separated from the rest of the production activities in the economy. In addition, part I contains information regarding changes in the stocks of natural assets. Part II describes the physical relationships between the natural environment and the producing sectors of the economy. Part III represents economic cost of actual or potential deterioration of environmental and natural resource assets associated with economic activities. Constructing part III of the SEEA requires that a monetary value is placed on the use of the environment. Part IV represents information derived from extending the nation's production boundary to incorporate the economic functions of the natural environment. For example, a nation's production boundary might be extended to include the value of wetlands in mitigating floods, filtering water for drinking, and serving as a nursery for commercial fish. This study focuses on part I of the SEEA, the disaggregation of the U.S. I-O table into environmental and nonenvironmental components.

2.1.2. *Review of Relevant Input-Output Concepts*

Before discussing the procedure for constructing the disaggregated U.S. I-O tables, it is helpful to review the relevant I-O concepts. Figure 2.1 shows a schematic representation of one type of I-O matrix, the transactions table. A transactions table records the value of sales and purchases among producing and consuming sectors of the economy.

The transactions table in Figure 2.2 is divided into three quadrants. In the upper-left quadrant, the typical entry (X_{ij}) records the sales by the sector in the i^{th} row to the sector in the j^{th} column. X_{ij} is the amount of intermediate input I used to produce output j. For example, if the industry in the i^{th} row is woodpulp and the industry in the j^{th} column is paper, then reading across the row X_{ij} is the dollar value of the product that the woodpulp industry sells to the paper industry. Reading down the column, X_{ij} is the dollar value of the input that the paper industry purchases from the woodpulp industry.

In the upper-right quadrant, Y_i is the total *final* demand for the output of the sector in the i^{th} row. Final demand includes purchases for consumption, capital formation, inventory changes, imports, exports, and government purchases. The output of the i^{th} sector is X_i, which is computed by summing the quantities sold as inputs to other producing sectors (X_{ij}) and Y_i. The row total, then is equivalent to total demand (intermediate and final).

Figure 2.1

Input-Output Transactions Table

TO FROM	1	2	. . .	j	. . .	n	Y	X
1	X_{11}	X_{12}	. . .	X_{1j}	. . .	X_{1n}	Y_1	X_1
2	X_{21}	X_{22}		X_{2j}		X_{2n}	Y_2	Y_2
.	.			.		.	.	.
.	.			.		.	.	.
.	.			.		.	.	.
I	X_{i1}	X_{i2}	. . .	X_{ij}	. . .	X_{in}	Y_i	X_i
.	.			.		.	.	.
.	.			.		.	.	.
.	.			.		.	.	.
n	X_{n1}	X_{n2}	. . .	X_{nj}	. . .	X_{nn}	Y_n	X_n
V	V_1	V_2	. . .	V_j	. . .	V_n		
X	X_1	X_2	. . .	X_j	. . .	X_n		

The columns of the I-O matrix describe the purchases made by each sector. Note that in Figure 2.1, these purchases include payments to primary inputs or value added (V_j), as shown in the lower-left quadrant. Primary inputs include payments to labor, indirect business taxes, and property-type income (e.g. depreciation) in order to account for all costs incurred by the sectors. The sum of the column entries (X_j) is equivalent to total costs of production. The sum of column entries and the sum of row entries are equal in the I-O accounting framework.

2.2. CLASSIFICATION OF THE COSTS OF ENVIRONMENTAL PROTECTION

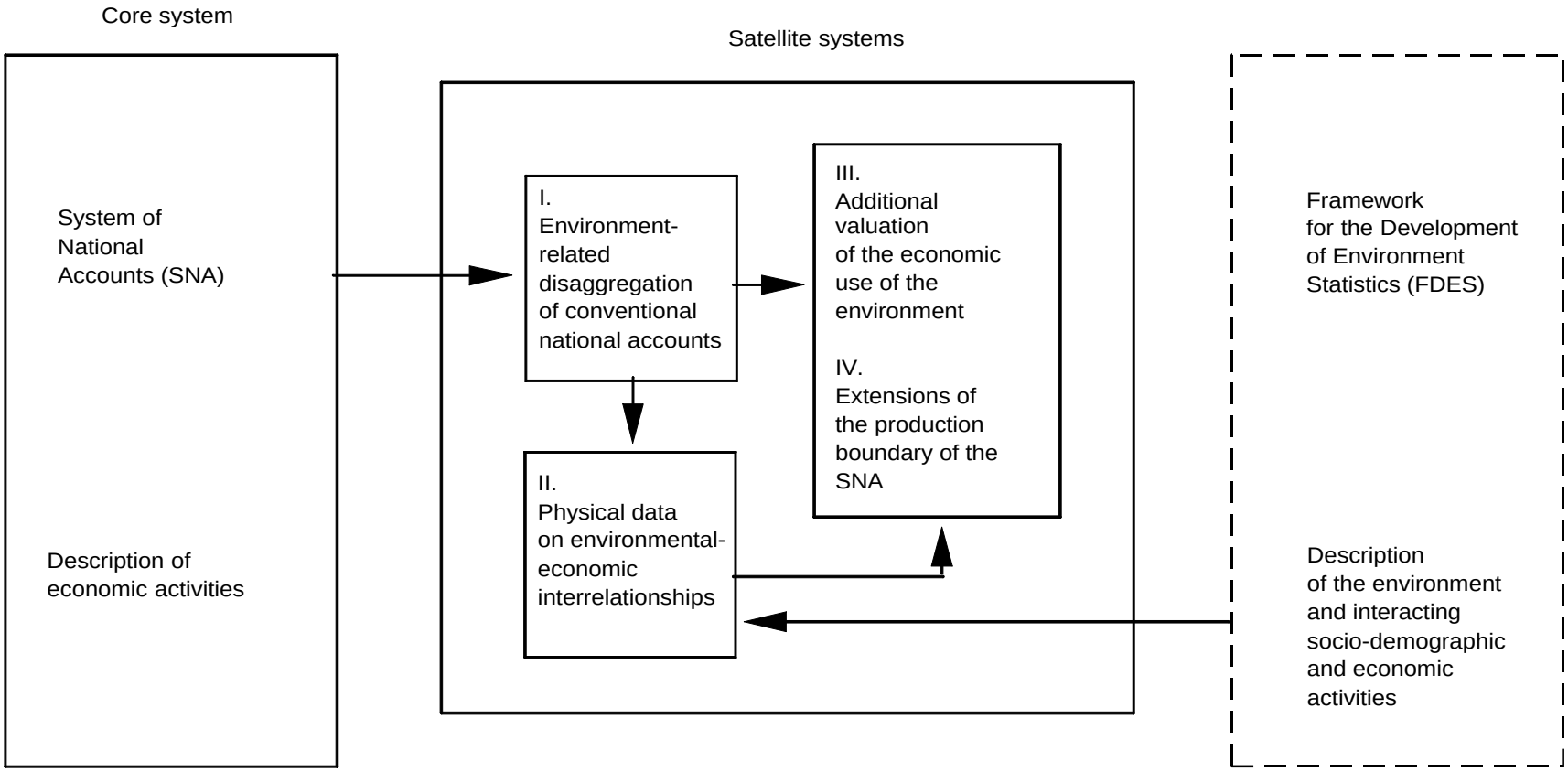
To trace the costs of complying with environmental regulation through the U.S. economy using an I-O framework requires first developing a scheme for classifying the various types of environmental costs.[5] The classification of any particular environmental control cost is important because it determines how the U.S. I-O tables are adjusted to account for that cost. The U.N.'s *Handbook for Integrated Environmental and Economic Accounting* (see U.N., 1993) provides some guidance for classifying EP activities in the economy. To follow the U.N. framework, it is assumed that all costs incurred due to environmental regulation can be traced to an EP activity. Once EP costs are classified and the I-O tables are adjusted, this information can be used to identify EP activities in the economy. These activities constitute the definition of the EP industry set forth in this study.

To disaggregate the monetary data associated with EP, the U.N. has proposed classifying environmental production and service activities into the following five categories: external EP activities, internal EP activities, fixed capital formation for EP, EP activities performed by households, and EP activities performed by governments. The U.N. has also illustrated application of this classification scheme in an I-O format.

External EP activities refers to establishments in which EP constitutes the main or secondary production activity. These activities can be either marketed or non-marketed. The key identifying characteristic of external EP activities is that they are delivered to other establishments, or a third party. External EP activities are represented as separate rows and columns in an I-O matrix. External EP activities include, for example, the services of solid waste management services and sewage treatment. Due to lack of information, remediation services are not treated as an external EP activity in this report.

Internal EP activities are for the establishment in which they are produced. Internal EP activities are ancillary activities analogous to administration or research and development activities. Internal EP activities are measured by inputs purchased for and combined as pollution abatement activity by a polluting industry. Internal EP activities are not separated from the main activities of an establishment, and in the I-O framework, are accounted for by separating out that portion of total inputs used by polluting industries for pollution abatement.

Figure 2.2: System for Integrated Environmental and Economic Accounting



Source: U.N., 1993

The category fixed capital formation for EP represents the accumulation of fixed assets or investment activities for EP. As an example, the purchase of a scrubber represents the accumulation of capital for air pollution abatement. Fixed capital formation for EP corresponds to gross private fixed domestic investment in the I-O format.

The final two categories, EP activities performed by households and governments are self-explanatory.

To classify the costs of complying with environmental regulation in the U.S., the U.N. classification scheme is followed as closely as possible. However, it should be noted that the measurement of foreign trade in EP equipment presents an additional set of difficulties. These difficulties and the actual measurement of EP trade are the subject of a separate report *International Trade in Environmental Protection Equipment: An Assessment of Existing Data* (U.S. EPA, 1993). In this study, the focus is on the domestic portion of the U.S. I-O tables.

2.3. MODIFICATION OF THE U.S. INPUT-OUTPUT TABLES

2.3.1. *Accounting for the Costs of Complying with Environmental Regulation*

The classification of EP costs according to the categories of external, internal, households, investment, and government serves as the basis for adjusting the U.S. I-O tables. The classification scheme determines where the EP costs are located within the input-output table (i.e., in which cells). Implicit in the procedure for adjusting the U.S. I-O tables is the assumption that EP costs are already embedded in the U.S. I-O tables published by the Bureau of Economic Analysis (BEA). The modification of the U.S. I-O tables involves isolating EP costs from the existing tables using supplementary information.

The categories for environmental control costs are now described in the I-O accounting framework. Referring to Figure 2.3a, expenditures on external EP activities is depicted as an additional row (i.e. the n+1 row in Figure 2.3a) in the standard I-O table. The entries in the shaded row, $X_{(n+1)I}$, represents the dollar value of purchases of external EP activities by the i^{th} industry. $Y_{(n+1)}$ represents purchases of goods and services from the external EP sector due to final demand expenditures.

Internal EP expenditures refers to the inputs purchased and combined as pollution abatement activity within a polluting firm. Generally, inputs used for internal pollution abatement activity are not separated from the primary activity of the polluting industry. The internal EP industry, then, is accounted for by separating out that portion of inputs used by polluting industries for pollution abatement. In Figure 2.3a, the inputs to internal EP activities, X_{ij}^{e}, and X_{ij}^{ne} are components of X_{ij}. X_{ij}^{e} represents the portion of input I used by industry j in internal EP activities and X_{ij}^{ne} is the amount of input I used in economic production. Note that in Figure 2.2, the notation X_{ij} was used to denote the total amount of input I used by industry j.

More specifically, it was assumed that X_{ij} includes the amount of input I used for purposes of pollution abatement by industry j. In addition, the value added associated with the EP activities of the internal EP industry, V_j^e, is a component of V_j. The primary distinction between external and internal EP expenditures is that internal expenditures are associated with pollution abatement activities performed within polluting industries. External expenditures are associated with the purchase of a complete EP activity from a third party.

The final three categories of EP costs are: household expenditures for EP, investment expenditures for EP, and government expenditures for EP. Note that these categories all represent an adjustment to final demand in the U.S. I-O table, which is depicted as the upper-right quadrant in Figure 2.3a. Final demand purchases for EP, Y_i^e, includes the U.N. categories of fixed capital formation (investment), consumption, and government expenditures for EP.

Figure 2.3b displays only the EP component of Figure 2.3a and is one of the I-O tables derived in Chapter 3. The sum of the i^{th} column, X_i^{e*}, in Figure 2.3b equals the total costs incurred by that sector due to environmental regulation. The sum of the i^{th} row, X_i^e, in Figure 2.3b equals the total demand for the output of the i^{th} sector due to EP activities. Hence, the row total represents the value of output of the i^{th} industry that is used for EP activities. Note that the row and column totals need not be equal in the EP costs I-O table. More specifically, the amount of, say, construction services used in EP activities does not imply that the construction sector engage in EP activities of equal value.

2.3.2. *The Modified I-O Tables as a Basis for Defining the Environmental Protection Industry*

Section 2.2.1 noted that one of the assumptions underlying this study is the assumption that all costs attributable to environmental protection activities can be traced to an EP activity. Under this assumption, the adjusted I-O tables identify EP activities in the economy. In this study, these EP activities constitute the definition of the EP industry.

Figure 2.4a depicts how the various types of EP activities are imbedded in the I-O framework while Figure 2.4b displays the EP industry I-O table. Figure 2.4b represents one of the I-O tables derived in Chapter 3. The difference between Figures 2.3a-2.3b and 2.4a-2.4b is that Figures 2.4a-2.4b include the inputs used in the production of external EP activities. Figure 2.3b, on the other hand, excludes inputs used in external EP activities, as these do not constitute EP costs *per se*. To include these in the I-O table which depict EP costs would lead to double counting.

Figure 2.3a

The BEA Input-Output Framework Modified to Separate Environmental Control Costs

TO FROM	1	2	. . .	n	(n+1)	Y	X
1	$X_{11}^{ne}+X_{11}^{e}$	$X_{12}^{ne}+X_{12}^{e}$	. . .	$X_{1n}^{ne}+X_{1n}^{e}$	$X_{1(n+1)}$	$Y_1^{ne}+Y_1^{e}$	$X_1^{ne}+X_1^{e}$
2	$X_{21}^{ne}+X_{21}^{e}$	$X_{22}^{ne}+X_{22}^{e}$		$X_{2n}^{ne}+X_{2n}^{e}$	$X_{2(n+1)}$	$Y_2^{ne}+Y_2^{e}$	$X_2^{ne}+X_2^{e}$
.	.			.	.	.	.
.	.			.	.	.	.
.	.			.	.	.	.
n	$X_{n1}^{ne}+X_{n1}^{e}$	$X_{n2}^{ne}+X_{n2}^{e}$	. . .	$X_{nn}^{ne}+X_{nn}^{e}$	$X_{n(n+1)}$	$Y_n^{ne}+Y_n^{e}$	$X_n^{ne}+X_n^{e}$
(n+1)	$X_{(n+1)1}$	$X_{(n+1)2}$	. . .	$X_{(n+1)n}$	$X_{(n+1)(n+1)}$	$Y_{(n+1)}$	$X_{(n+1)}$
V	$V_1^{ne}+V_1^{e}$	$V_2^{ne}+V_2^{e}$	. . .	$V_n^{ne}+V_n^{e}$	$V_{(n+1)}$		
X	$X_1^{ne*}+X_1^{e*}$	$X_2^{ne*}+X_2^{e*}$	. . .	$X_n^{ne*}+X_n^{e*}$	$X_{(n+1)}$		

Figure 2.3b

EP Costs Displayed in an Input-Output Framework

TO FROM	1	2	. . .	n	(n+1)	Y	X
1	X_{11}^{e}	X_{12}^{e}	. . .	X_{1n}^{e}		Y_1^{e}	X_1^{e}
2	X_{21}^{e}	X_{22}^{e}		X_{2n}^{e}		Y_2^{e}	X_2^{e}
.	.			.		.	.
.	.			.		.	.
.	.			.		.	.
n	X_{n1}^{e}	X_{n2}^{e}	. . .	X_{nn}^{e}		Y_n^{e}	X_n^{e}
(n+1)	$X_{(n+1)1}$	$X_{(n+1)2}$	. . .	$X_{(n+1)n}$	$X_{(n+1)(n+1)}$	$Y_{(n+1)}$	$X_{(n+1)}$
V	V_1^{e}	V_2^{e}	. . .	V_n^{e}			
X	X_1^{e*}	X_2^{e*}	. . .	X_n^{e*}	$X_{(n+1)(n+1)}$		

Figure 2.4a

The BEA Input-Output Framework Modified to Display the EP Industry

TO / FROM	1	2	. . .	n	(n+1)	Y	X
1	$X_{11}^{ne}+X_{11}^{e}$	$X_{12}^{ne}+X_{12}^{e}$	. . .	$X_{1n}^{ne}+X_{1n}^{e}$	$X_{1(n+1)}$	$Y_1^{ne}+Y_1^{e}$	$X_1^{ne}+X_1^{e}$
2	$X_{21}^{ne}+X_{21}^{e}$	$X_{22}^{ne}+X_{22}^{e}$		$X_{2n}^{ne}+X_{2n}^{e}$	$X_{2(n+1)}$	$Y_2^{ne}+Y_2^{e}$	$X_2^{ne}+X_2^{e}$
.	.			.	.	.	.
.	.			.	.	.	.
.	.			.	.	.	.
n	$X_{n1}^{ne}+X_{n1}^{e}$	$X_{n2}^{ne}+X_{n2}^{e}$	. . .	$X_{nn}^{ne}+X_{nn}^{e}$	$X_{n(n+1)}$	$Y_n^{ne}+Y_n^{e}$	$X_n^{ne}+X_n^{e}$
(n+1)	$X_{(n+1)1}$	$X_{(n+1)2}$	. . .	$X_{(n+1)n}$	$X_{(n+1)(n+1)}$	$Y_{(n+1)}$	$X_{(n+1)}$
V	$V_1^{ne}+V_1^{e}$	$V_2^{ne}+V_2^{e}$	. . .	$V_n^{ne}+V_n^{e}$	$V_{(n+1)}$		
X	$X_1^{ne*}+X_1^{e*}$	$X_2^{ne*}+X_2^{e*}$	. . .	$X_n^{ne*}+X_n^{e*}$	$X_{(n+1)}$		

Figure 2.4b

The EP Industry in an Input-Output Framework

TO / FROM	1	2	. . .	n	(n+1)	Y	X
1	X_{11}^{e}	X_{12}^{e}	. . .	X_{1n}^{e}	$X_{1(n+1)}$	Y_1^{e}	X_1^{e}
2	X_{21}^{e}	X_{22}^{e}		X_{2n}^{e}	$X_{2(n+1)}$	Y_2^{e}	X_2^{e}
.	.			.	.	.	.
.	.			.	.	.	.
.	.			.	.	.	.
n	X_{n1}^{e}	X_{n2}^{e}	. . .	X_{nn}^{e}	$X_{n(n+1)}$	Y_n^{e}	X_n^{e}
(n+1)	$X_{(n+1)1}$	$X_{(n+1)2}$	. . .	$X_{(n+1)n}$	$X_{(n+1)(n+1)}$	$Y_{(n+1)}$	$X_{(n+1)}$
V	V_1^{e}	V_2^{e}	. . .	V_n^{e}	$V_{(n+1)}$		
X	X_1^{e*}	X_2^{e*}	. . .	X_n^{e*}	$X_{(n+1)}$		

The presentation of EP activities as shown by Figure 2.4a has drawbacks, in practice. Specifically, the differing treatments of external and internal EP activities complicates the accounting method. To simplify the presentation of EP activities in the I-O tables, the U.N. has proposed "externalization" of the internal EP sector. Figure 2.5 provides a schematic representation of the externalization procedure. The process involves transferring the inputs associated with internal EP activities to the row and column in the I-O table that represents the external EP sector.

As shown by column (n+1) in Figure 2.5, all inputs associated with the production of the output of internal and external EP activities are included. Reading down column (n+1) gives the dollar value of each of the intermediate inputs used in pollution abatement activity in the economy. As shown by row (n+1), the inputs used for internal EP activities in each sector are aggregated with purchases of the output of the external EP sector. The individual entries in row (n+1) are the total operation and maintenance costs for EP undertaken by business sectors plus purchases of external EP services to satisfy final demand, $Y_{(n+1)}$.

2.4. IDENTIFICATION OF COMPONENTS OF THE ENVIRONMENTAL PROTECTION "INDUSTRY"

The conceptual framework outlined above is used to identify which activities in the U.S. economy constitute EP activities. In total, these EP activities form the definition of the EP industry. The EP activities included in the EP industry definition are now detailed.

2.4.1. *External Environmental Protection Activities*

External EP activities are the portion of the EP industry that is best defined by existing data sources. Sectors providing external EP services are included in the 1977 and 1982 benchmark (540 sector) I-O tables published by the BEA.[6] The primary difficulty in identifying external EP activities is that the 540 sector I-O tables are not sufficiently disaggregated.

External EP activities consist of the following three I-O sectors:

1. "Environmental" Water Supply (part of BEA I-O sector 68.0301)
2. Sewerage Systems (part of BEA I-O sector 79.0300)
3. Solid Waste Management Services (part of BEA I-O sector 68.0302)

Figure 2.5

Externalization of Internal Environmental Protection Activities

TO / FROM	1	2	. . .	n	(n+1)	Y	X
1	X_{11}^{ne}	X_{12}^{ne}	. . .	X_{1n}^{ne}	$\sum X_{1j}^{e} + X_{1(n+1)}$	$Y_1^{ne} + Y_1^{e}$	$X_1^{ne} + X_1^{e}$
2	X_{21}^{ne}	X_{22}^{ne}	. . .	X_{2n}^{ne}	$\sum X_{2j}^{e} + X_{2(n+1)}$	$Y_2^{ne} + Y_2^{e}$	$X_2^{ne} + X_2^{e}$
.	.			.	.	.	.
.	.			.	.	.	.
.	.			.	.	.	.
n	X_{n1}^{ne}	X_{n2}^{ne}	. . .	X_{nn}^{ne}	$\sum X_{nj}^{e} + X_{n(n+1)}$	$Y_n^{ne} + Y_n^{e}$	$X_n^{ne} + X_n^{e}$
(n+1)	$\sum X_{i1}^{e} + X_{(n+1)1} + V_1^{e}$	$\sum X_{i2}^{e} + X_{(n+1)2} + V_2^{e}$	. . .	$\sum X_{in}^{e} + X_{(n+1)n} + V_n^{e}$	$X_{(n+1)(n+1)}$	$Y_{(n+1)}$	$\sum\sum X_{ij}^{e} + \sum V_j^{e} + X_{(n+1)}$
V	V_1^{ne}	V_2^{ne}	. . .	V_n^{ne}	$\sum V_j^{e} + V_{(n+1)}$		
X	$X_1^{ne*} + X_1^{e*}$	$X_2^{ne*} + X_2^{e*}$	. . .	$X_n^{ne*} + X_n^{e*}$	$\sum\sum X_{ij}^{e*} + \sum V_j^{e} + X_{(n+1)}$		

These sectors involve activities unrelated to EP and the values that appear in the corresponding rows and columns in the U.S. I-O tables must be adjusted. Following EPA, expenditures for water supply which are unrelated to drinking water treatment are not considered EP expenditures.[7] Thus, expenditures unrelated to water treatment must be subtracted from I-O sector 68.0301 (Water Supply) to isolate EP expenditures. Other state and local government enterprises (BEA I-O 79.0300) includes, among other services, the operation of public sewage treatment plants. The expenditures associated with the services unrelated to public sewage treatment must be subtracted to adjust for expenditures unrelated to EP. The row and column corresponding to I-O sector 68.0302 (Sanitary Services, Steam Supply & Irrigation) must be adjusted to subtract steam supply, irrigation, and other non-solid waste abatement activities. This allows for isolation of the Solid Waste Management Services sector. These adjustments are described in more detail in Chapter 3 of this report.

2.4.2. *Sectors Whose Output is Used Solely for EP*

The output of the following three sectors is used exclusively in EP activities:

1. New Sewer System Facilities (11.0307 in the BEA I-O tables)
2. Sewer Facility Construction: Repair & Maintenance (BEA I-O sector 12.0210)
3. Industrial Air Pollution Control Equipment Industry (part of BEA I-O sector 49.0300)

Production in these sectors is not classified as an EP activity. However, the output of these sectors is purchased by other sectors and combined with other goods and services to perform EP activities. Also, the output of these sectors is used for no other purpose but EP.

Ideally, all sectors that produce pollution abatement goods and services would be isolated and reported separately. The primary difficulty with separating out these sectors is that some types of EP goods (e.g., chemicals) are used for both EP and non-EP activities. To isolate production of goods for EP activities, the output would need to be classified by end use, not by producing industry, as it is classified in the I-O tables. The one exception is industrial air pollution control equipment, which has its own SIC code (SIC 35646). Although the 540 sector I-O table corresponds to a 4-digit level of aggregation, other data sources, namely "Selected Industrial Air Pollution Control Equipment," (MA-35J) *Current Industrial Reports* (U.S. Department of Commerce, Bureau of the Census), are used to isolate the production of air pollution control equipment from the published I-O tables. Expenditures unrelated to air pollution control equipment are subtracted from I-O 49.0300 (Blowers and Fans).

2.4.3. *Internal Environmental Protection Activities*

2.4.3.1. Inputs to Abate Pollution Within the Production Process

Inputs, except for the intermediate inputs purchased from the external EP industry, are difficult to isolate. The expenditures associated with pollution abatement activities that firms perform for their own use are typically lumped with other production expenditures. Defining the internal EP sector consists of separating the expenditures associated with pollution abatement from other expenditures incurred in the production process.

Expenditures on inputs to abate pollution within the production process, or the operation and maintenance expenditures associated with pollution abatement, consist of two components:

1. Value added, which is comprised of labor, depreciation, and indirect business taxes.
2. Intermediate inputs, which are the quantities of output purchased from other sectors to be used in performing EP activities.

There are three components of value added in the I-O table: payments to labor, depreciation, and indirect business taxes. For manufacturing sectors, the U.S. Department of Commerce (Bureau of the Census), *Current Industrial Reports* (MA-200), reports data on labor and depreciation expenses associated with pollution abatement at the 4-digit SIC industry level.[8]

As for the final component of value-added, indirect business taxes, the 1980 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) introduced environmental excise taxes on the petro-chemical, inorganic chemical and petroleum industries to provide a source of funds for Superfund. After its expiration, the Superfund Amendment and Reauthorization Act of 1986 (SARA) reimposed the excise taxes. The environmental excise tax is paid by the petroleum and the chemical industries. In addition, an additional tax on fuel is imposed for the Leaking Underground Storage Tank Trust Fund.

The MA-200 report also includes data on other operation and maintenance costs, or more specifically "materials and supplies" and "services and other costs" used for pollution abatement, which can be used to approximate expenditures on intermediate inputs. To allocate the broad category of "materials" expenditures to the specific intermediate inputs, it is necessary to follow a procedure similar to Ketkar (1980, 1983a, 1983b, 1984). In Ketkar's work, engineering studies and information obtained from surveys of polluting industries are used to compute the percentage of total operating costs allocated to the input categories of: electricity, labor, solid waste collection, equipment leasing, chemicals, depreciation, etc. The details of the procedures for disaggregating "materials" expenditures is discussed in Chapter 3 of this report.

For nonmanufacturing sectors, the BEA data are less detailed. Data reported for manufacturing industries are used to derive much of the data for expenditure patterns for nonmanufacturing. Again, Chapter 3 provides a more detailed explanation of the sources for allocating expenditures for intermediate inputs for air, water and solid waste pollution abatement in both manufacturing and nonmanufacturing sectors.

2.4.3.2. Intermediate Input Expenditures by Business for Motor Vehicles

EPA and BEA report expenditures by business for abating the pollution from motor vehicles. For these expenditures, there is a durable goods and nondurable goods and services (current account) component. The nondurable component, which consists of a fuel economy penalty, a fuel price penalty, and maintenance expenditures, is classified as an intermediate input expenditure. Within the I-O framework, the fuel economy penalty and fuel price penalty are classified as Petroleum Refining and Related Industries (BEA I-O sector 31.0101). The motor vehicle maintenance expenditure is an intermediate input expenditure on Automotive Exhaust System Repair Shops (BEA I-O sector 75.0002). This sector includes the repair, installation, or sales and installation of automotive catalytic converters. Both BEA and the MA-200 survey exclude these expenditures from their calculations of plant operation and maintenance EP expenditures by business. The BEA lists these business maintenance expenditures for motor vehicles under the motor vehicles category.

2.4.4. *Household Environmental Protection Activities*

The BEA defines two categories of EP expenditures by households: motor vehicle pollution abatement and septic systems. For each category, there is a durable and nondurable goods and services component. Both the durable (capital) and nondurable (current account) goods and services components for motor vehicles are classified as household consumption expenditures, while only the nondurable component for septic systems is classified as consumption expenditures. The durable component for septic systems is classified as household investment expenditures and is discussed below.

Durable goods expenditures by households for motor vehicles are the initial cost of pollution abatement equipment. Capital account expenditures include catalytic converters, the devices used to abate motor vehicle air pollution emissions. The expenditures associated with autos and trucks are assigned to consumption expenditures for motor vehicles and car bodies (BEA I-O sector 59.0301). The expenditures associated with motorcycles are assigned to consumption expenditures for motorcycles, bicycles, and parts (BEA 61.0500)

Nondurable expenditures for motor vehicles is composed of: a fuel economy penalty, a fuel price penalty, and maintenance costs. The fuel economy penalty and fuel price penalty are classified as consumption expenditures for Petroleum Refining and Related industries (BEA I-O sector 31.0101). The motor vehicle maintenance cost is assigned to consumption expenditures

of Automotive Exhaust System Repair Shops (BEA I-O sector 75.0002). This sector includes the installation, repair, or sales and installation of automotive catalytic converters.

Finally, septic system cleaning, which BEA classifies as an EP expenditure for nondurable goods and services, is assigned to consumption expenditures of Repair Shops and Related Services, NEC (BEA I-O 73.0101), which includes sewer cleaning and rodding.

2.4.5. *Investment Activities for Environmental Protection*

2.4.5.1. Households

Household investment expenditures for EP are defined as the durable good expenditures for septic tanks, septic systems, and connectors to public sewer systems. These expenditures are classified as investment expenditures since the purchase of housing is classified as an investment expenditure. Septic tanks and septic systems are assigned to New Residential Construction (BEA I-O sectors 11.0101 through 11.0105, inclusive). The connectors to sewer systems are assigned to New Sewer System Facilities (BEA I-O 11.0307).

2.4.5.2. Businesses

Business investment expenditures for pollution abatement include expenditures for motor vehicles as well as for production processes. Business expenditures associated with emission devices (durable goods) for autos and trucks are assigned to investment expenditures on motor vehicles and car bodies (BEA I-O sector 59.0301). The expenditures associated with airplanes are assigned to investment expenditures on aircraft (BEA 60.0100)

Other industry investment expenditures for EP are more difficult to classify. BEA, EPA, and the MA-200 report total capital expenditures for air, water, and solid waste pollution abatement. The expenditures reported in these sources, however, are not disaggregated into specific I-O categories (e.g., construction, equipment, etc.). As is the case for intermediate materials inputs, engineering studies must be used. Chapter 3 provides a detailed description of specific data sources as well as the procedures applied in the estimation of the patterns for investment expenditures for pollution abatement.

2.4.6. *Government Environmental Protection Activities*

Five categories of activities in the U.S. I-O tables embody purchases that constitute the government purchases of goods and services for EP activities:

1. State and Local Government Purchases for Sewerage (BEA I-O 99.1003)
2. State and Local Government Purchases for Sanitation (BEA I-O 99.1004)
3. State and Local Government Purchases for Highways (part of BEA I-O 99.3001)

4. State and Local Government Purchases for Water (part of BEA I-O 99.3006)
5. State and Local Government Purchases for Natural and Agricultural Resources and Recreation (part of BEA I-O 99.3008)

The categories of purchases for water supply and sewerage by government are solely capital expenditures. Operation and maintenance expenditures related to water supply and sewerage are captured by other sectors discussed in Section 2.4.1.

Following EPA and BEA, all state and local government purchases for sewerage (BEA I-O 99.1003) are counted as EP expenditures. EPA counts all state and local government purchases for sanitation (I-O 99.1004) as EP expenditures, while BEA counts only a percentage (see Farber and Rutledge, 1989, p. 18). The EPA convention is followed in this report. BEA assumes that federal, state, and local government expenditures to prevent highway erosion are a percentage of highway construction and engineering capital expenditures (see Rutledge and Leonard, 1992). Since virtually all expenditures for highway erosion abatement are by state and local government, state and local government purchases for highways (BEA I-O 99.3001) is used to account for these expenditures. This report uses the BEA dollar value to determine the fraction of government highway expenditures that are for EP activities.

The BEA does not count government expenditures for water as environmental expenditures. The EPA (1990, p. F-17) argues that the portion of expenditures by state and local government purchases for water (BEA I-O 99.3006) that are for water treatment should be classified as EP expenditures and includes 18.4 percent of capital expenditures for water. This report uses the EPA fraction to determine the amount of capital expenditures for drinking water that are labeled as EP expenditures.

The EPA (1990, p. F-7) also counts 20 percent of state and local government natural resource expenditures (capital and operation and maintenance) as EP expenditures. BEA, in contrast, excludes all government expenditures for natural resources from its calculation of EP expenditures. This report uses the EPA dollar value to determine the percentage of expenditures for natural resources that are counted as EP expenditures.

2.5. SUMMARY

In this study, the EP industry is defined by tracing the costs of complying with environmental regulation through the U.S. economy. The accounting framework applied is the input-output (I-O) transaction matrix.

Within the I-O framework, five categories of pollution abatement activities have been identified. External EP activities are EP goods and services purchased from third parties. Internal EP activities are the EP services firms perform for own purposes. The third, fourth, and fifth categories of EP activities are EP activities performed by households, EP investment

activities, and EP activities performed by governments. Table 2.1 summarizes the activities included in each of these categories as well as the primary data sources. Chapter 3 of this report will describe, in excruciating detail, the process for generating estimates for each of the components of the EP industry in 1982.

Table 2.1

Summary of Environmental Protection (EP) Industry Components

EP Industry Component	Subcomponent	Description (Data Source)	Notes
External		I-O sector 68.0301 (Water Supply & Sewerage Systems)	Adjust row and column in I-O table to isolate expenditures for water treatment.
		I-O sector 79.0300 (Other State and Local Government Enterprises)	Adjust row and column in I-O table to isolate expenditures for sewerage services.
		I-O sector 68.0302 (Sanitary Services, Steam Supply, & Irrigation)	Adjust row and column in I-O table to isolate expenditures for solid waste management services.
Sectors Whose Output is Used Solely for EP		I-O sector 11.0307 (New Sewer System Facilities)	Take directly from the I-O table.
		I-O sector 12.0210 (Repair & Maintenance of Sewer Facilities)	Take directly from the I-O table.
		I-O sector 49.0300 (Blowers and Fans)	Adjust row and column in I-O table to isolate industrial air pollution control equipment.
Internal	Inputs (Value-added)	MA-200 for labor and depreciation; IRS publication for indirect business taxes	No data source that corresponds to MA-200 for nonmanufacturing sectors.

Table 2.1 (continued)

Component	Subcomponent	Description	Notes
Internal	Inputs (Production Process)	MA-200 reports for other operation and maintenance expenditures.	Engineering studies to disaggregate "materials" expenditures; no data source that corresponds to MA-200 for nonmanufacturing sectors.
	Inputs (Motor Vehicles)	Fuel economy penalty, fuel price penalty, and maintenance expenditure (nondurable component)	Data reported by both EPA and BEA. Use EPA estimates and BEA technique to determine business share of motor vehicle EP operation and maintenance expenditures.
Households		Household expenditures for motor vehicles (durable and nondurable components) and septic systems (nondurable component).	Data reported by both BEA and EPA. Use EPA estimate and BEA technique to determine household share of motor vehicle EP equipment and operation and maintenance expenditure.
Investment	Households	Household investment for environmental protection is the durable good component of expenditures for septic tanks, septic systems, and connectors to public sewer systems (durable component).	Reported by BEA and I-O table.
	Businesses	Business investment for environmental protection is 1) durable component for motor vehicles and 2) capital expenditures for air, water, and solid waste.	1)See household expenditures for motor vehicles. 2) Data reported by BEA, EPA, and in MA-200. Use BEA and MA-35J data and engineering studies for air, water, and solid waste capital expenditures.

Table 2.1 (continued)

Component	Subcomponent	Description	Notes
Government		I-O sector 99.3001 (State and Local Government Purchases for Highways)	Count a fraction of the column in the I-O table; the fraction determined by BEA dollar value.
		I-O sector 99.1003 (State and Local Government Purchases for Sewage)	Take directly from I-O table.
		I-O sector 99.1004 (State and Local Government Purchases for Sanitation)	Take directly from I-O table.
		I-O sector 99.3006 (State and Local Government Purchases for Water)	Count a fraction of the column in the I-O table; the fraction determined by EPA.
		I-O sector 99.3008 (State and Local Government Purchases for Natural and Agricultural Resources and Recreation)	Count a fraction of the column in the I-O table; the fraction determined by EPA dollar value.

Notes:
EPA data refers to data reported in *Environmental Investments: The Cost of a Clean Environment*.
BEA data refers to data reported in *Survey of Current Business*.
MA-200 data refers to data reported by the U.S. Department of Commerce (Bureau of the Census) in *Current Industrial Reports*.
MA-35J data refers to data reported by the U.S. Department of Commerce (Bureau of the Census) in *Current Industrial Reports*.

Notes for Chapter 2

1. At this point, the distinction between "costs" and "expenditures" warrants clarification. The term expenditure is usually refers to tangible out-of-the pocket expenses while cost is a broader economic costs. For example, depreciation typically is not referred to as an expenditure because no transaction is associated with this expense. Depreciation is, however, a cost.

2. In addition, environmental fees, taxes, and penalties do not count has EP industry revenues.

3. For a detailed discussion of the complications and idiosyncracies of various estimates of the size of the EP industry, see the OTA (1994) report, *Industry, Technology, and the Environment: Competitive Challenges and Business Opportunities* (pp. 75-79 and 97-99).

4. For an in-depth description of the SEEA, see United Nations, 1993.

5. In reality environmental protection costs/expenditures/activities consist of two types: those that reduce pollution and those that reduce the effects of pollution. This study focuses on the first type.

6. The benchmark input-output table refers to input-output tables constructed for those years in which an economic census takes place.

7. The EPA (1990, p. F-3) has determined that 12.4 percent of operation and maintenance expenditures for drinking water are for water treatment.

8. Throughout this report "BEA data" will refer to data reported in *Survey of Current Business* while "MA-200 data" will refer to data reported by the U.S. Department of Commerce (Bureau of the Census) in "Pollution Abatement Costs and Expenditures" *Current Industrial Reports*, unless otherwise noted. Also, unless otherwise noted, "EPA data" will refer to data reported in *Environmental Investments: The Cost of a Clean Environment*.

3. THE ENVIRONMENTAL PROTECTION INPUT-OUTPUT TABLES

The purpose of this chapter is to generate the data needed to fill the cells of the environmental protection (EP) input-output (I-O) matrices as well as to document all data sources and data construction techniques. Attention has been focused upon 1977 and 1982 since these were the two most recent economic census years for which benchmark I-O tables had been compiled during the time this report was written. The BEA I-O table, "The Use of Commodities by Industries" forms the basis of this report. The 540 sector I-O table is first aggregated to 41 sectors. Table 3.1 lists the sectors in the EP I-O tables. The detailed concordance of the 41 sector table to the 540 sector "The Use of Commodities by Industries" table is presented in Appendix A.

3.1. EXTERNAL ENVIRONMENTAL PROTECTION ACTIVITIES

The three external EP sectors are: "environmental" water supply (I-O 35), sewerage systems (I-O 36), and solid waste management services (I-O 37). These three I-O sectors are derived from information contained in the U.S. I-O tables. "Environmental" water supply is part of BEA I-O sector 68.0301 (private water supply and sewerage systems), sewerage systems is part of BEA I-O sector 79.0300 (other state and local government enterprises), and solid waste management services is part of BEA I-O sector 68.0302 (sanitary services, steam supply, and irrigation). The procedures for deriving estimates of these activities are discussed below. The EP I-O tables are generated for both 1977 and 1982. However, for illustrative purposes, the discussion focuses on 1982.

3.1.1. The Secondary Production Problem

The starting point for constructing the EP I-O tables is the BEA I-O table, "The Use of Commodities by Industries." The row entries in this table represent commodities while the column entries represent industries. Reading across any row "I," each entry represents the dollar value of commodity "I" sold to each industry or purchased as final demand. Reading down any column "j," each entry is the dollar value of the commodities purchased as intermediate inputs for producing the output of industry "j." If each industry only produces one commodity and each commodity is produced by only one industry, (i.e., if there is no secondary production), then the row and column totals will be equal. The primary difficulty in extracting EP expenditures from sectors 68.0301, 68.0302, and 79.0300 is this secondary production problem.

The first step in isolating EP activities in sectors 68.0301, 68.0302, and 79.0300 is to start with a control total for the output of the individual EP activities. This control total is derived using additional sources of information, generally data on EP expenditures published by EPA or BEA. The next step is to generate the individual row and column entries that correspond to this control total. The row entries are determined by the ratio of the EP control total to the

Table 3.1 Input-Output Sectors

Code	Description
1	Agriculture, forestry, and fisheries
2	Mining
3	Construction
4	Food and kindred products
5	Tobacco manufactures
6	Textile mill products
7	Apparel and other textile products
8	Lumber and wood products
9	Furniture and fixtures
10	Paper and allied products
11	Printing and publishing
12	Chemicals and allied products
13	Petroleum refining
14	Rubber and plastic products
15	Leather and leather products
16	Stone, clay and glass products
17	Primary metals
18	Fabricated metal products
19	Machinery, except electrical
20	Electrical machinery
21	Motor vehicles
22	Other transportation equipment
23	Instruments

Table 3.1 (continued)

Code	Description
24	Miscellaneous manufacturing
25	Transportation and warehousing
26	Communication
27	Electric utilities
28	Gas utilities
29	Trade
30	Finance, insurance and real estate
31	Other services
32	Government enterprises
33	New sewer system facilities (construction)
34	Maintenance and repair of sewer facilities (construction)
35	Water supply (“environmental”)
36	Sewerage systems
37	Solid waste management services
38	Industrial air pollution control equipment
39	Noncomparable imports and scrap
40	Government industry
41	Other industry
Nonenvir. PCE	“Nonenvironmental” Personal consumption expenditures (PCE)
Envir. PCE	“Environmental” PCE
Nonenvir. GPFI	“Nonenvironmental” Gross private fixed investment (GPFI)
Envir. GPFI	“Environmental” GPFI

Table 3.1 (continued)

Code	Description
Inventory	Change in inventories
Exports	Exports
Imports	Imports
Nonenvir. G.	"Nonenvironmental" government expenditures
Sewer.	State and local purchases, sewerage
Sanit.	State and local purchases, sanitation
Water Supply	State and local purchases, "environmental" water supply
Highways	State and local purchases, highways (erosion, "environmental" component)
Natural Resources	State and local purchases, natural resources ("environmental")

associated sector row total. Because of the secondary production problem, determining the individual column entries is more difficult. First, the industries that produce *commodities* 68.0301, 68.0302, and 79.0300 must be determined. This information, shown in Table 3.2, is reported in the U.S. I-O tables. The next step is to identify the inputs used by each of the industries to produce each of the EP commodities, and this is done by making use of the industry technology assumption (discussed in Section 3.1.2). The inputs are aggregated by commodity so that the row and column totals are equal for each of the external EP activities sectors. A detailed description of this procedure is now provided for each of the external EP activities sectors.

Table 3.2

Producing Industries for Commodities Classified as External EP Activities

Commodities	Producing Industries	1977 Value (millions)	1982 Value (millions)
68.0301	TOTAL	6,389.4	10,778.6
	68.0100	8.5	
	68.0301	1,122.8	1,777.6
	78.0200	1.4	
	78.0400	3.7	
	79.0300	5,253.0	9,001.0
68.0302	TOTAL	4,349.4	6,793.2
	65.0300	1,264.2	1,758.5
	68.0100	74.7	103.1
	68.0302	3,001.1	4,659.9
	79.0300	9.4	271.7
79.0300	TOTAL	4,961.1	9,425.7
	68.0301	53.8	107.7
	79.0300	4,907.3	9,318.0

3.1.2. *"Environmental" Water Supply*

The EP component of BEA I-O sector 68.0301 consists of the component of water supply associated with water treatment services. According to the I-O sector description (see U.S. Department of Commerce, BEA, 1991, p.71), sector 68.0301 also includes private sewerage services. However, for purposes of constructing the EP I-O tables, it was assumed that all sewage treatment services are publicly provided. Hence, it was assumed that the output of sector 68.0301 consists only of water supply.[1]

Following EPA, the percentage of operation and maintenance expenditures for water supply that are for water treatment were counted as EP expenditures. Total output of "environmental" water supply was estimated by multiplying the output of commodity 68.0301 by 0.124, EPA's estimate of the proportion of water supply expenditures that are for water treatment (U.S. EPA 1990, p. F-3). For 1982, multiplying the value of the output of commodity 68.0301 ($10,778.6 million) by 0.124, yielded a value of $1,336.5 million for the "environmental" component of water supply. The row entries for "environmental" water supply were determined by multiplying each cell associated with commodity (row) 68.0301 by 0.124.

In order to generate column entries for "environmental" water supply, the industries that produce commodity 68.0301 were determined. Table 3.2 shows that, in 1982, commodity 68.0301 was produced by industries 68.0301 and 79.0300. To assist in isolating the inputs used by industry 79.0300 to produce commodity 68.0301, the industry technology assumption was adopted; it was assumed that all commodities produced by an industry are produced with the same production function. Likewise, when the same commodity is produced in different industries, it is produced with different production technologies.

Table 3.2 shows that, in 1982, 16.5 percent of commodity 68.0301 was produced by industry 68.0301 and 83.5 percent of commodity 68.0301 was produced by industry 79.0300. The output of "environmental" water supply was allocated to industries 68.0301 and 79.0300 according to these percentages. Using this method, industry 68.0301 produced $220.4 million and industry 79.0300 produced $1,116.1 million of "environmental" water supply (see Section 3.1.3 for a more detailed discussion of issues related to industry 79.0300).

For 1982, the I-O tables report the output of industry 68.0301 at $1,885.3 million and output of industry 79.0300 at $28,566.1 million. Using the values derived above, "environmental" water supply constitutes 11.7 percent of the total output of industry 68.0301 and 3.9 percent of the output of industry 79.0300. The inputs used to produce "environmental" water supply were isolated by multiplying each column cell entry for industries 68.0301 and 79.0300 by the percentage of "environmental" water supply in total industry output (11.7 for industry 68.0301 and 3.9 for industry 79.0300).

One adjustment to the procedure for isolating inputs to "environmental" water supply for industry 79.0300 was made. First, note from Table 3.2, industry 79.0300 produced commodities 68.0301, 79.0300, and 68.0302. Production of all or part of these three commodities represents an EP activity. Production of the EP components of commodities 79.0300 and 68.0302 by industry 79.0300 is discussed in Sections 3.1.3 and 3.1.4. Next, from the published I-O table, the entire output of commodity 12.0210 (Maintenance and Repair of Sewer Facilities) was purchased by industry 79.0300. It was assumed that all of the output of commodity 12.0210 ($3,088.1 million) was purchased as an input to sewerage services. As a consequence, the input values for industry 79.0300 for each EP activity as well non-EP activities were re-weighted. After re-weighting, 4.49 percent of all other inputs purchased by industry 79.0300 were used to produce "environmental" water supply (see Sections 3.1.3 and 3.1.4 for further discussion).

The two columns resulting from these computations when added together, are the inputs required to produce "environmental" water supply. The residual (i.e., the "nonenvironmental") expenditures for water supply and the inputs used by the water supply industry which are not for water treatment were assigned to Other Services (I-O sector 31).

3.1.3. *Sewerage Systems*

The EP component of I-O sector 79.0300 consists of sewerage services. I-O sector 79.0300 includes, among other things, publicly provided sewerage services (Ritz 1980, p. 18). Recall from Section 3.1.2, it has been assumed that all sewage treatment services are publicly provided. It follows that all sewerage services produced in the economy are in commodity 79.0300. The control total for 79.0300 (i.e., operation and maintenance expenditures by government enterprises for sewerage) was obtained from information published by the BEA.[2] The BEA (see Rutledge and Vogan 1994, p. 48) reports expenditures for sewerage of $5,159 million in 1982.

The row entries, or the use of sewerage services by various sectors, were determined as follows. The MA-200 report (U.S. Department of Commerce, Bureau of the Census, *Current Industrial Reports*) provides manufacturing payments to government for sewerage ($539.3 million). This report uses the MA-200 values as the cell values for purchases of sewerage services by the various manufacturing sectors. However, the MA-200 does not report payments by nonmanufacturing sectors and final demand. To derive estimates of payments by nonmanufacturing sectors and final demand, total manufacturing purchases of sewerage services ($539.3 million) were first subtracted from the total purchases of sewerage services ($5,159 million). The residual represents expenditures for sewerage by all other sectors of the economy and was distributed among nonmanufacturing sectors ($920.2 million) and households (i.e. personal consumption expenditures) in proportion to purchases of commodity 79.0300. The only final demand category to which purchases of sewerage services were assigned is personal consumption expenditures (PCE). The value assigned to PCE is $3,699.5 million.

According to Table 3.2, commodity 79.0300 was produced by industries 68.0301 and 79.0300 in 1982, with 1.1 percent produced by industry 68.0301 and 98.9 percent produced by industry 79.0300. These percentages were used to allocate production of sewerage services to industries 68.0301 and 79.0300. Using this method, $56.7 million of sewerage services were produced by industry 68.0301 and $5,102.3 million were produced by industry 79.0300.

To isolate the inputs used by industries 79.0300 and 68.0301 to produce commodity 79.0300, the industry technology assumption was once again adopted (see section 3.1.2. for a discussion of this assumption). For 1982, the I-O tables report the output of industry 68.0301 at $1,885.3 million and the output of industry 79.0300 at $28,566.1 million. Sewerage services constituted 3 percent of the output of industry 68.0301 and 17.9 percent of the output of industry 79.0300. The inputs used by industry 68.0301 to produce sewerage services were isolated by multiplying each column entry for industry 68.0301 by the percentage of the total output of industry 68.0301 accounted for by sewerage services (3 percent). The inputs used by industry 79.0300 to produce sewerage services were isolated by multiplying each column cell for industry 79.0300 by the percentage of the total output of industry 79.0300 accounted for by sewerage services (17.9 percent).

One adjustment to the procedure for isolating inputs to sewerage services for industry 79.0300 was made. Recall from Section 3.1.2 and from Table 3.2, industry 79.0300 produces commodities 68.0301, 79.0300, and 68.0302. Also, it was assumed that all of the output of commodity 12.0210 (maintenance and repair of sewer facilities) was purchased by industry 79.0300 as an input to sewerage services and the input values discussed above were re-weighted. As a consequence of re-weighting, 7.9 percent of all other inputs purchased by industry 79.0300 were used to produce sewerage services, the environmental portion of commodity 79.0300.

The portion of BEA I-O industry 79.0300 inputs that are not part of EP activities were assigned to Government Enterprises (I-O 32).

3.1.4. *Solid Waste Management Services*

The EP portion of BEA I-O sector 68.0302 consists of solid waste management services (I-O 37), which is part of sanitary services. In addition to sanitary services, sector 68.0302 includes steam supply and irrigation activities. According to the 1982 I-O table, the output of commodity 68.0302 was $6,793.2 million. Two sources of information were used to generate the control total for the output of solid waste management services: data published by the BEA and data reported in the MA-200.

The BEA reports that private solid waste disposal expenditures were $5,106.9 million in 1982.[3] According to Farber and Rutledge (1989, p. 14) these values are expenditures for "... private contract and self-service disposal of solid waste." The BEA value, then, provides an estimate of total expenditures on solid waste pollution abatement.[4] The total includes not only

solid waste management services but also the operation and maintenance expenditures associated with solid waste pollution abatement. Operation and maintenance expenditures for solid waste pollution abatement must be subtracted from the BEA total to get expenditures for solid waste management services. The BEA value excludes depreciation costs associated with private solid waste disposal.

The MA-200 provides estimates of labor, materials, depreciation, and services expenses for solid waste pollution abatement for manufacturing sectors. Expenditures for services ($855.5 million) were assumed to consist of purchases of solid waste management services. Section 3.3.3 describes the procedure for deriving estimates of labor, materials, and depreciation expenses for solid waste pollution abatement for nonmanufacturing sectors. Labor and materials expenses for manufacturing ($562.4 million) and nonmanufacturing sectors ($193.3 million) were subtracted from the BEA total to get a control total, which is the amount of solid waste management services purchased by manufacturing sectors, nonmanufacturing sectors, and households ($4,238.2 million). Of this total, $855.5 million (the MA-200 value for solid waste management services) is by manufacturing sectors. Thus, expenditures (excluding depreciation) by nonmanufacturing sectors and households totaled $3,382.7 million in 1982.

Next, the individual entries representing the use of solid waste management services by all sectors in the economy were derived. For manufacturing sectors, the MA-200 reports total purchases of solid waste services (by industry) and these values were used as the row entries. For nonmanufacturing sectors and households, the total value of purchases of solid waste management services ($3,382.7 million) was divided by total purchases of commodity 68.0302 ($4,126.8 million) to form the proportion 0.82. This proportion is the percentage of total expenditures on commodity 68.0302 which are classified as EP, and was applied across the row in the I-O table which represents purchases of commodity 68.0302 for nonmanufacturing sectors and households.

To isolate the inputs used for producing solid waste management services, the industries that produce commodity 68.0302 were determined. Table 3.2 shows that 25.9 percent was produced by industry 65.0300, 1.5 percent by industry 68.0100, 68.6 percent by industry 68.0302, and 4 percent by industry 79.0300. Production of solid waste management services ($4,238.2 million) was allocated across industries 65.0300, 68.0100, 68.0302, and 79.0300 on the basis of these shares. The inputs to solid waste services were assigned on the basis of the percentage of total industry output accounted for by solid waste services. Equivalently, the industry technology assumption was used. Table 3.3 lists the producing industries for solid waste management services, total industry output, total amount of solid waste management services produced, and solid waste management services as a percentage of industry output.

Table 3.3

Total Production and Producing Industries for Solid Waste Management Services

Industry	Industry Output (millions of dollars)	Total Amount of Solid Waste Services Produced (millions of dollars)	Share of Solid Waste Services in Industry Output
65.0300	$74,190.4	$1,097.1	1.5%
68.0100	104,172.3	$64.3	0.1%
68.0302	4,659.9	$2,907.3	62.4%
79.0300	28,566.1	$169.5	0.6%

As for "environmental" water supply and sewerage services, an adjustment to the procedure for isolating inputs to solid waste management services for industry 79.0300 was made. Recall from Sections 3.1.2 and 3.1.3, it was assumed that all of the output of commodity 12.0210 (Maintenance and Repair of Sewer Facilities) was purchased by industry 79.0300 as an input to sewerage services. As a consequence, all input values derived using the industry technology assumption were re-weighted. After re-weighting, 0.67 percent of all other inputs purchased by industry 79.0300 were used to produce solid waste management services.

The columns of inputs used by each of the industries 68.0302, 65.0300, 68.0100, and 79.0300 for producing solid waste management services added together provide the total inputs required to produce the output of the Solid Waste Management Services sector (I-O sector 37). The inputs used to produce non-EP commodity 68.0302 by industries 65.0300 and 68.0100 were placed in I-O sectors 25 and 27, respectively. These are the I-O sectors that contain industries 65.0300 and 68.0100 in the original aggregation of the 540 sector I-O table. The inputs used by industry 68.0302 to produce non-EP commodity 68.0302 were assigned to Other Services (I-O 31). Finally, the inputs used by industry 79.0300 for production of nonenvironmental commodity 68.0302 were assigned to Government Enterprises (I-O sector 32).

3.2. SECTORS WHOSE OUTPUT IS USED SOLELY FOR EP

The output of the following three sectors is used exclusively for EP activities:

1. New Sewer System Facilities (BEA I-O sector 11.0307)
2. Sewer Facility Construction: Repair & Maintenance (BEA I-O sector 12.0210)
3. Industrial Air Pollution Control Equipment Industry (part of BEA I-O sector 49.0300).

While production in these sectors is not classified as an EP activity, they are discussed separately since their output is purchased by other sectors and combined with other goods and services to perform EP activities.

3.2.1. *Environmental Construction Sectors: New Sewer System Facilities and Repair and Maintenance of Sewer Facilities*

The output values and associated row and column entries for BEA I-O sectors 11.0307 (New Sewer System Facilities) and 12.0210 (Sewer Facility Construction: Repair and Maintenance) were taken directly from the I-O tables. There is no secondary production associated with either of these sectors.

However, it should be noted that a difficulty in reconciling the values in the I-O tables and those reported by BEA was encountered. BEA (Rutledge and Vogan 1994, p. 48) reports government enterprise purchases of fixed capital for water (public sewer systems) at $6,407 million in 1982, which is less than the output of commodity 11.0307 of $8,524.7 million. Of the $8,524.7 million reported for commodity 11.0307 in the I-O table, $2,454.2 million is purchased for Gross Private Fixed Investment (GPFI). It was assumed that the primary reason for the discrepancy is that BEA classifies GPFI expenditures associated with commodity 11.0307 under its category "Capital Expenditures for Water Pollution Abatement," and does not include GPFI in its total for government enterprise fixed capital. Sections 3.5.1 and 3.5.2 discuss how purchases of commodity 11.0307 for GPFI are addressed in this study in further detail.

3.2.2. *Industrial Air Pollution Control Equipment*

For air pollution control equipment, the Department of Commerce publication, "Selected Industrial Air Pollution Control Equipment," (MA35J) lists the value of the shipments of SIC product code 35646 (air pollution control equipment). The value of shipments for air pollution control equipment was used to calculate the proportion of the total value of the industry output of Blowers and Fans (I-O 49.0300) accounted for by air pollution equipment (SIC 35646). The column entries for BEA I-O sector 49.0300 were multiplied by the ratio of the value of shipments for SIC 35646 ($906 million) to the value of output for industry 49.0300 ($2,100.1

million) to estimate the inputs used in the production of air pollution control equipment. The column entries for air pollution control equipment were assigned to I-O sector 38. All remaining inputs used by industry 49.0300 were assigned to I-O Sector 19 (Machinery, except electrical).

As with new sewer system facilities, there was some difficulty with reconciling the values in the I-O tables and those reported by other government sources. In the I-O tables, $556.6 million were assigned as GPFI for BEA I-O sector 49.0300. Of this $556.6 million, $418.6 were for SIC 35646 (air pollution control equipment). This differs from the value reported in the 1982 MA35J for 1982 ($905.2 million). The reason for the discrepancy is that the I-O table values are generated using data from the *Census of Manufactures*. In 1982, the *Census of Manufactures* reported shipments for SIC 35646 at $425.6 million. This value was adjusted for exports and changes in business inventories and used in the published I-O tables.[5] The *Census of Manufactures* values differ because they measure shipments only from manufacturing establishments. The MA35J report includes shipments from both manufacturing establishments and design construction firms. Since design construction firms do not perform manufacturing as their primary activity, they are excluded from the *Census of Manufactures*.

For purposes of constructing the EP I-O tables, the MA35J data were assumed to be correct since they were most consistent with the engineering studies used to construct capital expenditure patterns for air pollution control (see Section 3.5.2.1). More specifically, the MA35J values as a percent of total capital expenditures for air pollution control were more in line with the percentage of equipment in investment-related expenditures for air pollution indicated by engineering studies. As a consequence the value used for air pollution GPFI in constructing the I-O tables was increased by $487.4 million, the difference between the values used in the I-O table and the MA35J report.

It was assumed that the only use for air pollution control equipment is GPFI. The remaining row entries for sector 49.0300 were assigned to I-O Sector 19 (Machinery, except electrical).

Finally, it is worth noting that there is a secondary production issue associated with sector 49.0300. Industry 49.0300 produces a number of commodities other than 49.0300 and commodity 49.0300 is produced by a number of industries other than 49.0300. Total output of commodity 49.0300 is $2,014.1 million, of which $1,846.7 million is produced by industry 49.0300. To maintain simplicity in the calculations, it was assumed that the output of SIC 35646 is only produced by industry 49.0300.

3.3. INTERNAL ENVIRONMENTAL PROTECTION ACTIVITIES

3.3.1. *Manufacturing Sectors*

The inputs used to abate pollution within the production process, or the operation and maintenance expenditures associated with pollution abatement, consist of labor, depreciation, and services and materials inputs purchased from other sectors in the economy. As noted in Chapter 2, expenditures on materials inputs for pollution abatement are published as an aggregate. The primary difficulty in representing internal EP activities in the EP I-O tables is disaggregating expenditures on materials into specific I-O categories.

The Census MA-200 report was the source of pollution abatement operation and maintenance expenditures data for manufacturing industries. The MA-200 reports $3,455.9 million for air, and $2,949.1 million for water. The BEA (supplied by Gary Rutledge - letter of June 6, 1994) reports manufacturing O&M expenditures of $2,654.8 million for air, $2,453.3 million for water both of which are lower than the MA-200 values. Typically, the MA-200 disaggregates operation and maintenance costs by type of expenditure (depreciation, labor, materials and supplies, etc.) and type of pollution abated (air, water, and solid waste), but not type of expenditure by type of pollution. The sum of the data across either type of expenditure or media is the total operating costs of pollution abatement activities for an industry. However, in 1979, the MA-200 survey published separate data on the amount of each type of expenditure for each type of pollutant abated. The 1979 survey provides the best source of data for disaggregating the expenditures for air, water and solid waste by type of operating cost in 1977 and 1982.

The first step in disaggregating pollution abatement materials costs involved assuming that the expenditure pattern for air, water, and solid waste pollution abatement by type of operating cost for manufacturing industries observed in 1979 held for 1977 and 1982. The expenditure pattern data was placed in a matrix with the columns of the matrix representing the type of expenditure and the rows representing expenditure by medium. For 1979, published data filled all cells of the matrix. For 1977 and 1982, published data provided only row and column totals. A procedure that maintains the row and column totals observed for 1977 and 1982 was applied to estimate matrix entries. Briefly, the adjustment procedure involved solving a constrained nonlinear optimization program.[6] By performing this initial disaggregation procedure, expenditures on (1) materials and supplies, (2) services, (3) labor, and (4) depreciation were obtained for each medium. This allowed for the use of engineering studies of specific pollution abatement processes to further disaggregate "materials and supplies" into intermediate input categories that appear in the I-O table (e.g., electricity or construction). Disaggregation of materials expenditures required using engineering studies to generate expenditure patterns for air, water, and solid waste pollution abatement processes.

3.3.1.1. Air Pollution Abatement

For air pollution abatement processes, the estimates for labor, depreciation, and services costs were derived from the MA-200 data and used directly. All expenditures for services, which includes equipment rental and leasing services, were assigned to I-O sector 31 (Other Services). Expenditure patterns to disaggregate "materials and supplies" were obtained for five types of air pollution control equipment (thermal incinerators, fluid-bed catalytic incinerators, fabric filter systems, electrostatic precipitators, and flue gas desulfurization systems).

The *OAQPS Control Cost Manual* (U.S. EPA, 1990) was the source for determining the operating costs expenditure patterns for fabric filters, electrostatic precipitators, thermal incinerators, and catalytic incinerators. The manual provides "example problems," which estimate the specific categories for the annual costs associated with the operation of each pollution control system.[7] In addition to the materials and supplies expenses, the example problems reported labor expenses, depreciation, and waste disposal. The values for labor expenses and depreciation were not used, since they were derived using the MA-200 survey. The estimates of the costs of disposing of air pollution abatement residuals (e.g., ash and sludge) were not used since it was assumed that disposal of residuals are reported as solid waste disposal expenditures in the MA-200.

For flue gas desulfurization (FGD) systems, information on lime FGD systems assembled by the Radian Corporation (1982a, 1982b) was the source.[8] As with the other air pollution control systems, it was assumed that labor and depreciation costs of the pollution control equipment are captured in the MA-200 report and the focus was on those items which are part of materials and supplies. Because Radian reported a combined value for labor and material maintenance, this value had to be adjusted in order to maintain consistency with the *OAQPS Control Cost Manual*. Following the *OAQPS Control Cost Manual*, it was assumed that the labor and material cost components of maintenance expenditures are equal.

The expenditure patterns for fabric filters, electrostatic precipitators, thermal incinerators, catalytic incinerators, and FGD systems were weighted according to the relative value of the shipments for each type of equipment, using data from the Department of Commerce publication, "Selected Industrial Air Pollution Control Equipment" (MA35J). The patterns were aggregated to form an overall expenditure pattern. Table 3.4 gives the distribution values for each type of air pollution control system as well as the aggregate expenditure pattern applied to the 1977 and 1982 data.[9] Appendix B provides greater detail of the procedure used to derive these expenditure patterns.

Table 3.4

Distribution of Materials Component of Operation and Maintenance Expenditures for Air Pollution Abatement by I-O Sector

I-O Sector	Thermal Incinerators	Fluid-bed Catalytic Incinerators	Filter Systems	Electrostatic Precipitators	FGD Systems	1977 Aggregate	1982 Aggregate
3	0.023	0.052	0.168	0.055	0.232	0.104	0.152
6			0.116			0.032	0.034
12		0.107			0.065	0.008	0.025
16					0.398	0.043	0.146
19			0.098			0.027	0.029
27	0.112	0.311	0.569	0.713	0.235	0.591	0.477
28	0.849	0.465				0.042	0.024
30	0.016	0.065	0.049	0.232		0.145	0.087
31					0.070	0.008	0.026

3.3.1.2. Water Pollution Abatement

For water pollution abatement expenditures, the estimates for labor, depreciation, and service costs were derived from the MA-200 data. Expenditures for services and other costs, which include expenditures on equipment leasing and environmental laboratories were assigned to I-O sector 31 (Other Services).

To disaggregate expenditures on materials and supplies, expenditure patterns for settling, biological oxidation, neutralization, filtration, and coagulation were taken from DeRenzo (1978). The expenditure pattern for chlorination was taken from the American Society of Civil Engineers and the American Water Works Association (1990). To weight and aggregate these patterns, data from the "Water Use in Manufacturing" survey from the *1977 Census of Manufactures* and the "Water Use in Mineral Industries" from the *1977 Census of Mineral Industries* were used. These publications present data for 1978 on the number of gallons of discharged water treated by each of 10 methods for 4 digit SIC manufacturing and mineral industries.[10] The expenditure patterns were weighted by the share of discharged water treated by

a particular wastewater treatment process. Table 3.5 presents the expenditure pattern used in this study. Appendix B explains the procedure for deriving this pattern in greater detail.

The limitations of using this approach to disaggregating operation and maintenance expenditures for water pollution abatement warrant mention. First, the expenditure pattern for a specific wastewater treatment process varies within an industry as the size of the treatment operation changes. This occurs due to the existence of economies of scale in the wastewater treatment process. Second, the expenditure pattern for a particular type of wastewater treatment process varies across industries. Third, it is not possible to obtain expenditure patterns for all types of water treatment processes. Given the tentative nature of the data used to generate them, these expenditure patterns must be viewed with caution.

3.3.1.3. Solid Waste Pollution Abatement

For solid waste pollution abatement processes, the estimates for labor and depreciation costs derived from the MA-200 data were used directly. It was assumed that all service expenditures were for solid waste management services (I-O 37). Thus, the row entries in I-O sector 37 represent expenditures by each sector for solid waste management services. This assumption misses any purchases of services for solid waste abatement other than solid waste management services (e.g., equipment leasing).

Table 3.5

Distribution of Materials Component of Operation and Maintenance Expenditures for Water Pollution Abatement by I-O Sector

I-O Sector	Settling	Biological Oxidation	Neutralization	Coagulation	Chlorination	Filtration	Aggregate*
3	0.237	0.824	0.101	0.584	0.016	0.714	0.350
12	0.388		0.010	0.253	0.966	0.060	0.265
16	0.043	0.077	0.867	0.065		0.005	0.183
27	0.332	0.099	0.022	0.098	0.018	0.221	0.202

*This pattern was applied to both the 1977 and 1982 data.

Next, to allocate materials and supplies specific I-O sectors, it was assumed that the expenditure pattern for sludge removal is representative of the expenditure pattern for all materials purchased for solid waste disposal. Expenditure patterns for wash-water recovery, alum sludge disposal, and lime sludge disposal were taken from the American Society of Civil Engineers and American Water Works Association (1990, pp. 340-343). Due to the lack of information on the number of each type of disposal technique in operation, the aggregate expenditure pattern was formed by taking a simple average of the three example expenditure patterns. The expenditure patterns for wash-water recovery, alum sludge disposal, and lime sludge disposal as well as the average expenditure pattern is presented in Table 3.6. Appendix B gives a more detailed explanation of the procedure used for deriving these patterns.

3.3.2. *Electric Utilities*

3.3.2.1. Air Pollution Abatement

A large percentage of air pollution abatement costs in the electric utilities sector are fuel related.[11] The fuel related expenditures come in the form of a premium paid by the utilities for low-sulfur coal. This premium is incurred when electric utilities switch from high-sulfur to low-sulfur coal rather than install pollution abatement devices. The BEA includes this premium in its calculation of current account expenditures by electric utilities (see Farber and Rutledge, 1989, p. 13), but does not report the premium separately. However, data on the premium were obtained from BEA.[12] The BEA fuel premium value was treated as a purchase of inputs from Mining (I-O sector 3).

Table 3.6

Distribution of Materials Component of Operation and Maintenance Expenditures for Solid Waste Pollution Abatement by I-O Sector

I-O Sector	Wash-Water Recovery	Alum Sludge Disposal	Lime Sludge Disposal	Aggregate*
3	0.080	0.287	0.561	0.309
12	0.796	0.185		0.327
27	0.124	0.528	0.439	0.364

*This pattern is applied to both the 1977 and 1982 data.

The next task was to generate estimates of current account expenditures for the categories of labor, depreciation, services, and materials and supplies. BEA's values for current account expenditures ($35.6 million for public and $465.4 for private) exclude depreciation. *Statistics of Privately Owned Electric Utilities in the United States 1977* and *Financial Statistics of Selected Electric Utilities 1982*, Department of Energy (DOE) publications, provide data on depreciation ($336.2 million) associated with pollution abatement across all media.[13] These data were disaggregated by first calculating average capital expenditures (in constant dollars) by medium for the current year and the preceding four years. The relative share in total capital expenditures was calculated for each medium on the basis of these averages. The DOE depreciation total was disaggregated into depreciation associated with air, water, and solid waste pollution abatement according to these average shares. BEA's current account expenditures of private electric utilities for air pollution abatement (net of the premium paid for low-sulfur coal) were allocated to labor, materials and supplies, and services using the average expenditure pattern for manufacturing (taken from the 1979 MA-200 report). This expenditure pattern was re-weighted since the BEA values exclude depreciation. Materials and supplies are further disaggregated into specific I-O categories according to the expenditure patterns reported in Table 3.4.

3.3.2.2. Water Pollution Abatement

As with air pollution control expenditures, depreciation values were derived from DOE publications (see Section 3.3.2.1). The average expenditure pattern for manufacturing in 1979 was used to disaggregate BEA's (see Rutledge letter of June 6, 1994) current account costs for water pollution abatement ($17.4 million by public and $164.8 million by private) into labor, materials and supplies, and services. The expenditure pattern was re-weighted because BEA excludes depreciation from its current account values. Materials and supplies expenditures were disaggregated using the expenditure pattern for water pollution control reported in Table 3.5.

3.3.2.3. Solid Waste Pollution Abatement

The BEA reports capital expenditures but not current account expenditures for solid waste. Operating expenditures for labor and materials and supplies were estimated using the average expenditure pattern for solid waste reported in the 1979 MA-200. Operating expenses for labor were estimated by multiplying total capital expenditures by electric utilities for solid waste pollution abatement by the ratio of labor expenditures for solid waste pollution abatement to capital expenditures for solid waste pollution abatement. Operating expenses of materials were estimated by multiplying total capital expenditures by electric utilities for solid waste pollution abatement by the ratio of materials expenditures for solid waste pollution abatement to capital expenditures for solid waste pollution abatement. These ratios were calculated from the 1979 MA-200. Depreciation expenses were derived from DOE data (see Section 3.3.2.1). Expenditures for Sanitary Services (I-O 37) by Electric Utilities (I-O 27) serves as the estimate

of expenditures for services.[14] Materials expenses were further disaggregated into specific I-O sectors using the expenditure pattern reported in Table 3.6.

3.3.3. *Other Nonmanufacturing Sectors*

Data on current account expenditures for air ($564.7 million) and water ($931.6 million) pollution abatement (excluding depreciation) by "mining and other nonmanufacturing establishments" were obtained from the BEA. BEA also provided data on pollution abatement capital stock, which was presented separately for "mining" and "other nonmanufacturing sectors."[15] Total current account expenditures were initially disaggregated into current account expenditures for air and water pollution abatement for "mining" and "other nonmanufacturing establishments" using the BEA data on pollution abatement capital stock.

The BEA (Environmental Economics Division, BEA, 1986) reports capital expenditures for air, water and solid waste for the following nonmanufacturing sectors (excluding electric utilities) in 1977 and 1982:

1. Mining
2. Transportation (railroad, air and other)
3. Public Utilities (gas)
4. Trade and Services[16]
5. Communication and other[17]

It was assumed that the transportation sector has no current account pollution abatement expenditures. The current account expenditures for air and water pollution abatement by "other nonmanufacturing establishments" derived above were allocated to the more specific industry categories of public utilities (gas), trade and services, and communication on the basis of each industry's average share of pollution abatement capital expenditures between 1978 and 1982. This yielded estimates of total operation and maintenance expenditures for both air and water pollution abatement. Total current account expenditures were further disaggregated into labor, materials, and services components using the average expenditure pattern for manufacturing (from the 1979 MA-200), similar to the procedure used for electric utilities.

Labor and materials expenditures for solid waste abatement were calculated using the solid waste capital expenditures data for nonmanufacturing and information for manufacturing in 1979. The ratio of labor expenditures to total capital expenditures and the ratio of materials expenditures to total capital expenditures for solid waste pollution abatement were computed for manufacturing in 1979.[18] These ratios were multiplied by the capital expenditures for solid waste for the various nonmanufacturing sectors in order to derive estimates for labor and materials expenditures for mining, public utilities (gas), trade and services, and communication. Expenditures for Solid Waste Management Services (I-O 37) by the individual nonmanufacturing sectors served as estimates of expenditures for services associated with solid

waste abatement. Section 3.1.4. contains a more detailed explanation of how these values were derived.

Depreciation expenses were calculated by using the 1979 MA-200 data to compute the ratio of depreciation expenses to capital expenditures for air, water, and solid waste, and then by multiplying these three ratios by EP capital expenditures. This yielded estimates of depreciation expenses by media associated with pollution abatement for mining, public utilities (gas), trade and services, and communication and other.

Labor, materials, and depreciation expenses for trade and services and communication were further disaggregated by distributing the expenditures to more specific I-O sectors on the basis of the value of each sector's output.[19] Materials and supplies expenditures for air, water, and solid waste were disaggregated using the expenditure patterns for manufacturing sectors.

3.3.4. *Miscellaneous Internal Environmental Protection Activities*

3.3.4.1. Motor Vehicles

Internal EP activities include operation and maintenance expenditures for motor vehicles pollution abatement by business. These consist of pollution abatement costs and credits associated with light duty vehicles (e.g., autos), trucks, and aircraft. EPA (1990) disaggregates these expenditures into the following categories: fuel price penalty, fuel economy penalty, and maintenance expenditures.[20]

The fuel price penalty and fuel economy penalty were aggregated and assigned as purchases of intermediate inputs from Petroleum Refining (I-O sector 13). According to EPA, total fuel price penalty and fuel economy penalty for autos and trucks was $1,911.2 million in 1982. This includes expenditures by both businesses and households. To isolate expenditures by businesses, *Survey of Current Business* data were used to compute the percentages of expenditures for automobiles and truck attributable to personal consumption and producers' durable equipment.[21] For 1982, the estimate of fuel price penalty and the fuel economy penalty for businesses was $760.1 million. This value was distributed to specific sectors based upon purchases of commodity 31.0101 (Petroleum refining, which is part of I-O 13).

Maintenance expenditures were treated as purchases of Other Services (I-O sector 31), since Other Services includes the Automotive and Repair Shop sector. The introduction of pollution abatement devices reduces some of the operation and maintenance expenditures associated with certain types of motor vehicles. To avoid introducing negative cell values into the I-O table, these values were set equal to zero. The increase in operation and maintenance expenditures for trucks assigned to business ($9.7 million) should be assigned to to different sectors based upon the relative purchases of commodity 75.0002 (Automotive Repair Shops and

Services, which is part of I-O 31). However, given the small values resulting from this assignment procedure, these expenditures were set equal to zero as well.

3.3.4.2. Environmental Taxes

Environmental excise taxes on the petro-chemical, inorganic chemical and petroleum industries were introduced in 1980 under CERCLA. Values for these taxes were taken from the Internal Revenue Service (see Belal 1987, p. 53).[22] Environmental excise taxes on petro-chemicals ($153.3 million) and inorganic chemicals ($41.3 million) were assigned to I-O sector 12 and taxes on petroleum ($37.7 million) were assigned to I-O sector 13. The environmental tax on both imported and domestic petroleum was included as revenue generated by the environmental tax on petroleum.

3.3.4.3. Research and Development

Ideally, internal EP activities would include research and development expenditures by business. These are excluded due to uncertainty regarding the types of goods and services purchased for these activities and the exact industries that performed these activities. According to BEA (see Rutledge and Vogan 1994, p. 45) private expenditures for research and development equaled $1,009 million in 1982.

3.3.4.4. Costs Recovered

The BEA (see Rutledge and Vogan 1994, p. 45) and the MA-200 data report information on costs recovered. These costs recovered are ".. the value of material or energy reclaimed through pollution abatement activities..." (see Farber and Rutledge 1989, p.16). According to BEA (see Rutledge and Vogan, 1994, p. 45) costs recovered equaled -$1,463 million in 1982. Costs recovered were excluded to avoid introducing negative cell values into the I-O table. In addition, disaggregated values for the relative amounts of materials and energy recovered are not available.

3.3.4.5. Agricultural Business

Current account expenditures by agricultural business were excluded due to uncertainty regarding the types of goods and services purchased. According to BEA (see Rutledge and Vogan, 1994, p. 48) these expenditures, which were for feedlot operations only, were $6 million in 1982.

3.3.4.6. Government Enterprise : Other

Current account expenditures by a fertilizer plant owner by the Tennessee Valley authority are excluded. According to BEA (see Rutledge and Vogan, 1994, p. 48) these expenditures were $2 million in 1982.

3.3.4.7. Internal EP Activities of the External EP Sectors

The procedure for allocating business operation and maintenance expenditures for motor vehicle pollution abatement resulted in some of the inputs of the external EP sectors being used for pollution abatement. All expenditures for inputs of the external EP sectors were included as EP costs. To avoid double counting of expenditures, the internal EP activities of the external EP sectors were not counted separately in the estimates of EP activities.

3.4. HOUSEHOLD ENVIRONMENTAL PROTECTION ACTIVITIES

3.4.1. *Purchases from External Environmental Protection Sectors*

Household purchases from the external environmental protection sectors of the economy consist of "Environmental" Water Supply (I-O 35), Sewerage Services (I-O 36), and Solid Waste Management Services (I-O 37). The derivation of each of these components is discussed in detail in Sections 3.1.2, 3.1.3, and 3.1.4 respectively.

3.4.2. *Purchases for the Operation and Maintenance of Septic Systems and Sewer Connections*

The BEA reports expenditures associated with the operation and maintenance of "private septic systems and sewer connections linking household plumbing to street sewers" (see Rutledge and Vogan 1994, p. 48 and p. 49, footnote 3). Expenditures on septic tank cleaning services and sewer cleaning and rodding services $436 million were assigned to Other Services (I-O 31).

3.4.3. *Purchases for Operation and Maintenance of Motor Vehicles*

The EPA reports the fuel price penalty and fuel economy penalty associated with emissions control devices on motor vehicles. Although BEA collects data on similar categories, this study uses EPA data. The household sector was assigned $1,151.1 million in purchases of commodity 31.0101 (this is part of I-O 13). Section 3.3.4.1 contains additional information on the distribution of the fuel price penalty and fuel economy penalty for autos and trucks between households and business. All motorcycle expenditures were assigned to personal consumption expenditures (PCE). Pollution abatement devices on motor vehicles reduced expenditures (assigned to commodity 75.0002) for certain types of motor vehicles. To avoid introducing negative cell values into the I-O table, these expenditures were set equal to zero. The increase in

operation and maintenance expenditures for trucks allocated to households was assigned to PCE of I-O sector 31. These expenditures are discussed in greater detail in section 3.3.4.1.

3.4.4. *Purchases of Environmental Protection Equipment on Motor Vehicles*

The EPA reports expenditures associated with pollution abatement equipment on new motor vehicles for the following mobile source categories: automobiles, trucks, aircraft, and motorcycles.[23] Although BEA collects similar data (see Rutledge and Vogan, 1994, p. 48), this study uses EPA data.

It was assumed that all expenditures for motorcycles are by households and accordingly, classified as consumption expenditures. It was assumed that all expenditures for aircraft are by business, and hence, were assigned to gross private fixed investment (GPFI). EP expenditures for motorcycles ($102.3 million) were assigned to PCE for Other Transportation Equipment (I-O sector 22). EP expenditures for aircraft are discussed in section 3.5.2.4.

Expenditures for pollution abatement equipment for automobiles and trucks (I-O 21) were allocated to consumption and investment based on *Survey of Current Business* data on personal consumption expenditures and producers' durable equipment for trucks and autos. The estimates for expenditures on automobile pollution abatement were split into consumption ($2,170.5 million in 1982) and investment (1,021.6 million in 1982) on the basis of the percentage of expenditures on automobiles and trucks accounted for by consumption and investment (see Section 3.3.4.1). The estimates for expenditures on truck pollution abatement are split into consumption ($255.8 million in 1982) and investment (359.8 million in 1982) in a similar fashion (see section 3.5.2.4).

3.5. INVESTMENT ACTIVITIES FOR ENVIRONMENTAL PROTECTION

3.5.1. *Households*

Household investment activities for EP are defined by BEA as the durable component of expenditures for “private septic systems and sewer connections linking household plumbing to street sewers” (see Rutledge and Vogan 1994, p. 49, footnote 3). Household investment expenditures for EP consist of expenditures for septic tanks, septic systems, and connectors to public sewer systems. The BEA (see Rutledge and Vogan, 1994, p. 48) reports household investment expenditures for EP of $1,124 million in 1982. In the U.S. I-O tables, these expenditures were assigned to one of two sectors. To maintain consistency with the U.S. I-O tables, a general rule of thumb for disaggregating the expenditure between new residential construction (part of I-O 3) and new sewer system facilities (I-O 33) was followed: two-thirds of the BEA value was assigned to I-O 3 and one-third was assigned to I-O 33.[24] In 1982, $749.3 million was assigned to I-O 3 and $374.7 million was assigned to I-O 33. The residual $2,079.5

($2,454.2 - $374.7) million purchases of I-O 33 for GPFI was assigned to capital expenditures by business for water pollution abatement (see section 3.5.2.2).

3.5.2. *Businesses*

BEA (see Rutledge letter of June 6, 1994) reports total capital (plant and equipment) expenditures for air ($4,961 million), water ($2,811 million), and solid waste ($969 million) pollution abatement by "... manufacturing, ... privately and cooperatively owned electric utilities and other nonmanufacturing companies" (see Rutledge and Vogan 1994, p. 49 footnote 2). In addition, BEA (see Rutledge letter of June 6, 1994) reports purchases by government enterprises (publicly owned electric utilities) of fixed capital for air ($426 million) and water ($75 million). These values combined yield total capital expenditures for air ($5,387 million), water ($2,886 million), and solid waste ($969 million) pollution abatement and were used as the control totals in this study.[25] No distinction was made between "end-of-line" and "change in production process" capital expenditures. All capital expenditures were treated as if they are "end-of-line."

The EP capital expenditures data are not disaggregated into specific I-O categories (e.g., construction, installation, equipment, etc.) As for intermediate materials inputs, engineering studies were used to disaggregate the data. Descriptions of the procedures followed for air, water, and solid waste are presented below.

3.5.2.1. Air

The *OAQPS Control Cost Manual* (U.S. EPA, 1990) was the source for determining the capital cost expenditure pattern for fabric filters, electrostatic precipitators, thermal incinerators, and catalytic incinerators. For flue gas desulfurization (FGD) systems, information on lime FGD systems assembled by the Radian Corporation (1982a, 1982b) was the source. The patterns were weighted according the relative value of the shipments for each type of equipment, using data from the Department of Commerce publication, "Selected Industrial Air Pollution Control Equipment" (MA35J) and aggregated to form an overall expenditure pattern for both 1977 and 1982.

Both the BEA and the Commerce (MA35J) data were used. The MA35J estimates of shipments of industrial air pollution control equipment served as cost estimates for mechanical devices. Using this information, the aggregate expenditure patterns for 1977 and 1982 were adjusted to maintain the ratio of shipments of industrial air pollution control equipment to total capital expenditures for air pollution abatement found in the BEA and MA35J reports.

Exports and imports of pollution abatement equipment were excluded in this study. The 1982 I-O table assigned only $6.7 million of shipments of SIC 35646 to exports. The report *International Trade in Environmental Protection Equipment: An Assessment of Existing Data* (U.S. EPA, 1993) discusses U.S. trade in industrial air pollution control equipment. The data

indicate that the U.S. enjoyed a trade surplus in air pollution control equipment in 1982 (U.S. EPA, 1993, p. 10). Hence, in 1982, the actual domestic use of industrial air pollution control equipment was less than shipments of air pollution control equipment. This results in some inaccuracy in the air pollution plant and equipment capital expenditures patterns. Section 3.2.2. contains a more detailed discussion of the issues surrounding the different estimates of shipments of the air pollution control equipment industry.

Table 3.7 provides the distribution values for capital expenditures for fabric filters, electrostatic precipitators, thermal incinerators, catalytic incinerators, and FGD systems as well as the aggregate expenditure pattern applied to the 1977 and 1982 data. Appendix B contains a detailed description of how the patterns were derived. No distinction between new systems and retro-fit systems was made.

Table 3.7

Distribution of Materials Component of Capital Expenditures for Air Pollution Abatement by I-O Sector

I-O Sector	Thermal Incinerators	Fluid-bed Catalytic Incinerators	Filter Systems	Electrostatic Precipitators	FGD Systems	1977 Aggregate	1982 Aggregate
3	0.395	0.394	0.567	0.569	0.443	0.656	0.587
6			0.044			0.014	0.015
18			0.051	0.012	0.069	0.034	0.050
19			0.059	0.013	0.115	0.044	0.072
20			0.025	0.005	0.054	0.019	0.033
23	0.053	0.053	0.039	0.038		0.042	0.028
25	0.026	0.026	0.020	0.019	0.053	0.029	0.037
38	0.526	0.527	0.195	0.344	0.266	0.162	0.178

3.5.2.2. Water

For water pollution abatement capital expenditures, information from the *Development Document for Effluent Guidelines and Standards for the Nonferrous Metals Forming and Iron and Steel/Copper/Aluminum Metal Powder Production and Powder Metallurgy Point Source Category* (U.S. EPA 1984) were used. The percentages for each I-O category in total costs were computed using the cost equations for recommended treatment and control technologies and the midpoint for the range of validity for each equation. Table 3.8 presents the expenditure pattern and Appendix B explains the procedure for deriving this pattern in greater detail.

The 1982 benchmark input-output table reports purchases of New Sewer System Facilities (BEA I-O 11.0307) of $2,454.2 million for Gross Private Fixed Investment (see Section 3.2.1 for a discussion of this issue). After allowing for private septic systems (see Section 3.5.1), the residual ($2,079.5 million) constitutes purchases of New Sewer System facilities by business. It was assumed that these expenditures are included in the BEA values for capital expenditures by business for water pollution abatement ($2,886 million). The purchases of New Sewer System facilities were subtracted from the BEA control total of capital expenditures for water pollution abatement ($2,886 million). The residual capital expenditure of $886.5 ($2,886 - $2,079.5) million is distributed according to the capital expenditure pattern shown in Table 3.8.

Table 3.8

Distribution of Materials Component of Capital Expenditures for Water Pollution Abatement by I-O Sector

I-O Sector	Aggregate*
3	0.272
16	0.188
18	0.219
19	0.321

*This pattern is applied to both the 1977 and 1982 data.

3.5.2.3. Solid Waste

For solid waste, capital expenditures were allocated on the assumption that the expenditures for sludge removal are representative of the expenditure pattern for all capital expenditures for solid waste disposal. Values for wash-water recovery, alum sludge disposal, and lime sludge disposal reported by the American Society of Civil Engineers and American Water Works Association (1990) were used. A simple average was used to aggregate the three patterns into an overall capital expenditure pattern for solid waste. The expenditure patterns for wash-water recovery, alum sludge disposal, and lime sludge disposal as well as the average expenditure pattern is presented in Table 3.9. Appendix B gives a more detailed explanation of the procedure used for deriving these patterns.

3.5.2.4. Motor Vehicles and Aircraft

The EPA (see endnote 20) is the source of data for business capital expenditures for motor vehicle pollution abatement devices. Business investment expenditures on automobile emission devices ($1,021.6 million in 1982) and truck emission devices ($359.8 million in 1982) were classified as investment expenditures for motor vehicles (I-O 21) and expenditures for aircraft (I-O 22) ($34.1 million in 1982). Expenditures for the fuel price penalty and fuel economy penalty were aggregated and used to adjust purchases of Petroleum Refining (I-O sector 13) as intermediate inputs. Section 3.3.4.1. contains a discussion of the treatment of the fuel price penalty and fuel economy penalty.

Table 3.9

Distribution of Materials Component of Capital Expenditures
for Solid Waste Pollution
Abatement by I-O Sector

I-O Sector	Wash-Water Recovery	Alum Sludge Disposal	Lime Sludge Disposal	Aggregate*
3	0.563	0.362	0.359	0.428
12	0.088	0.046		0.045
19	0.349	0.526	0.589	0.488
21		0.066	0.052	0.039

*This pattern is applied to both the 1977 and 1982 data.

3.5.2.5. Miscellaneous

Capital expenditures by agricultural business were excluded due to uncertainty regarding the types of purchases associated with these expenditures. According to Rutledge and Vogan (1994, p. 48) these expenditures, which are for feedlot operations only, were $3 million in 1982.

3.6. GOVERNMENT ENVIRONMENTAL PROTECTION ACTIVITIES

3.6.1. *State and Local Government Purchases for Sewerage, Sanitation, Highways, Water, and Natural and Agricultural Resources and Recreation*

Following BEA and EPA, all state and local government purchases for sewerage (I-O 99.1003) and sanitation (I-O 99.1004) are counted as EP expenditures. EPA also counts all government purchases for sanitation as EP expenditures. BEA, on the other hand, (see Farber and Rutledge, 1989, p. 18) excludes 30 percent of *Governmental Finances* data for solid waste disposal expenditures from sanitation in its measure. This report followed EPA and used the values from the I-O table on government purchases for sewerage and sanitation.[26]

BEA counts a percentage of highway construction and engineering capital expenditures as federal, state, and local government expenditures to prevent highway erosion (see Farber and Rutledge, 1989, p. 17). Virtually all of these expenditures are by state and local government ($276 million by state and local government and $8 million by the federal government, see Rutledge and Vogan 1994, p. 48). To incorporate highway erosion abatement expenditures, the ratio of the BEA dollar value for highway erosion abatement expenditures ($284 million) to total state and local government purchases for highways (the column sum for I-O sector 99.3001 = $34,083 million) is computed. This ratio (0.0083), when multiplied by each row entry in I-O sector 99.3001, gives the values for highway erosion abatement.

Following EPA, the portion of capital expenditures by state and local government purchases for water (I-O sector 99.3006) that are for water treatment are classified as EP. The EPA (1990, p. F-3) counts 18.4 percent of capital purchases for water as water treatment expenditures. In this study, water treatment expenditures are isolated by taking 18.4 percent of each entry in I-O sector 99.3006.

The EPA (1990, p. F-7) also counts 20 percent of natural resource expenditures as EP expenditures. These expenditures consist of state and local government capital and operation and maintenance expenditures for natural resources. To isolate these expenditures, the ratio of the EPA dollar value for natural resource expenditures counted as EP expenditures ($1,303 million) to state and local government purchases for natural and agricultural resources and recreation (the column sum for BEA I-O sector 99.3008 = $12,619 million) is computed. This

ratio (0.1032), when multiplied by each column entry in BEA I-O sector 99.3008, gives the values for natural resources, which are counted as EP expenditures.

3.6.2. *Regulation and Monitoring*

Regulation and monitoring expenditures were included with non-environmental governmental expenditures due to uncertainty regarding the types of purchases associated with these expenditures. According to Rutledge and Vogan (1994, p. 45), federal expenditures equaled $820 million and state and local expenditures equaled $577 million in 1982.

3.6.3. *Research and Development*

Research and development expenditures by government were included with non-environmental governmental expenditures due to uncertainty regarding the types of purchases associated with these expenditures. According to Rutledge and Vogan (1994, p. 45), federal expenditures equaled $604 million and state and local expenditures equaled $28 million in 1982.

3.6.4. *BEA Category of Government Environmental Expenditures, Excluding Highway Erosion*

Federal expenditures, excluding highway erosion abatement, and state and local expenditures, excluding highway erosion abatement, were also included with non-environmental governmental expenditures due to uncertainty regarding the types of purchases associated with these expenditures. According to Rutledge and Vogan (1994, p. 48), federal expenditures, excluding highway erosion, equaled $316 million and state and local expenditures were less than $500,000 in 1982.

3.6.5. *Other and Unallocated*

BEA (August 24, 1994 telephone conversation with Rick Kaglic) report unallocated expenditures for federal government EP activities of $168 million and expenditures for state and local government EP activities of $38 million. These expenditures were assigned to non-environmental government expenditures due to uncertainty regarding the type of goods and services purchased.

3.7. THE U.S. ENVIRONMENTAL PROTECTION I-O TABLES

Tables 3.10 and 3.11 are the U.S. EP I-O tables for 1977. Table 3.10 shows the distribution of environmental control costs in the United States.[27] This table, which corresponds to Figure 2.3b in Chapter 2, illustrates which goods and services are purchased as a result of EP expenditures. Table 3.11 shows the environmental protection "industry" for the United States. and corresponds to Table 2.4b in Chapter 2. Table 3.11 differs from Table 3.10 because Table 3.11 shows which goods and services are purchased by the external environmental protection services sectors.

Tables 3.12 and 3.13 are the U.S. EP I-O tables for 1982. Similar to the 1977 tables, Table 3.12 shows the distribution of environmental control costs in the United States and corresponds to Figure 2.3b in Chapter 2. Table 3.13 shows the environmental protection industry for the United States and corresponds to Table 2.4b in Chapter 2.

One difficulty that has not been resolved warrants mention. In generating the "Externalized Internal Environmental Protection Expenditures" I-O table (which is not presented in this report), negative values appear in some cells of the I-O. For example, the cell value associated with non-EP purchases of I-O 16 (Stone, Clay, and Glass) by I-O 27 (Electric Utilities) is -46.8 million. For the most part, these negative cell values are relatively small. This occurs because more purchases of those cells are assigned for EP activities than were assigned to those cells by the BEA in the original I-O table. The externalization process results in the subtraction of the value of purchases from a sector for EP activities that is greater than the cell value in the original I-O table. Future research might involve an attempt to reconcile the original I-O cell values with the engineering estimates used to disaggregate materials expenditures for EP activities.

Table 3.10
1977 Environmental Protection Expenditures Input-Output Table (millions of dollars)

	01	02	03	04	05	06	07	08	09	10
01										
02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03	2.5	47.5	4.9	9.3	3.7	3.6	3.7	8.1	1.9	29.8
04										
05										
06	0.3	0.9	0.6	1.0	0.0	0.1	0.0	0.2	0.1	1.6
07										
08										
09										
10										
11										
12	1.2	36.4	2.4	5.1	3.7	3.1	3.8	7.2	1.7	20.3
13	53.2	12.0	58.8	11.0	0.6	3.7	2.8	6.3	1.3	19.6
14										
15										
16	1.7	22.5	3.3	5.6	0.2	0.9	0.1	1.6	0.3	15.8
17										
18										
19	0.2	0.8	0.5	0.9	0.0	0.1	0.0	0.2	0.1	1.4
20										
21										
22										
23										
24										
25										
26										
27	4.8	43.2	9.6	18.3	4.6	5.1	4.4	10.9	2.8	39.0
28	0.2	0.6	0.4	0.7	0.0	0.1	0.0	0.2	0.0	1.1
29										
30	0.7	2.3	1.4	2.6	0.1	0.4	0.0	0.6	0.2	4.1
31	7.3	86.3	14.6	57.3	0.5	11.4	1.5	9.1	3.2	131.4
32										
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	1.5	6.1	0.7	19.3	0.2	5.9	1.3	3.1	1.6	12.4
36	5.7	8.6	26.9	101.2	2.3	16.2	5.5	1.8	2.2	33.5
37	0.0	27.7	41.2	48.9	1.0	8.7	1.3	10.9	6.1	36.1
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39										
40										
41										
Total	79.4	294.9	165.4	281.0	16.9	59.3	24.4	60.3	21.5	346.1
Labor	7.9	125.0	15.6	52.1	3.2	9.0	1.6	19.1	4.4	82.6
IBTs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other VA	6.1	92.6	12.0	46.6	2.8	8.8	1.6	12.7	4.8	126.3
Total VA	13.9	217.7	27.7	98.7	6.0	17.8	3.2	31.8	9.2	208.9
Output	93.4	512.6	193.1	379.7	22.9	77.1	27.6	92.1	30.7	555.0

Table 3.10 (cont.)
1977 Environmental Protection Expenditures Input-Output Table (millions of dollars)

	11	12	13	14	15	16	17	18	19	20
01										
02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03	4.0	59.1	59.7	11.9	3.7	12.0	40.7	5.4	5.9	4.9
04										
05										
06	0.1	4.1	8.5	0.9	0.0	1.5	6.5	0.5	0.4	0.4
07										
08										
09										
10										
11										
12	3.9	35.9	24.4	7.8	3.8	6.3	14.5	3.5	4.2	3.4
13	3.6	28.5	122.7	10.5	0.4	9.4	14.7	4.3	6.4	3.4
14										
15										
16	0.3	36.3	45.3	6.0	0.2	7.1	32.6	2.6	2.4	2.1
17										
18										
19	0.1	3.5	7.2	0.8	0.0	1.3	5.6	0.4	0.4	0.3
20										
21										
22										
23										
24										
25										
26										
27	5.3	84.7	134.5	19.3	4.4	26.9	100.2	10.0	10.3	8.3
28	0.1	2.9	6.0	0.6	0.0	1.1	4.6	0.3	0.3	0.3
29										
30	0.2	10.5	21.6	2.3	0.0	3.9	16.7	1.2	1.1	0.9
31	3.3	295.7	293.3	55.1	2.3	31.7	322.1	24.9	19.0	27.0
32										
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.1	42.0	17.1	9.5	0.3	3.1	14.1	4.4	6.0	6.4
36	4.5	35.0	4.1	9.6	5.0	6.4	19.7	21.5	19.4	17.0
37	9.7	93.3	21.6	33.6	2.4	20.7	73.8	21.0	27.8	22.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39										
40										
41										
Total	35.1	731.4	765.9	167.8	22.6	131.5	665.8	100.1	103.6	96.4
Labor	4.1	204.1	167.7	47.5	1.9	46.7	232.8	26.1	29.2	27.8
IBTs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other VA	2.1	192.4	160.1	34.5	1.9	54.1	250.1	18.1	16.8	17.6
Total VA	6.2	396.5	327.8	82.0	3.8	100.8	482.9	44.2	46.0	45.4
Output	41.3	1127.9	1093.7	249.8	26.4	232.3	1148.7	144.3	149.6	141.8

Table 3.10 (cont.)
1977 Environmental Protection Expenditures Input-Output Table (millions of dollars)

	21	22	23	24	25	26	27	28	29	30
01										
02	0.0	0.0	0.0	0.0	0.0	0.0	538.4	0.0	0.0	0.0
03	6.6	3.5	4.0	1.9	0.0	1.2	59.4	11.2	21.4	22.4
04										
05										
06	0.6	0.1	0.1	0.0	0.0	0.1	4.7	0.4	1.4	1.5
07										
08										
09										
10										
11										
12	4.3	3.1	3.7	1.8	0.0	0.6	39.9	7.9	13.9	14.5
13	2.4	3.7	1.9	2.1	138.9	1.9	131.0	2.8	80.2	11.6
14										
15										
16	3.1	0.8	0.6	0.2	0.0	0.8	28.0	5.9	11.9	12.4
17										
18										
19	0.5	0.1	0.1	0.0	0.0	0.1	4.0	0.3	1.2	1.3
20										
21										
22										
23										
24										
25										
26										
27	12.2	4.9	5.1	2.6	0.0	2.3	101.9	11.8	31.1	32.5
28	0.4	0.1	0.1	0.0	0.0	0.1	3.3	0.3	1.0	1.0
29										
30	1.5	0.3	0.2	0.1	0.0	0.3	11.9	1.0	3.6	3.8
31	19.9	11.6	9.0	3.3	0.0	3.5	123.5	23.5	49.8	52.1
32										
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	3.9	5.8	0.9	0.4	4.8	2.4	5.0	1.3	5.7	20.0
36	18.8	7.7	4.9	2.5	53.9	23.7	4.8	3.5	137.4	32.0
37	25.5	13.4	8.0	5.4	22.7	40.4	30.7	0.9	438.8	176.7
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39										
40										
41										
Total	99.6	55.0	38.6	20.6	220.4	77.4	1086.4	70.8	797.5	381.7
Labor	50.5	26.1	10.0	3.3	0.0	3.7	230.7	28.5	65.2	68.0
IBTs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other VA	29.2	9.5	6.6	1.4	0.0	2.9	153.2	20.4	44.3	46.3
Total VA	79.7	35.6	16.6	4.7	0.0	6.6	383.9	48.8	109.5	114.3
Output	179.3	90.6	55.2	25.3	220.4	84.0	1470.3	119.7	907.0	496.0

Table 3.10 (cont.)
1977 Environmental Protection Expenditures Input-Output Table (millions of dollars)

	31	32	33	34	35	36	37	38	39	40	41	Total Int.
01												
02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		538.4
03	13.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		466.6
04												
05												
06	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		37.6
07												
08												
09												
10												
11												
12	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		290.5
13	56.3	6.3	0.7	0.6	0.0	0.0	0.0	0.0	0.0	0.0		813.5
14												
15												
16	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		258.5
17												
18												
19	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		32.1
20												
21												
22												
23												
24												
25												
26												
27	20.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		771.8
28	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		26.5
29												
30	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		96.2
31	32.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		1726.0
32												
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
34	26.1	1214.3	0.0	0.0	66.0	241.2	0.5	0.0	0.0	0.0		1548.1
35	37.7	11.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0		255.7
36	104.9	7.1	1.0	0.1	0.0	0.0	0.4	0.1	0.0	0.5		749.7
37	369.6	16.6	1.0	0.3	0.9	1.8	65.6	0.1	0.0	0.0		1726.2
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
39												
40												
41												
Total	682.1	1255.3	2.8	1.0	68.7	243.1	66.4	0.1	0.0	0.5		9337.5
Labor	40.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		1635.0
IBTs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
Other VA	28.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		1404.2
Total VA	69.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		3039.2
Output	751.0	1255.3	2.8	1.0	68.7	243.1	66.4	0.1	0.0	0.5		12376.7

Table 3.10 (cont.)
1977 Environmental Protection Expenditures Input-Output Table (millions of dollars)

	Non-envir. PCE	Envir. PCE	Non-envir. GPFI	Envir. GPFI	Inventory	Exports	Imports	Non-Envir. Gov't.	Sanit.	Sewer.	Hwy	Water	Nat. Res.	Final Demand	Output
01		0.0		0.0					0.0	0.0	0.2	0.0	12.1	12.3	12.3
02		0.0		0.0					0.0	0.0	0.5	0.0	0.4	0.9	539.3
03		0.0		4442.6					0.0	0.0	143.9	333.0	282.9	5202.4	5669.0
04		0.0		0.0					0.0	0.0	0.0	0.0	0.9	0.9	0.9
05		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
06		0.0		51.0					0.0	4.4	0.0	0.0	0.1	55.6	93.2
07		0.0		0.0					0.0	2.7	0.1	0.0	2.0	4.8	4.8
08		0.0		0.0					0.0	0.0	0.0	0.0	0.1	0.1	0.1
09		0.0		0.0					3.6	1.6	0.1	0.0	3.3	8.5	8.5
10		0.0		0.0					0.0	2.1	0.2	0.8	6.2	9.2	9.2
11		0.0		0.0					0.0	0.0	0.2	0.0	14.5	14.7	14.7
12		0.0		26.6					0.0	16.4	1.2	0.0	10.9	55.2	345.7
13		0.0		0.0					0.0	207.3	0.8	0.0	18.1	226.2	1039.7
14		0.0		0.0					0.0	2.1	0.1	0.0	1.8	4.0	4.0
15		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
16		0.0		547.9					0.0	0.0	0.0	0.0	0.7	548.7	807.1
17		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.1	0.1
18		0.0		754.8					0.0	6.5	0.2	0.0	1.1	762.6	762.6
19		0.0		1377.4					56.4	39.4	1.6	11.0	8.1	1493.8	1525.9
20		0.0		189.4					0.0	0.0	0.2	0.2	4.6	194.5	194.5
21		1492.7		775.9					36.9	47.5	3.0	16.2	9.4	888.8	888.8
22		0.0		13.4					0.0	0.0	0.1	0.3	2.6	16.3	16.3
23		0.0		149.3					9.6	9.2	0.1	0.4	3.2	171.9	171.9
24		0.0		0.0					0.0	0.0	0.3	0.0	6.6	6.8	6.8
25		0.0		98.4					2.3	34.4	1.2	0.6	12.6	149.5	149.5
26		0.0		0.0					0.0	2.1	0.3	0.0	8.7	11.0	11.0
27		0.0		0.0					0.0	0.0	2.7	0.0	4.2	6.9	778.7
28		0.0		0.0					0.0	0.0	0.7	0.0	6.6	7.3	33.8
29		0.0		0.0					21.2	33.1	1.4	3.0	24.5	83.2	83.2
30		0.0		0.0					0.0	30.8	0.1	0.0	13.8	44.7	140.9
31		308.1		0.0					0.0	27.8	0.0	0.0	4.0	31.7	1757.7
32		0.0		0.0					0.0	18.3	0.0	0.0	0.3	18.6	18.6
33		0.0		314.0				53.0	5295.0	79.0	0.0	0.0	0.0	5741.0	5741.0
34		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	1548.1
35		0.0		0.0					0.0	0.0	0.0	0.0	0.2	0.2	255.9
36		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	749.7
37		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	1726.2
38		0.0		617.3					0.0	0.0	0.0	0.0	0.0	617.3	617.3
39		0.0		0.0					0.0	0.0	2.9	6.1	497.4	506.4	506.4
40									0.0	1498.7	31.4	0.0	0.0	1530.1	1530.1
41		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total															
Labor															1635.0
IBTs															0.0
Other VA															1404.2
Total VA															
Output		1800.8		9358.0					5425.0	2063.4	193.4	371.7	961.7	18373.1	30749.7

Table 3.11
1977 Environmental Protection Industry Input-Output Table (millions of dollars)

	01	02	03	04	05	06	07	08	09	10
01										
02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03	2.5	47.5	4.9	9.3	3.7	3.6	3.7	8.1	1.9	29.8
04										
05										
06	0.3	0.9	0.6	1.0	0.0	0.1	0.0	0.2	0.1	1.6
07										
08										
09										
10										
11										
12	1.2	36.4	2.4	5.1	3.7	3.1	3.8	7.2	1.7	20.3
13	53.2	12.0	58.8	11.0	0.6	3.7	2.8	6.3	1.3	19.6
14										
15										
16	1.7	22.5	3.3	5.6	0.2	0.9	0.1	1.6	0.3	15.8
17										
18										
19	0.2	0.8	0.5	0.9	0.0	0.1	0.0	0.2	0.1	1.4
20										
21										
22										
23										
24										
25										
26										
27	4.8	43.2	9.6	18.3	4.6	5.1	4.4	10.9	2.8	39.0
28	0.2	0.6	0.4	0.7	0.0	0.1	0.0	0.2	0.0	1.1
29										
30	0.7	2.3	1.4	2.6	0.1	0.4	0.0	0.6	0.2	4.1
31	7.3	86.3	14.6	57.3	0.5	11.4	1.5	9.1	3.2	131.4
32										
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	1.5	6.1	0.7	19.3	0.2	5.9	1.3	3.1	1.6	12.4
36	5.7	8.6	26.9	101.2	2.3	16.2	5.5	1.8	2.2	33.5
37	0.0	27.7	41.2	48.9	1.0	8.7	1.3	10.9	6.1	36.1
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39										
40										
41										
Total	79.4	294.9	165.4	281.0	16.9	59.3	24.4	60.3	21.5	346.1
Labor	7.9	125.0	15.6	52.1	3.2	9.0	1.6	19.1	4.4	82.6
IBTs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other VA	6.1	92.6	12.0	46.6	2.8	8.8	1.6	12.7	4.8	126.3
Total VA	13.9	217.7	27.7	98.7	6.0	17.8	3.2	31.8	9.2	208.9
Output	93.4	512.6	193.1	379.7	22.9	77.1	27.6	92.1	30.7	555.0

Table 3.11 (cont.)
1977 Environmental Protection Industry Input-Output Table (millions of dollars)

	11	12	13	14	15	16	17	18	19	20
01										
02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03	4.0	59.1	59.7	11.9	3.7	12.0	40.7	5.4	5.9	4.9
04										
05										
06	0.1	4.1	8.5	0.9	0.0	1.5	6.5	0.5	0.4	0.4
07										
08										
09										
10										
11										
12	3.9	35.9	24.4	7.8	3.8	6.3	14.5	3.5	4.2	3.4
13	3.6	28.5	122.7	10.5	0.4	9.4	14.7	4.3	6.4	3.4
14										
15										
16	0.3	36.3	45.3	6.0	0.2	7.1	32.6	2.6	2.4	2.1
17										
18										
19	0.1	3.5	7.2	0.8	0.0	1.3	5.6	0.4	0.4	0.3
20										
21										
22										
23										
24										
25										
26										
27	5.3	84.7	134.5	19.3	4.4	26.9	100.2	10.0	10.3	8.3
28	0.1	2.9	6.0	0.6	0.0	1.1	4.6	0.3	0.3	0.3
29										
30	0.2	10.5	21.6	2.3	0.0	3.9	16.7	1.2	1.1	0.9
31	3.3	295.7	293.3	55.1	2.3	31.7	322.1	24.9	19.0	27.0
32										
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.1	42.0	17.1	9.5	0.3	3.1	14.1	4.4	6.0	6.4
36	4.5	35.0	4.1	9.6	5.0	6.4	19.7	21.5	19.4	17.0
37	9.7	93.3	21.6	33.6	2.4	20.7	73.8	21.0	27.8	22.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39										
40										
Total	35.1	731.4	765.9	167.8	22.6	131.5	665.8	100.1	103.6	96.4
Labor	4.1	204.1	167.7	47.5	1.9	46.7	232.8	26.1	29.2	27.8
IBTs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other VA	2.1	192.4	160.1	34.5	1.9	54.1	250.1	18.1	16.8	17.6
Total VA	6.2	396.5	327.8	82.0	3.8	100.8	482.9	44.2	46.0	45.4
Output	41.3	1127.9	1093.7	249.8	26.4	232.3	1148.7	144.3	149.6	141.8

Table 3.11 (cont.)
1977 Environmental Protection Industry Input-Output Table (millions of dollars)

	21	22	23	24	25	26	27	28	29	30
01										
02	0.0	0.0	0.0	0.0	0.0	0.0	538.4	0.0	0.0	0.0
03	6.6	3.5	4.0	1.9	0.0	1.2	59.4	11.2	21.4	22.4
04										
05										
06	0.6	0.1	0.1	0.0	0.0	0.1	4.7	0.4	1.4	1.5
07										
08										
09										
10										
11										
12	4.3	3.1	3.7	1.8	0.0	0.6	39.9	7.9	13.9	14.5
13	2.4	3.7	1.9	2.1	138.9	1.9	131.0	2.8	80.2	11.6
14										
15										
16	3.1	0.8	0.6	0.2	0.0	0.8	28.0	5.9	11.9	12.4
17										
18										
19	0.5	0.1	0.1	0.0	0.0	0.1	4.0	0.3	1.2	1.3
20										
21										
22										
23										
24										
25										
26										
27	12.2	4.9	5.1	2.6	0.0	2.3	101.9	11.8	31.1	32.5
28	0.4	0.1	0.1	0.0	0.0	0.1	3.3	0.3	1.0	1.0
29										
30	1.5	0.3	0.2	0.1	0.0	0.3	11.9	1.0	3.6	3.8
31	19.9	11.6	9.0	3.3	0.0	3.5	123.5	23.5	49.8	52.1
32										
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	3.9	5.8	0.9	0.4	4.8	2.4	5.0	1.3	5.7	20.0
36	18.8	7.7	4.9	2.5	53.9	23.7	4.8	3.5	137.4	32.0
37	25.5	13.4	8.0	5.4	22.7	40.4	30.7	0.9	438.8	176.7
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39										
40										
Total	99.6	55.0	38.6	20.6	220.4	77.4	1086.4	70.8	797.5	381.7
Labor	50.5	26.1	10.0	3.3	0.0	3.7	230.7	28.5	65.2	68.0
IBTs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other VA	29.2	9.5	6.6	1.4	0.0	2.9	153.2	20.4	44.3	46.3
Total VA	79.7	35.6	16.6	4.7	0.0	6.6	383.9	48.8	109.5	114.3
Output	179.3	90.6	55.2	25.3	220.4	84.0	1470.3	119.7	907.0	496.0

Table 3.11 (cont.)
1977 Environmental Protection Industry Input-Output Table (millions of dollars)

	31	32	33	34	35	36	37	38	39	40	41	Total Int.
01					0.6	2.1	0.3					3.0
02	0.0	0.0	0.0	0.0	0.4	1.0	4.1	0.0	0.0	0.0	0.0	543.8
03	13.2	0.0	0.0	0.0	133.7	425.2	71.6	0.0	0.0	0.0	0.0	1097.2
04					0.1	0.0	0.6					0.7
05					0.0	0.0	0.0					0.0
06	1.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	37.8
07					0.5	1.9	0.5					2.9
08					0.0	0.0	29.7					29.7
09					0.0	0.0	0.0					0.0
10					2.3	2.4	1.1					5.9
11					1.6	5.2	2.1					8.9
12	8.1	0.0	0.0	0.0	13.4	37.9	68.2	0.0	0.0	0.0	0.0	410.0
13	56.3	6.3	0.7	0.6	9.1	29.7	187.1	0.0	0.0	0.0	0.0	1039.5
14					0.3	0.8	10.3					11.4
15					0.0	0.1	0.0					0.2
16	7.7	0.0	0.0	0.0	2.5	9.5	0.5	0.0	0.0	0.0	0.0	271.0
17					0.0	0.0	0.0					0.0
18					4.8	1.1	15.8					21.7
19	0.9	0.0	0.0	0.0	7.3	27.5	2.4	0.0	0.0	0.0	0.0	69.3
20					1.8	5.7	1.9					9.4
21					1.0	1.1	3.5					5.5
22					0.8	3.1	0.0					3.9
23					2.3	2.3	1.9					6.4
24					0.9	3.3	4.6					8.8
25					6.4	20.1	110.6					137.2
26					2.7	10.4	30.0					43.2
27	20.7	0.0	0.0	0.0	80.1	278.4	6.7	0.0	0.0	0.0	0.0	1137.0
28	0.7	0.0	0.0	0.0	41.3	156.8	3.5	0.0	0.0	0.0	0.0	228.2
29					15.0	44.0	86.5					145.5
30	2.6	0.0	0.0	0.0	14.6	34.3	28.0	0.0	0.0	0.0	0.0	173.0
31	32.7	0.0	0.0	0.0	27.5	83.8	141.3	0.0	0.0	0.0	0.0	1978.6
32					3.6	8.9	4.7					17.1
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	26.1	1214.3	0.0	0.0	66.0	241.2	0.5	0.0	0.0	0.0	0.0	1548.1
35	37.7	11.0	0.0	0.0	0.5	1.8	0.0	0.0	0.0	0.0	0.0	256.2
36	104.9	7.1	1.0	0.1	0.0	0.0	0.4	0.1	0.0	0.5	0.0	749.7
37	369.6	16.6	1.0	0.3	0.9	1.8	65.6	0.1	0.0	0.0	0.0	1726.2
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39					0.1	0.1	0.2					0.4
					0.0	0.0	0.0					
40					0.0	0.0	0.0					0.0
Total	682.1	1255.3	2.8	1.0	442.2	1441.5	884.7	0.1	0.0	0.5	0.0	11727.6
Labor	40.5	0.0	0.0	0.0	181.2	627.8	662.7	0.0	0.0	0.0	0.0	3106.7
IBTs	0.0	0.0	0.0	0.0	8.1	1.6	83.3	0.0	0.0	0.0	0.0	93.0
Other VA	28.5	0.0	0.0	0.0	160.8	466.1	563.4	0.0	0.0	0.0	0.0	2594.4
Total VA	69.0	0.0	0.0	0.0	350.1	1095.5	1309.4	0.0	0.0	0.0	0.0	5794.1
Output	751.0	1255.3	2.8	1.0	792.3	2537.0	2194.0	0.1	0.0	0.5	0.0	17521.7

Table 3.11 (cont.)
1977 Environmental Protection Industry Input-Output Table (millions of dollars)

	Non-envir. PCE	Envir. PCE	Non-envir. GPFI	Envir. GPFI	Inventory	Exports	Imports	Non-Envir. Gov't.	Sanit.	Sewer.	Hwy	Water	Nat. Res.	Final Demand	Output
01		0.0		0.0					0.0	0.0	0.2	0.0	12.1	12.3	15.3
02		0.0		0.0					0.0	0.0	0.5	0.0	0.4	0.9	544.7
03		0.0		4442.6					0.0	0.0	143.9	333.0	282.9	5202.4	6299.5
04		0.0		0.0					0.0	0.0	0.0	0.0	0.9	0.9	1.7
05		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
06		0.0		51.0					0.0	4.4	0.0	0.0	0.1	55.6	93.4
07		0.0		0.0					0.0	2.7	0.1	0.0	2.0	4.8	7.7
08		0.0		0.0					0.0	0.0	0.0	0.0	0.1	0.1	29.8
09		0.0		0.0					3.6	1.6	0.1	0.0	3.3	8.5	8.5
10		0.0		0.0					0.0	2.1	0.2	0.8	6.2	9.2	15.1
11		0.0		0.0					0.0	0.0	0.2	0.0	14.5	14.7	23.6
12		0.0		26.6					0.0	16.4	1.2	0.0	10.9	55.2	465.2
13		0.0		0.0					0.0	207.3	0.8	0.0	18.1	226.2	1265.7
14		0.0		0.0					0.0	2.1	0.1	0.0	1.8	4.0	15.4
15		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.2
16		0.0		547.9					0.0	0.0	0.0	0.0	0.7	548.7	819.7
17		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.1	0.1
18		0.0		754.8					0.0	6.5	0.2	0.0	1.1	762.6	784.4
19		0.0		1377.4					56.4	39.4	1.6	11.0	8.1	1493.8	1563.1
20		0.0		189.4					0.0	0.0	0.2	0.2	4.6	194.5	203.9
21		1492.7		775.9					36.9	47.5	3.0	16.2	9.4	2381.5	2387.0
22		0.0		13.4					0.0	0.0	0.1	0.3	2.6	16.3	20.3
23		0.0		149.3					9.6	9.2	0.1	0.4	3.2	171.9	178.3
24		0.0		0.0					0.0	0.0	0.3	0.0	6.6	6.8	15.7
25		0.0		98.4					2.3	34.4	1.2	0.6	12.6	149.5	286.6
26		0.0		0.0					0.0	2.1	0.3	0.0	8.7	11.0	54.2
27		0.0		0.0					0.0	0.0	2.7	0.0	4.2	6.9	1143.9
28		0.0		0.0					0.0	0.0	0.7	0.0	6.6	7.3	235.4
29		0.0		0.0					21.2	33.1	1.4	3.0	24.5	83.2	228.7
30		0.0		0.0					0.0	30.8	0.1	0.0	13.8	44.7	217.7
31		308.1		0.0					0.0	27.8	0.0	0.0	4.0	339.8	2318.4
32		0.0		0.0					0.0	18.3	0.0	0.0	0.3	18.6	35.7
33	0.0	0.0		314.0				53.0	5295.0	79.0	0.0	0.0	0.0	5741.0	5741.0
34	0.0	0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	1548.1
35	479.7	0.0	0.0	0.0	0.0	0.8	0.0	55.4	0.0	0.0	0.0	0.0	0.2	536.1	792.3
36	1787.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1787.3	2537.0
37	467.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	467.8	2194.0
38	0.0	0.0	-0.0	617.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	617.3	617.3
39		0.0		0.0					0.0	0.0	2.9	6.1	497.4	506.4	506.8
40		0.0		0.0					0.0	1498.7	31.4	0.0	0.0	1530.1	1530.1
Total															
Labor															3106.7
IBTs															93.0
Other VA															2594.4
Total VA															
Output	2734.8	1800.8	-0.0	9358.0	0.0	0.8	0.0	108.4	5425.0	2063.4	193.4	371.7	961.7	18482.3	36003.9

Table 3.12
1982 Environmental Protection Expenditures Input-Output Table (millions of dollars)

	01	02	03	04	05	06	07	08	09	10
01										
02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03	0.2	104.8	6.6	21.2	0.8	2.8	0.7	4.3	1.0	72.4
04										
05										
06	0.0	2.2	0.6	1.0	0.1	0.1	0.0	0.2	0.1	2.4
07										
08										
09										
10										
11										
12	0.1	80.2	3.7	14.2	0.3	1.9	0.4	3.1	0.5	51.2
13	55.0	13.1	67.8	7.6	0.7	2.2	3.3	4.8	1.4	15.4
14										
15										
16	0.1	49.4	4.3	11.8	0.5	1.6	0.4	2.0	0.6	38.9
17										
18										
19	0.0	1.9	0.5	0.9	0.1	0.1	0.0	0.2	0.1	2.1
20										
21										
22										
23										
24										
25										
26										
27	0.4	99.0	11.4	25.9	1.9	3.4	0.9	5.8	2.1	75.1
28	0.0	1.6	0.4	0.7	0.1	0.1	0.0	0.2	0.1	1.7
29										
30	0.0	5.7	1.6	2.7	0.3	0.3	0.1	0.6	0.3	6.2
31	0.6	190.9	18.4	50.1	1.7	4.0	0.6	7.1	1.9	120.8
32										
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	11.6	20.9	3.3	9.4	0.1	1.6	0.4	2.2	0.5	24.0
36	36.8	10.0	41.7	175.1	3.0	17.2	6.3	3.5	5.8	61.7
37	227.0	177.0	103.4	63.9	1.3	7.0	1.0	13.6	8.1	53.1
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39										
40										
41										
Total	331.9	756.7	263.7	384.6	10.9	42.3	14.1	47.6	22.4	525.1
Labor	0.6	282.8	19.8	69.4	6.1	9.3	1.7	20.0	4.7	119.6
IBTs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other VA	0.3	177.8	10.5	68.7	5.9	9.0	2.4	20.6	4.8	177.4
Total VA	0.9	460.6	30.3	138.1	12.0	18.3	4.1	40.6	9.5	297.0
Output	332.9	1217.3	294.1	522.7	22.9	60.6	18.2	88.2	31.9	822.1

Table 3.12 (cont.)
1982 Environmental Protection Expenditures Input-Output Table (millions of dollars)

	11	12	13	14	15	16	17	18	19	20
01										
02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03	1.1	144.5	143.5	33.3	0.6	12.7	82.6	12.9	9.3	12.7
04										
05										
06	0.2	5.6	17.6	1.5	0.0	1.4	8.1	0.6	0.4	0.5
07										
08										
09										
10										
11										
12	0.5	102.2	65.0	22.9	0.4	6.8	43.5	8.8	6.5	8.7
13	7.4	21.2	119.1	4.6	0.2	3.8	7.1	4.6	6.1	3.7
14										
15										
16	0.8	75.9	105.8	18.0	0.2	8.0	56.0	7.2	4.7	6.9
17										
18										
19	0.1	4.8	15.0	1.3	0.0	1.2	6.9	0.5	0.4	0.5
20										
21										
22										
23										
24										
25										
26										
27	2.6	161.8	289.3	40.1	0.5	24.4	144.3	15.1	11.7	14.7
28	0.1	3.9	12.4	1.1	0.0	1.0	5.7	0.4	0.3	0.4
29										
30	0.4	14.3	44.9	3.9	0.0	3.5	20.6	1.5	1.1	1.4
31	8.3	344.4	438.9	70.1	1.1	40.3	341.1	18.8	23.5	34.6
32										
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.7	36.5	10.4	6.7	0.3	2.3	34.4	1.7	3.8	4.3
36	7.8	67.4	7.6	16.2	6.3	7.4	28.3	27.7	22.6	27.7
37	11.3	193.9	85.0	55.2	2.4	39.4	105.1	33.0	45.7	56.4
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39										
40										
41										
Total	41.3	1176.5	1354.6	274.9	12.1	152.0	883.7	132.8	136.3	172.5
Labor	6.9	323.1	357.5	100.9	1.4	55.6	297.3	39.4	42.4	56.0
IBTs	0.0	194.6	37.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other VA	5.7	282.0	215.7	90.4	1.4	55.4	375.7	24.8	32.5	36.2
Total VA	12.6	799.7	610.9	191.3	2.8	111.0	673.0	64.2	74.9	92.2
Output	53.9	1976.2	1965.5	466.2	14.9	263.0	1556.7	197.0	211.2	264.7

Table 3.12 (cont.)
1982 Environmental Protection Expenditures Input-Output Table (millions of dollars)

	21	22	23	24	25	26	27	28	29	30
01										
02	0.0	0.0	0.0	0.0	0.0	0.0	1477.9	0.0	0.0	0.0
03	11.5	7.4	4.6	0.9	0.0	1.7	114.0	24.3	28.1	27.9
04										
05										
06	1.1	0.3	0.2	0.1	0.0	0.2	7.8	1.4	1.5	1.5
07										
08										
09										
10										
11										
12	6.7	5.3	3.5	0.6	0.0	1.0	81.7	15.5	18.8	18.7
13	3.4	3.6	2.3	1.9	180.0	2.1	57.0	2.5	82.2	13.7
14										
15										
16	6.8	3.7	2.0	0.5	0.0	1.1	47.8	14.6	15.3	15.2
17										
18										
19	0.9	0.3	0.1	0.1	0.0	0.1	6.6	1.2	1.3	1.3
20										
21										
22										
23										
24										
25										
26										
27	20.5	8.7	5.5	1.6	0.0	3.0	186.4	30.8	37.0	36.8
28	0.8	0.2	0.1	0.1	0.0	0.1	5.5	1.0	1.1	1.1
29										
30	2.7	0.8	0.4	0.2	0.0	0.4	19.9	3.5	4.0	3.9
31	14.5	14.6	7.6	4.7	0.0	4.8	209.7	59.7	62.9	62.5
32										
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.8	1.4	0.6	0.2	5.8	3.5	7.2	1.8	77.7	6.6
36	27.0	12.1	5.5	3.1	71.2	15.3	6.7	5.0	392.8	45.8
37	39.7	26.5	8.8	5.5	114.9	354.2	131.4	7.0	273.9	259.4
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39										
40										
41										
Total	136.4	84.9	41.1	19.4	371.9	387.6	2359.5	168.2	996.7	494.4
Labor	79.1	45.1	24.4	3.5	0.0	5.2	460.0	61.0	81.1	80.6
IBTs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other VA	62.2	12.2	9.6	3.8	0.0	2.8	336.2	31.5	37.9	37.7
Total VA	141.3	57.3	34.0	7.3	0.0	7.9	796.2	92.5	119.0	118.3
Output	277.7	142.2	75.1	26.7	371.9	395.5	3155.6	260.7	1115.7	612.6

Table 3.12 (cont.)
1982 Environmental Protection Expenditures Input-Output Table (millions of dollars)

	31	32	33	34	35	36	37	38	39	40	41	Total Int.
01												
02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1477.9
03	19.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	908.1
04												
05												
06	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.1
07												
08												
09												
10												
11												
12	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	585.6
13	47.3	9.6	0.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	755.9
14												
15												
16	11.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	511.4
17												
18												
19	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.5
20												
21												
22												
23												
24												
25												
26												
27	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1288.6
28	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.0
29												
30	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	148.6
31	46.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2204.9
32												
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
35	63.7	16.6	0.0	0.0	0.7	1.2	3.1	0.0	0.0	0.0	0.0	366.0
36	283.5	9.3	1.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1459.5
37	423.5	22.8	2.6	0.9	1.0	0.7	156.1	0.4	0.0	0.0	0.0	3112.4
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39												
40												
41												
Total	943.1	58.3	5.2	1.5	1.8	2.0	159.2	0.4	0.0	0.0	0.0	12967.5
Labor	57.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2712.4
IBTs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	232.3
Other VA	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2159.0
Total VA	85.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5103.7
Output	1029.0	58.3	5.2	1.5	1.8	2.0	159.2	0.4	0.0	0.0	0.0	18071.3

Table 3.12 (cont.)
1982 Environmental Protection Expenditures Input-Output Table (millions of dollars)

	Non-envir. PCE	Envir. PCE	Non-envir. GPFI	Envir. GPFI	Inventory	Exports	Imports	Non-Envir. Gov't.	Sanit.	Sewer.	Hwy	Water	Nat. Res.	Final Demand	Output
01		0.0		0.0					3.0	0.0	0.0	0.0	14.5	17.6	17.6
02		0.0		0.0					0.0	0.0	0.6	0.0	0.5	1.1	1479.0
03		0.0		4310.6					100.0	0.0	226.5	614.2	282.3	5533.6	6441.8
04		0.0		0.0					0.0	0.0	0.0	0.0	1.5	1.5	1.5
05		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
06		0.0		81.8					8.4	0.0	0.0	0.0	0.2	90.4	148.4
07		0.0		0.0					5.1	0.0	0.1	0.0	2.9	8.1	8.1
08		0.0		0.0					0.0	0.0	0.0	0.0	0.1	0.1	0.1
09		0.0		0.0					2.4	5.5	0.1	1.2	4.4	13.6	13.6
10		0.0		0.0					2.2	0.0	0.1	0.0	6.8	9.1	9.1
11		0.0		0.0					1.8	0.0	0.0	0.0	15.0	16.8	16.8
12		0.0		43.6					29.5	0.0	0.0	0.0	21.3	94.4	680.1
13		1149.9		0.0					401.9	0.0	0.7	0.0	31.1	1583.6	2339.5
14		0.0		0.0					0.0	0.0	0.0	0.0	2.0	2.0	2.0
15		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
16		0.0		222.1					0.8	0.0	0.0	0.0	2.7	225.6	737.0
17		0.0		0.0					0.0	0.0	0.0	0.0	0.1	0.1	0.1
18		0.0		531.2					11.5	0.0	0.3	0.0	6.5	549.5	549.5
19		0.0		1244.5					73.2	102.7	2.8	18.4	9.8	1451.4	1501.0
20		0.0		179.9					0.3	0.0	0.4	0.5	6.8	187.8	187.8
21		2423.7		1417.8					83.8	65.3	4.6	26.5	12.6	4034.4	4034.4
22		102.2		34.1					0.0	0.0	0.0	0.5	3.5	140.2	140.2
23		0.0		152.6					19.0	19.1	0.2	0.7	6.6	198.2	198.2
24		0.0		0.0					0.2	0.0	0.0	0.0	13.2	13.4	13.4
25		0.0		201.7					65.0	4.9	1.7	1.3	19.5	294.1	294.1
26		0.0		0.0					4.4	0.0	0.1	0.0	14.1	18.6	18.6
27		0.0		0.0					0.0	0.0	4.8	0.0	6.9	11.7	1300.3
28		0.0		0.0					0.0	0.0	0.0	0.0	6.7	6.8	47.7
29		0.0		0.0					71.0	37.5	1.3	5.5	43.2	158.5	158.5
30		0.0		0.0					29.5	0.0	0.0	0.0	10.4	39.9	188.5
31		440.0		0.0					-36.1	0.0	-0.5	0.0	57.6	461.1	2666.0
32		0.0		0.0					38.6	0.0	0.0	0.0	4.2	42.8	42.8
33		0.0		2454.2				470.7	122.0	5477.8	0.0	0.0	0.0	8524.7	8524.7
34		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
35		832.6	0.0	0.0	0.0	2.2	0.0	133.6	0.0	0.0	0.0	0.0	2.2	970.5	1336.5
36		3699.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3699.5	5159.0
37		1125.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1125.8	4238.2
38		0.0		906.0					0.0	0.0	0.0	0.0	0.0	906.0	906.0
39		0.0		0.0					0.0	0.0	3.9	8.3	0.0	12.2	12.2
40		0.0		0.0					2093.0	0.0	36.2	0.0	693.4	2822.6	2822.6
41		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total															
Labor															2712.4
IBTs															232.3
Other VA															2159.0
Total VA															
Output		9773.7		11780.1	0.0	2.2	0.0	604.3	3130.5	5712.8	284.0	677.1	1302.6	33267.3	51338.5

Table 3.13
1982 Environmental Protection Industry Input-Output Table (millions of dollars)

	01	02	03	04	05	06	07	08	09	10
01										
02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03	0.2	104.8	6.6	21.2	0.8	2.8	0.7	4.3	1.0	72.4
04										
05										
06	0.0	2.2	0.6	1.0	0.1	0.1	0.0	0.2	0.1	2.4
07										
08										
09										
10										
11										
12	0.1	80.2	3.7	14.2	0.3	1.9	0.4	3.1	0.5	51.2
13	55.0	13.1	67.8	7.6	0.7	2.2	3.3	4.8	1.4	15.4
14										
15										
16	0.1	49.4	4.3	11.8	0.5	1.6	0.4	2.0	0.6	38.9
17										
18										
19	0.0	1.9	0.5	0.9	0.1	0.1	0.0	0.2	0.1	2.1
20										
21										
22										
23										
24										
25										
26										
27	0.4	99.0	11.4	25.9	1.9	3.4	0.9	5.8	2.1	75.1
28	0.0	1.6	0.4	0.7	0.1	0.1	0.0	0.2	0.1	1.7
29										
30	0.0	5.7	1.6	2.7	0.3	0.3	0.1	0.6	0.3	6.2
31	0.6	190.9	18.4	50.1	1.7	4.0	0.6	7.1	1.9	120.8
32										
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	11.6	20.9	3.3	9.4	0.1	1.6	0.4	2.2	0.5	24.0
36	36.8	10.0	41.7	175.1	3.0	17.2	6.3	3.5	5.8	61.7
37	227.0	177.0	103.4	63.9	1.3	7.0	1.0	13.6	8.1	53.1
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39										
40										
41										
Total	331.9	756.7	263.7	384.6	10.9	42.3	14.1	47.6	22.4	525.1
Labor	0.6	282.8	19.8	69.4	6.1	9.3	1.7	20.0	4.7	119.6
IBTs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other VA	0.3	177.8	10.5	68.7	5.9	9.0	2.4	20.6	4.8	177.4
Total VA	0.9	460.6	30.3	138.1	12.0	18.3	4.1	40.6	9.5	297.0
Output	332.9	1217.3	294.1	522.7	22.9	60.6	18.2	88.2	31.9	822.1

Table 3.13 (cont.)
1982 Environmental Protection Industry Input-Output Table (millions of dollars)

	11	12	13	14	15	16	17	18	19	20
01										
02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03	1.1	144.5	143.5	33.3	0.6	12.7	82.6	12.9	9.3	12.7
04										
05										
06	0.2	5.6	17.6	1.5	0.0	1.4	8.1	0.6	0.4	0.5
07										
08										
09										
10										
11										
12	0.5	102.2	65.0	22.9	0.4	6.8	43.5	8.8	6.5	8.7
13	7.4	21.2	119.1	4.6	0.2	3.8	7.1	4.6	6.1	3.7
14										
15										
16	0.8	75.9	105.8	18.0	0.2	8.0	56.0	7.2	4.7	6.9
17										
18										
19	0.1	4.8	15.0	1.3	0.0	1.2	6.9	0.5	0.4	0.5
20										
21										
22										
23										
24										
25										
26										
27	2.6	161.8	289.3	40.1	0.5	24.4	144.3	15.1	11.7	14.7
28	0.1	3.9	12.4	1.1	0.0	1.0	5.7	0.4	0.3	0.4
29										
30	0.4	14.3	44.9	3.9	0.0	3.5	20.6	1.5	1.1	1.4
31	8.3	344.4	438.9	70.1	1.1	40.3	341.1	18.8	23.5	34.6
32										
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.7	36.5	10.4	6.7	0.3	2.3	34.4	1.7	3.8	4.3
36	7.8	67.4	7.6	16.2	6.3	7.4	28.3	27.7	22.6	27.7
37	11.3	193.9	85.0	55.2	2.4	39.4	105.1	33.0	45.7	56.4
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39										
40										
41										
Total	41.3	1176.5	1354.6	274.9	12.1	152.0	883.7	132.8	136.3	172.5
Labor	6.9	323.1	357.5	100.9	1.4	55.6	297.3	39.4	42.4	56.0
IBTs	0.0	194.6	37.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other VA	5.7	282.0	215.7	90.4	1.4	55.4	375.7	24.8	32.5	36.2
Total VA	12.6	799.7	610.9	191.3	2.8	111.0	673.0	64.2	74.9	92.2
Output	53.9	1976.2	1965.5	466.2	14.9	263.0	1556.7	197.0	211.2	264.7

Table 3.13 (cont.)
1982 Environmental Protection Industry Input-Output Table (millions of dollars)

	21	22	23	24	25	26	27	28	29	30
01										
02	0.0	0.0	0.0	0.0	0.0	0.0	1477.9	0.0	0.0	0.0
03	11.5	7.4	4.6	0.9	0.0	1.7	114.0	24.3	28.1	27.9
04										
05										
06	1.1	0.3	0.2	0.1	0.0	0.2	7.8	1.4	1.5	1.5
07										
08										
09										
10										
11										
12	6.7	5.3	3.5	0.6	0.0	1.0	81.7	15.5	18.8	18.7
13	3.4	3.6	2.3	1.9	180.0	2.1	57.0	2.5	82.2	13.7
14										
15										
16	6.8	3.7	2.0	0.5	0.0	1.1	47.8	14.6	15.3	15.2
17										
18										
19	0.9	0.3	0.1	0.1	0.0	0.1	6.6	1.2	1.3	1.3
20										
21										
22										
23										
24										
25										
26										
27	20.5	8.7	5.5	1.6	0.0	3.0	186.4	30.8	37.0	36.8
28	0.8	0.2	0.1	0.1	0.0	0.1	5.5	1.0	1.1	1.1
29										
30	2.7	0.8	0.4	0.2	0.0	0.4	19.9	3.5	4.0	3.9
31	14.5	14.6	7.6	4.7	0.0	4.8	209.7	59.7	62.9	62.5
32										
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.8	1.4	0.6	0.2	5.8	3.5	7.2	1.8	77.7	6.6
36	27.0	12.1	5.5	3.1	71.2	15.3	6.7	5.0	392.8	45.8
37	39.7	26.5	8.8	5.5	114.9	354.2	131.4	7.0	273.9	259.4
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39										
40										
41										
Total	136.4	84.9	41.1	19.4	371.9	387.6	2359.5	168.2	996.7	494.4
Labor	79.1	45.1	24.4	3.5	0.0	5.2	460.0	61.0	81.1	80.6
IBTs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other VA	62.2	12.2	9.6	3.8	0.0	2.8	336.2	31.5	37.9	37.7
Total VA	141.3	57.3	34.0	7.3	0.0	7.9	796.2	92.5	119.0	118.3
Output	277.7	142.2	75.1	26.7	371.9	395.5	3155.6	260.7	1115.7	612.6

Table 3.13 (cont.)
1982 Environmental Protection Industry Input-Output Table (millions of dollars)

	31	32	33	34	35	36	37	38	39	40	41	Total Int.
01					3.5	5.9	1.5					10.9
02	0.0	0.0	0.0	0.0	1.1	2.0	12.6	0.0	0.0	0.0	0.0	1493.5
03	19.8	0.0	0.0	0.0	275.9	416.3	90.0	0.0	0.0	0.0	0.0	1690.4
04					0.2	0.2	0.7					1.1
05					0.0	0.0	0.0					0.0
06	1.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	58.1
07					1.0	1.8	0.4					3.3
08					0.0	0.0	65.6					65.6
09					0.0	0.0	0.0					0.0
10					9.2	4.5	3.8					17.5
11					2.8	3.6	8.0					14.4
12	12.8	0.0	0.0	0.0	47.0	73.3	177.1	0.0	0.0	0.0	0.0	883.1
13	47.3	9.6	0.9	0.3	20.9	37.0	381.2	0.0	0.0	0.0	0.0	1194.9
14					20.1	6.2	12.1					38.4
15					0.0	0.1	0.1					0.2
16	11.2	0.0	0.0	0.0	10.8	9.8	1.6	0.0	0.0	0.0	0.0	533.5
17					0.0	0.0	0.0					0.1
18					14.7	4.4	87.3					106.3
19	1.1	0.0	0.0	0.0	30.1	53.4	9.8	0.0	0.0	0.0	0.0	142.8
20					5.9	8.3	3.3					17.6
21					0.9	0.9	227.9					229.7
22					1.0	1.9	0.2					3.1
23					2.1	1.4	147.2					150.8
24					1.4	1.9	1.2					4.5
25					14.4	21.1	255.4					290.9
26					14.8	17.1	21.3					53.1
27	28.0	0.0	0.0	0.0	133.8	238.6	31.5	0.0	0.0	0.0	0.0	1692.5
28	0.9	0.0	0.0	0.0	195.8	352.7	276.7	0.0	0.0	0.0	0.0	866.2
29					41.7	51.1	173.5					266.3
30	3.2	0.0	0.0	0.0	71.9	75.2	222.4	0.0	0.0	0.0	0.0	518.0
31	46.8	0.0	0.0	0.0	62.1	83.6	210.8	0.0	0.0	0.0	0.0	2561.4
32					2.2	3.3	3.3					8.8
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	3088.1	0.0	0.0	0.0	0.0	0.0	3088.1
35	63.7	16.6	0.0	0.0	0.7	1.2	3.1	0.0	0.0	0.0	0.0	366.0
36	283.5	9.3	1.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1459.5
37	423.5	22.8	2.6	0.9	1.0	0.7	156.1	0.4	0.0	0.0	0.0	3112.4
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39					0.0	0.1	14.6					14.8
40					0.0	0.0	0.0					0.0
41					0.0	0.0	0.0					0.0
Total	943.1	58.3	5.2	1.5	987.1	4565.5	2600.7	0.4	0.0	0.0	0.0	20957.8
Labor	57.9	0.0	0.0	0.0	250.7	386.2	1286.7	0.0	0.0	0.0	0.0	4636.0
IBTs	0.0	0.0	0.0	0.0	17.9	5.8	122.6	0.0	0.0	0.0	0.0	378.6
Other VA	28.0	0.0	0.0	0.0	80.9	201.5	228.3	0.0	0.0	0.0	0.0	2669.7
Total VA	85.9	0.0	0.0	0.0	349.5	593.5	1637.5	0.0	0.0	0.0	0.0	7684.2
Output	1029.0	58.3	5.2	1.5	1336.5	5159.0	4238.2	0.4	0.0	0.0	0.0	28642.1

Table 3.13 (cont.)
1982 Environmental Protection Industry Input-Output Table (millions of dollars)

	Non-envir. PCE	Envir. PCE	Non-envir. GPFI	Envir. GPFI	Inventory	Exports	Imports	Non-Envir. Gov't.	Sanit.	Sewer.	Hwy	Water	Nat. Res.	Final Demand	Output
01		0.0		0.0					3.0	0.0	0.0	0.0	14.5	17.6	28.5
02		0.0		0.0					0.0	0.0	0.6	0.0	0.5	1.1	1494.6
03		0.0		4310.6					100.0	0.0	226.5	614.2	282.3	5533.6	7224.0
04		0.0		0.0					0.0	0.0	0.0	0.0	1.5	1.5	2.7
05		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
06		0.0		81.8					8.4	0.0	0.0	0.0	0.2	90.4	148.5
07		0.0		0.0					5.1	0.0	0.1	0.0	2.9	8.1	11.3
08		0.0		0.0					0.0	0.0	0.0	0.0	0.1	0.1	65.6
09		0.0		0.0					2.4	5.5	0.1	1.2	4.4	13.6	13.6
10		0.0		0.0					2.2	0.0	0.1	0.0	6.8	9.1	26.6
11		0.0		0.0					1.8	0.0	0.0	0.0	15.0	16.8	31.2
12		0.0		43.6					29.5	0.0	0.0	0.0	21.3	94.4	977.5
13		1149.9		0.0					401.9	0.0	0.7	0.0	31.1	1583.6	2778.6
14		0.0		0.0					0.0	0.0	0.0	0.0	2.0	2.0	40.4
15		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.2
16		0.0		222.1					0.8	0.0	0.0	0.0	2.7	225.6	759.1
17		0.0		0.0					0.0	0.0	0.0	0.0	0.1	0.1	0.1
18		0.0		531.2					11.5	0.0	0.3	0.0	6.5	549.5	655.8
19		0.0		1244.5					73.2	102.7	2.8	18.4	9.8	1451.4	1594.3
20		0.0		179.9					0.3	0.0	0.4	0.5	6.8	187.8	205.3
21		2423.7		1417.8					83.8	65.3	4.6	26.5	12.6	4034.4	4264.1
22		102.2		34.1					0.0	0.0	0.0	0.5	3.5	140.2	143.3
23		0.0		152.6					19.0	19.1	0.2	0.7	6.6	198.2	349.0
24		0.0		0.0					0.2	0.0	0.0	0.0	13.2	13.4	17.9
25		0.0		201.7					65.0	4.9	1.7	1.3	19.5	294.1	585.0
26		0.0		0.0					4.4	0.0	0.1	0.0	14.1	18.6	71.7
27		0.0		0.0					0.0	0.0	4.8	0.0	6.9	11.7	1704.2
28		0.0		0.0					0.0	0.0	0.0	0.0	6.7	6.8	872.9
29		0.0		0.0					71.0	37.5	1.3	5.5	43.2	158.5	424.8
30		0.0		0.0					29.5	0.0	0.0	0.0	10.4	39.9	557.9
31		440.0		0.0					-36.1	0.0	-0.5	0.0	57.6	461.1	3022.5
32		0.0		0.0					38.6	0.0	0.0	0.0	4.2	42.8	51.6
33	0.0	0.0		2454.2				470.7	122.0	5477.8	0.0	0.0	0.0	8524.7	8524.7
34	0.0	0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	3088.1
35	0.0	832.6	0.0	0.0	0.0	2.2	0.0	133.6	0.0	0.0	0.0	0.0	2.2	970.5	1336.5
36	0.0	3699.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3699.5	5159.0
37	0.0	1125.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1125.8	4238.2
38	0.0	0.0	0.0	906.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	906.0	906.0
39		0.0		0.0					0.0	0.0	3.9	8.3	0.0	12.2	27.0
40		0.0		0.0					2093.0	0.0	36.2	0.0	693.4	2822.6	2822.6
41		0.0		0.0					0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total															
Labor															4636.0
IBTs															378.6
Other VA															2669.7
Total VA															
Output		9773.7		11780.1	0.0	2.2	0.0	604.3	3130.5	5712.8	284.0	677.1	1302.6	33267.3	61909.3

NOTES FOR CHAPTER 3

1. Total output of commodity 68.0301 includes both private and public water supply (Ritz, 1980, pp. 18 and A-19). Also, there is a significant discrepancy between the values for water supply estimated by EPA and those reported in the input-output tables. For example, EPA (1990, p. F-16) estimates total operation and maintenance expenditures for water supply at $4,245 million for 1977. The output reported for BEA commodity 68.0301 in the 1977 input-output table is $6,389.4 million. In 1982, the EPA (1990, p. F-16) estimates total operation and maintenance expenditures for water supply at $7,725 million while the 1982 benchmark I-O table shows a commodity output of $10,778.6 million for BEA I-O sector 68.0301.

2. There are two sources for operation and maintenance expenditures for sewerage. The BEA (see Rutledge and Vogan 1994, p. 48) reports expenditures of $2,537 million in 1977 and $5,159 million in 1982. The EPA (1990, p. F-7) reports expenditures of $2,329 million in 1977 and $4,792 million in 1982. In this report, the BEA data are used.

3. The 1977 and 1982 data were provided by the Environmental Economics Division at BEA (Rick Kaglic fax of August 16, 1994).

4. Payments by manufacturing plants to government for solid waste removal ($160.0 million in 1982) are excluded.

5. Data were provided by the Interindustry Economics Division at BEA (meeting with Belinda Bonds on January 19, 1994).

6. The data in the MA-200 report are characterized as 1) expenditure by media and 2) expenditure by type of input (i.e., labor, depreciation, materials and supplies, and services). Due to rounding, the methods of characterizing total pollution abatement expenditures are not equal. As a consequence, the values for expenditure by media are assumed correct. The values associated with the type of expenditure (typically services and equipment leasing) are adjusted so that they are equal to the values associated with media.

   For most industries, the rounding difference is $0.1-0.2 million. The largest discrepancy is $0.9 million. For larger discrepancies, the difference is proportionately distributed across the different expenditure categories (e.g., labor, depreciation, materials and supplies, services and equipment leasing).

   To estimate the matrix entries for 1977 and 1982, the matrix cell values observed in 1979 are used to generate an initial “guess” for the 1977 and 1982 cell values. To create an initial guess, the relative percentages attributable to each combination of expenditure (e.g., labor expenditures for air pollution abatement) are computed for 1979. These percentages are applied to the observed in 1977 and 1982 in order to decompose the totals for air, water, and

solid waste into expenditures on labor, depreciation, materials, and services by media. If these initial guesses are placed in the matrix with columns representing media and rows representing type of expenditure the row and column totals would not necessarily equal the row and column totals observed in 1977 and 1982.

The categories of inputs for the 1977 MA-200 survey are different than the categories for the 1979 and 1982 surveys. Specific information is provided on "equipment leasing" in the 1977 MA-200 survey while "materials, supplies and services" are aggregated into a single value. For 1979 and 1982, the two intermediate input categories are 1) materials and supplies and 2) services, equipment leasing, and other costs. Because materials, supplies, services and equipment leasing are combined into one category ("other") for 1977, it is necessary to take the value for "other" and disaggregate it into a materials and supplies component and a services and equipment leasing component before applying the programming procedure. This disaggregation is accomplished by applying the applying the proportions found in the 1979 MA-200 survey to the 1977 data.

It follows that the optimization problem is to choose the new cell values for 1977 and 1982 to fill the matrix so that the sum of the squared deviations from the initial guess, generated by the observed 1979 values, is minimized (see Schneider and Zenios, 1990). Mathematically, the constrained nonlinear optimization program is stated:

$$\underset{\{E\}}{\textit{Minimize}} \quad \sum_i \sum_j (N_{ij} - E_{ij})^2 \qquad \begin{aligned} i &= a,\ w,\ sw \\ j &= L,\ Dep,\ M,\ S \end{aligned}$$

s.t.

$$\begin{aligned} L_a + Dep_a + M_a + S_a &= a \\ L_w + Dep_w + M_w + S_w &= w \\ L_{sw} + Dep_{sw} + M_{SW} + S_{sw} &= sw \\ L_a + L_w + L_{sw} &= L \\ Dep_a + Dep_w + Dep_{sw} &= Dep \\ M_a + M_w + M_{sw} &= M \\ S_a + S_w + S_{sw} &= S \end{aligned}$$

N_{ij} is the is the percentage of total expenditures for the i^{th} media and the j^{th} type of expenditure in 1979. E_{ij} is the estimated percentage of total expenditures for the i^{th} media

and the j^{th} type of expenditure in 1977 and 1982. L, Dep, M, and S represent the share of total expenditures observed in 1977 and 1982 for labor, depreciation, materials, and services while a, w, and sw represent observed share of total expenditures on air, water, and solid waste. This programming problem is solved for each manufacturing sector in the input-output table.

7. The OAQPS example problems include a category "maintenance material," which is assigned to I-O sector 3, repair and maintenance construction. The OAQPS Manual (p. 2-26) suggests that materials includes items such as "... oil, other lubricants, duct tape, etc., and a host of small tools." For the purposes of this study, these expenses are considered to constitute a type of repair and maintenance construction. With more precise information, this material costs component might be more accurately depicted as demand for specific items, as opposed to generic "repair and maintenance construction."

8. The Radian report looks at two types of FGD systems: dry lime and limestone. The *Cost and Quality of Fuels for Electric Utility Plants* (Department of Energy) reports FGD capacity in operation. According to the MA35J report, electric utilities are the principal purchasers of FGD systems. As a consequence, it may be possible to derive weights for the relative importance of lime and limestone units installed at electric utilities and alternatively, assume that the expenditure pattern for FGD systems is the weighted average of the lime and limestone FGD systems.

9. The Commerce survey "Selected Industrial Air Pollution Control Equipment" (MA35J) reports some information on expenditures by specific industries for different types of pollution control equipment. Due to confidentiality considerations, some of the information is not published. For the purposes of this study, it is assumed that the aggregate expenditure pattern for the economy is identical for each industry. Obviously, to the extent that different industries use different types of pollution control equipment, this assumption leads to a inaccurate picture of the expenditure pattern for operating costs of air pollution control equipment for any particular industry.

10. The "Water Use in Mineral Industries" survey is also published in the *1982 Census of Mineral Industries*. However, the corresponding survey is not published for the *1982 Census of Manufacturing*. It is assumed that the relative importance of different methods of treatment in 1978 is representative of the distribution of the different methods of treatment in 1977 and 1982.

11. Fuel related costs include: operation, fly ash and sulfur removal, and differences in cost of environmentally clean fuel.

12. The Environmental Economics Division at BEA supplied the following information (Gary Rutledge letter of June 6, 1994):

Fuel Differential for Electric Utilities
(millions of dollars)

	1977	1982
Private Utility		$1,377.5
Gov't. Utility		$ 100.4
TOTAL	$538.4	$1,477.9

13. These publications also provide data for the following categories: depreciation expenses; labor, maintenance, materials, and supplies; replacement power costs; taxes and fees; administrative and general; esthetic (sic) costs and other. Since the data are published for pollution abatement as a whole, the categories of costs other than depreciation are not used in this study.

14. Under the heading "fuel related costs" *Statistics of Privately Owned Electric Utilities in the United States* (U.S. Department of Energy 1977) and *Financial Statistics of Selected Electric Utilities* (U.S. Department of Energy 1982) provides information on expenditures by private electric utilities for "fly ash and sulphur removal," which represent solid waste services. The following compares the DOE values to the values estimated by this study for purchases of solid waste management services by electric utilities:

	1977	1982
DOE (millions of dollars)	$59.1	$134.2
Solid Waste Management Services (I-O 37) (millions of dollars)	$37.4	$154.6

This indicates that use of I-O 37 data to approximate purchases of solid waste management services is relatively consistent with DOE estimates.

15. Data were provided by the Environmental Economics Division at BEA (Gary Rutledge letter of June 6, 1994).

16. The trade and services sector consists of: wholesale and retail trade, finance and insurance, real estate and rental, personal services, and business services.

17. The communication and other sector consists of: communication; social services and membership organizations; and forestry, fisheries and agricultural services.

18. The concordance between BEA's nonmanufacturing categories and this study's I-O sectors is:

Industry	This Study	BEA I-O Sector	Industry	This Study	BEA I-O Sector
Mining	2	5-10	*Trade and services*		
Transportation	25	65	Personal services	31	72
Public Utilities			Business services	31	73
Electric	27	68	*Communication and other*		
Gas	28	68	Forestry, fish., & ag. serv.	1	4
Trade and services			Construction	3	11,12
Wholesale and retail trade	29	69	Communication	26	66,67
Finance and insurance	30	70	Social services & member. org.	31	77
Real estate and rental	30	71			

Trade and services and communication and other are disaggregated using industry output as weights in assigning pollution abatement expenditures to the various input-output sectors.

19. The values for water pollution abatement for mining derived by using the 1979 MA-200 expenditure patterns are compared to values reported in the "Water Use Survey," *Census of Mineral Industries*. Census reports the following values for depreciation, labor, materials and supplies, and services expenditures associated with water pollution abatement:

Year	Total	Depreciation	Labor	Materials	Services
1978	200.6	33.9	44.1	79.4	43.2
1983	499.0	113.5	95.2	154.7	135.5

The values for mining estimated using the 1979 MA-200 expenditure patterns are:

Year	Total	Depreciation	Labor	Materials	Services
1977	312.5	40.7	75.5	117.6	78.8
1982	574.3	79.2	137.4	214.2	143.4

Thus, the estimated values are higher than the values reported by Census. The *Census of Mineral Industries* reports capital expenditures for water pollution abatement that are 10 to 90 percent larger than those reported by Environmental Economics Division, BEA (1986).

In addition, the *Census of Mineral Industries* reports the ratio of operating to capital expenditures of 0.82 in 1978 and 2.6 in 1983.

20. For 1977 and 1982, the estimates for expenditures for the fuel price penalty, fuel economy penalty, and maintenance expenditures are from *Environmental Investments: Cost of a Clean Environment* (U.S. EPA, 1990). Updated values for the fuel economy penalty for Light Duty Vehicles ($2,735 million in 1977 and $764 million in 1982) were obtained from the Economic Analysis and Research Branch in EPA's Office of Policy, Planning and Evaluation. The BEA price index for EP personal consumption (see Rutledge and Vogan 1994, pp. 45-47), which was 61.5 in 1977, 94.0 in 1982, and 96.6 in 1986, was used to convert the values in 1986 dollars to current dollars.

For 1977, the following values (in millions of 1986 dollars) were used:

	Maintenance Expenditure	Fuel Price Penalty	Fuel Economy Penalty
Automobiles	-$354	$384	$2,735*
Trucks	$50	$60	$504
Aircraft	$0	0	0
Motorcycles	$0	0	-$18

*Updated value obtained from the Economic Analysis and Research Branch in EPA's Office of Policy, Planning and Evaluation.

The above were converted to current dollars by multiplying by .64:

	Maintenance Expenditures	Fuel Price Penalty	Fuel Economy Penalty	Total Fuel Penalty
Automobiles	$0.0	$244.7	$1,743.0	$1,987.8
Trucks	$31.9	$38.2	$321.1	$359.4
Aircraft	$0.0	$0.0	$0.0	$0.0
Motorcycles	$0.0	$0.0	$0.0	$0.0
TOTAL	$32	$283.0	$2,064.1	$2,347.2

The negative value for maintenance expenditures in 1977 was treated as zero in the I-O table. All EP expenditures for aircraft were assigned to business. All EP expenditures for motorcycles were assigned to households.

For 1982, the following values (in millions of 1986 dollars) were used:

	Maintenance Expenditure	Fuel Price Penalty	Fuel Economy Penalty
Automobiles	-$823	$622	$764*
Trucks	$10	$218	$358
Aircraft	$1	$0	-$3
Motorcycles	$0	$0	-$42

*Updated value obtained from the Economic Analysis and Research Branch in EPA's Office of Policy, Planning and Evaluation.

The above were converted to current dollars by multiplying by 0.97:

	Maintenance Expenditure	Fuel Price Penalty	Fuel Economy Penalty	Total Fuel Penalty
Automobiles	$0.0	$605.9	$744.2	$1,350.1
Trucks	$9.7	$212.4	$348.7	$561.1
Aircraft	$1.0	$0.0	$0.0	$0.0
Motorcycles	$0.0	$0.0	$0.0	$0.0
TOTAL	$0.0	$818.3	$1,092.9	$1,911.2

The negative value for maintenance expenditures in 1982 was treated as zero in the I-O table. All EP expenditures for aircraft were assigned to business. All EP expenditures for motorcycles were assigned to households.

21. The following values, taken from the *Survey of Current Business* (U.S. Department of Commerce, Bureau of Economic Analysis 1981 and 1983), were used to compute the percentages of expenditures for automobiles and truck attributable to personal consumption and producers' durable equipment (in billions of current dollars):

	1977	1982
Autos		
Personal Consumption	44.5	52.9
Producers' Durable Equipment	19.1	24.9
Trucks		
Personal Consumption	11.2	11.8
Producers' Durable Equipment	18.3	16.6

For autos, only new auto purchases are included in the above values.

In 1982, 68 percent of automobile EP expenditures were assigned to PCE and 32 percent were assigned to business. In 1982, 41.5 percent of truck EP expenditures were assigned to PCE and 58.5 percent were assigned to business.

22. The Belal (1987) article is one of a series of articles in the *Statistics of Income Bulletin*, an IRS publication that reports quarterly tax collections by type of substance for 11 petrochemicals and 31 inorganic chemicals. The data reported in these articles and another IRS report, *Internal Revenue Report of Excise Taxes,* are not directly comparable. Barthold (1994) presents a detailed list of existing environmental excise taxes in the United States.

23. The following values for capital expenditures for mobile source pollution abatement (in millions of 1986 dollars) were compiled from EPA data (1990, pp. C-9 through C-18):

	1977	1982
Automobiles	$3,142	$3,277
Trucks	$385	$632
Aircraft	$21	$35
Motorcycles	$0	$105

The BEA price index for EP personal consumption (see Rutledge and Vogan 1994, pp. 45-47) which was 61.5 in 1977, 94.0 in 1982, and 96.6 in 1986, was used to convert the values in 1986 dollars to current dollars. The 1977 values were multiplied by 0.64 and the 1982 values are multiplied by 0.97. This yields the following values for capital expenditures for mobile source pollution abatement (in millions of 1977 and 1982 dollars, respectively) that were used in the input-output table:

	1977	1982
Automobiles	$2,002.4	$3,192.1
Trucks	$245.4	$615.6
Aircraft	$13.4	$34.1
Motorcycles	$0.0	$102.3

24. Telephone conversation with Gary Rutledge, October 1, 1993.

25. Since all EP capital expenditures related to solid waste are in plant and equipment , it was assumed that there are no EP expenditures associated with the remaining components (motor vehicle emission abatement, residential systems, and agricultural business).

26. The I-O table value of $5,713 million for government expenditures for sewerage is $694 million less than the BEA estimate of $6,407 million for government enterprise fixed capital - public sewer systems (see Rutledge and Vogan 1994, p. 48) in 1982. The I-O value of $3,131 million for state and local government expenditures for sanitation is $114 million more than the BEA estimate (see Rutledge and Vogan 1994, pp. 45 and 48) of $3,433 million in 1982 ($3,207 million for state and local government and $225 million for federal government). The U.S. EPA (1990, p. G-3) reports local government total expenditures for solid waste pollution abatement of $4,137 million in 1982.

27. The 1977 use and make I-O tables have minor errors due to merging parts of the 540 sector table with the 85 sector table. The original total I-O tables for 1977 and 1982 are presented in Appendix C.

4. EMPLOYMENT ASSOCIATED WITH THE ENVIRONMENTAL PROTECTION "INDUSTRY"

4.1. EMPLOYMENT IN EXTERNAL ENVIRONMENTAL PROTECTION ACTIVITIES

Table 4.1 presents estimates of the number of employees in the external EP activities for 1977 and 1982. Employment in external EP activities is generated by purchases of the output of these sectors both as intermediate inputs and to satisfy final demand. The following describes data sources and methods for constructing the estimates.[1]

4.1.1. *"Environmental" Water Supply*

Employment in "environmental" water supply was measured as the amount of employment in private and public water supply attributable to water treatment services. Employment in private water supply (SIC 494) was taken from *County Business Patterns* (U.S. Department of Commerce) and employment in water supply provided by government enterprises was taken from the *Public Employment*. Similar to disaggregating output for water supply sector into environmental and non-environmental components, 12.4 percent of water supply employment was allocated to water treatment (the environmental component of water supply as defined by EPA, 1990).

4.1.2. *Sewerage Systems*

It has been assumed that all sewage treatment services are publicly provided so employment figures were taken from *Public Employment*.

4.1.3. *Solid Waste Management Services*

Employment in sanitary services (SIC 495) served as an estimate of employment in private solid waste management services. This was taken directly from *Employment, Hours, and Earnings, United States, 1909-1990* (U.S. Bureau of Labor Statistics 1991). SIC 495 also includes any private sewerage services. However, for the purposes of this report, it was assumed that employment related to private sewerage services is zero.

Table 4.1

Employment in the External Environmental Protection Activities

(Number of Individuals)

I-O Sector	1977	1982
35	18,724	19,396
36	90,000	103,000
37	41,700	53,000
Total	150,424	175,396

4.2. EMPLOYMENT ASSOCIATED WITH INTERNAL ENVIRONMENTAL PROTECTION ACTIVITIES

Employment in internal EP activities consists of employment used directly in pollution abatement by regulated sectors. Data on total employment, total payments to labor, and total payments to labor used in EP activities were obtained for each industry. The MA-200 report was the source of data for payments to labor for EP by manufacturing sectors. Payments to labor for EP by nonmanufacturing sectors were estimated in Chapter 3. Total payments to labor for both manufacturing and non-manufacturing sectors were obtained from the benchmark I-O tables. For each industry, these data were used to calculate the ratio of payments to labor for EP to total payments to labor.

For each industry, total employment was multiplied by the EP labor payments-total labor payments ratio to estimate EP employment. The principal source of employment data was *Employment, Hours and Earnings, United States, 1909-1990* (U.S. Bureau of Labor Statistics, 1991). This report was supplemented by *County Business Patterns* (U.S. Department of Commerce) and the *Statistical Abstract of the United States* (U.S. Department of Commerce), which gives data for the "Agriculture, forestry, and fisheries" sector of the I-O table. The principal drawback of this approach is that it implicitly assumes that the composition of the labor force used for EP by an industry is identical to the composition of the labor force used by that industry for producing its marketable good or service.

Table 4.2 reports the results of the calculations described above for 1977 and 1982.

Table 4.2

Employment in Internal EP Activities by I-O Sector

(Number of Individuals)

I-O Sector	1977	1982
1	2,289	154
2	7,948	12,323
3	667	536
4	3,513	3,021
5	202	175
6	795	555
7	177	123
8	1,474	1,081
9	388	261
10	4,782	4,440
11	281	302
12	10,719	10,221
13	6,518	8,844
14	3,007	4,205
15	206	107
16	2,826	2,120
17	11,125	9,109
18	1,610	1,504
19	1,667	1,493
20	1,465	1,736
21	2,074	2,339
22	1,234	1,254

Table 4.2 (Continued)

I-O Sector	1977	1982
23	984	1,439
24	267	184
25	0	0
26	209	173
27	12,790	17,763
28	1,596	2,126
29	6,415	5,642
30	5,121	3,641
31	3,620	3,428
32	0	0
33	0	0
34	0	0
35	0	0
36	0	0
37	0	0
38	0	0
39	0	0
40	0	0
41	0	0
TOTAL	95,970	100,296

Note: Virtually all of the EP employment for I-O sector 2 is attributable to the higher cost of low sulfur coal purchased by the electric utility sector (I-O 27). This may bias the estimates upward slightly because this higher cost may not represent increased purchases of coal.

4.3. EMPLOYMENT IN SECTORS WHOSE OUTPUT IS USED SOLELY FOR EP

Table 4.3 reports estimated employment for the environmental construction sectors and the industrial air pollution control sector. The following describes the procedures and data sources used in constructing the estimates.

4.3.1. *Environmental Construction Sectors*

To estimate employment in the environmental construction sectors, it was assumed that the average salary is equal for all types of construction. Employment in each environmental construction sector was estimated by multiplying total employment in construction by that environmental construction sector's share of labor expenditures relative to total labor expenditures by the construction industry. Employment in construction was taken from *Employment, Hours, and Earnings, United States, 1909-1990* (U.S. Bureau of Labor Statistics 1991). Labor expenditures for construction and the environmental portion of the construction industry were taken directly from the BEA I-O tables.

The entire output of New Sewer Facility Construction (I-O 33) is purchased as final demand and thus, all employees of I-O 33 count as direct EP employment. The output of maintenance and repair of sewer facilities (I-O 34) is used as an intermediate input by Sewerage Services (I-O 36). As a result, none of the employees of I-O 34 count as direct EP employment.

4.3.2. *Industrial Air Pollution Control Equipment*

The industrial air pollution control equipment industry is a five-digit industry (SIC 35646) and the BLS employment data is reported at the four-digit level. To estimate the number of employees in the industrial air pollution control equipment industry, it was assumed that SIC 35646 has the same labor-output ratio as SIC 3564 (SIC 3564 is equivalent to BEA I-O sector 49.0300). Employment in the industrial air pollution control equipment industry was estimated by multiplying the BLS employment data for SIC 3564 by ratio of shipments of SIC 35646 (taken from the Department of Commerce publication, “Selected Industrial Air Pollution Control Equipment”) to gross output of SIC 3564 (taken from BEA I-O 49.0300). Since it has been assumed that all output of Air Pollution Control Equipment (I-O 38) is purchased for GPFI, all employees of I-O 38 count as EP employment.

4.4. EMPLOYMENT TO SUPPORT HOUSEHOLD, INVESTMENT, AND GOVERNMENT EP ACTIVITIES

Household, investment, and government EP activities were treated together since all of these activities represent an adjustment to final demand in the EP I-O tables. The procedure for determining the amount of employment needed to produce the goods and services required for household, investment, and government EP activities involved calculating the non-EP

employment to output ratio for each industry, using the employment data discussed previously and gross output data taken directly from U.S. I-O tables. Non-EP employment is simply total industry employment less employment used directly in EP activities. The non-EP employment-output ratio multiplied by the amount of each good and service purchased for EP final demand (computed by summing across the individual rows of the columns associated with EP final demand) yielded an estimate of the amount of non-EP employment for each industry that is used to produce the goods and services that are purchased for EP final demand. This procedure avoids double counting employees associated with internal EP activities.

In addition, a substantial portion of EP employment falls in the public sector (i.e., government industry). This consists of employment associated with state and local government purchases for: sanitation, highways, and natural resources. Data on government EP employment were obtained from *Public Employment* and were assigned as employment in government industry (I-O 40). All government employment in sanitation services was classified as EP employment. For 1982, employment in highway erosion abatement was estimated by multiplying the ratio of highway erosion abatement expenditures ($284 million) to total state and local government purchases for highways (the column sum for I-O sector 99.3001 = $34,083 million) total employment for highways. It was assumed that 20 percent (the percent of expenditures for natural resources related to EP) of state and local government employment related to natural resource activities is for EP. Table 4.3 lists the number of individuals employed in EP government (I-O 40) for 1977 and 1982.

Table 4.3

EP Employment in the Government Industry Sector

(Number of Individuals)

Final Demand Sector	1977	1982
Sanitation	133,000	116,000
“Environmental” Highways	5,040	4,391
“Environmental” Natural Resources	42,000	39,000
Total	180,040	159,391

For I-O sectors 35 through 37, employment attributable to final demand is captured in the employment in external environmental protection sectors figures in Table 4.1. Table 4.4 presents estimates for employment to support household, investment, and government EP activities by I-O sector.

4.5. SUMMARY

Table 4.5 provides totals for EP employment in 1977 and 1982. It should be noted that two key assumptions potentially affect these estimates. First, employment patterns for environmental protection activities of regulated industries are assumed to mirror the employment patterns used by the industry to produce its marketable good or service. Second, employment estimates associated with the internal environmental protection industry are only as accurate as the estimates of the amount of each output from each input-output sector that is purchased for EP activities.

The decline in EP employment between 1977 and 1982 can be attributed to two sources. First, the decline in employment associated with Household, Investment, and Government EP activities is primarily due to the reduction in employment associated with construction activities (see I-O sectors 3 and 33 in Table 4.4). Between 1977 and 1982, there was a substantial increase in payments per employee in the construction sector. Hence in 1982, a given amount of purchases of construction services generated less employment in the construction sector than in 1977. Second, the decline in Government industry employment is due primarily to a decline in sanitation employment (see Table 4.3).

Table 4.4

Employment Required to Support Household, Investment, and Government EP Activities

(Number of Individuals)

I-O Sector	1977	1982
1	320	321
2	9	6
3	75,111	49,294
4	8	9
5	0	0
6	991	1,200
7	150	172
8	2	1
9	237	248
10	121	75
11	335	246
12	506	618
13	448	1471
14	65	22
15	0	1
16	10,032	2,762
17	1	1
18	13,603	6,747
19	27,619	18,290

Table 4.4 (Continued)

I-O Sector	1977	1982
20	3,626	2,274
21	7,139	25,277
22	294	1,535
23	5,644	4,111
24	152	183
25	3,310	4,196
26	213	235
27	52	53
28	33	14
29	3,274	4,502
30	497	298
31	1,174	11,639
32	727	954
33	80,138	52,509
34	0	0
35	0	0
36	0	0
37	0	0
38	16,096	15,833
39	0	0
40	0	0
41	0	0
TOTAL	251,925	205,098

Table 4.5

Total Employment for EP Activities

(Number of Individuals)

EP Activity	1977	1982
External	150,424	175,396
Internal	95,970	100,296
Household, Investment, and Government	251,925	205,098
Government Industry	180,040	159,391
Total EP	678,359	640,181
EP Employment as a Percent of Total Employment	.79	.69

NOTES FOR CHAPTER 4

1. EPA employment is excluded from the employment figures presented in this chapter.

5. UPDATING THE ENVIRONMENTAL PROTECTION I-O TABLES

This chapter describes the procedures and data sources used to update the 1982 EP I-O tables to 1985, 1988, and 1991. Essentially the same data sources used to construct 1982 EP I-O tables were used for the updates. The key difference is in the sources used in updating the estimates for the three external EP activities sectors. For 1982, these sectors were derived from specific sectors in the 540 sector benchmark table. Since 1982 is the most recent benchmark I-O table for the United States available during the time this report was being prepared, alternative data sources were used.[1]

5.1. EXTERNAL ENVIRONMENTAL PROTECTION ACTIVITIES

Table 5.1 lists updated values for the output of the three external EP sectors. Data sources and construction procedures are described below.

5.1.1. *"Environmental" Water Supply*

Since exact source of the data used to estimate the commodity output of I-O 68.0301 in the 1982 benchmark table is unknown, the following procedure was adopted for purposes of updating "environmental" water supply. First, the ratio of commodity output for sector 68.0301 in the 1982 input-output table ($10,778.6 million) to the revenue of water supply utilities (taken from *Government Finances in 1981-82*) in 1982 ($8,597 million) was calculated. This ratio is multiplied by water supply revenue in 1985, 1988, and 1991 in order to approximate commodity output for 68.0301. *Government Finances* was the data source for revenue of water supply utilities in 1985, 1988, and 1991. It was again assumed that 12.4 percent of water supply expenditures are for water treatment (i.e., "environmental" water supply).

5.1.2. *Sewerage Services*

BEA (Rutledge and Vogan 1994) was the data source for sewerage services (government enterprise - public sewer systems).

5.1.3. *Solid Waste Management Services*

BEA (Rutledge and Vogan 1994) was the data source for solid waste management services. The BEA value was reduced by the amount of internal EP activities related to solid waste pollution abatement, using the same procedure as for the 1982 I-O table.[2] The residual served as the total for the output of solid waste management services.

Table 5.1

Updated Values for the Output of External EP Activities

(Millions of Dollars)

Sector	1985	1988	1991
"Environmental" Water Supply	$1,862.4	$2,380.9	$2,803.7
Sewerage	$6,557.0	$8,363.0	$11,052.0
Solid Waste	$7,089.2	$11,391.5	$15,049.0

5.2. SECTORS WHOSE OUTPUT CONSISTS SOLELY OF EP PRODUCTS

Table 5.2 lists updated values the two environmental construction sectors and the industrial air pollution control equipment sector. Data sources and construction procedures are described below.

5.2.1. *Environmental Construction Sectors: New Sewer System Facilities and Repair and Maintenance of Sewer Facilities*

Although BEA (see Rutledge and Vogan 1994) supplies estimates of public sewer construction, an alternative procedure is followed. The output of new sewer facilities is used entirely to satisfy various categories of final demand so output was estimated on the basis of the demand for new sewer facilities construction.

Government purchases of new sewer facilities were derived from non-EP government expenditures and various EP government expenditure categories. The expenditure pattern for government purchases of new sewer system facilities in 1982 was assumed to hold for 1985, 1988, and 1991. Since the amount of government purchases is published information, this makes it possible to determine the amount of new sewer facilities construction purchased.

In 1982, some of the new sewer facility construction output was assigned to GPFI. This was updated using total GPFI expenditures and assuming that the 1982 expenditure pattern for GPFI held for 1985, 1988, and 1991. The value for GPFI for new sewer facility construction obtained from this procedure was reduced by the value of residential purchases of new sewer facilities construction (see Section 5.5.1.). The residual is the value of GPFI expenditures of new sewer facilities assigned to business GPFI.

Table 5.2

Updated Values for the Output the Environmental Construction Sectors and the Industrial Air Pollution Control Equipment Sector

(Millions of Dollars)

	1985	1988	1991
New sewer construction	$10,573	$12,738	$14,223
Repair and maintenance of sewer facilities	$3,925	$5,006	$6,647
Air Pollution Control Equipment	$771	$550	$818

The output of repair and maintenance of sewer facilities (I-O 34) was assumed to be solely used as an intermediate input by the sewerage services sector. It was assumed that the ratio of the output of repair and maintenance of sewer facilities to sewerage services in 1982 held for 1985, 1988, and 1991. Multiplying the output of sewerage services by this ratio for each year yields the estimate of the output of the repair and maintenance of sewer facilities sector.

5.2.2. *Industrial Air Pollution Control Equipment*

Shipments from the air pollution control equipment industry (U.S. Dept. of Commerce) "Selected Industrial Air Pollution Control Equipment" (MA35J) was the source of the updated values for the output of the industrial air pollution control sector.

5.3. INTERNAL ENVIRONMENTAL PROTECTION ACTIVITIES

5.3.1. *Manufacturing Sectors*

"Pollution Abatement and Control Expenditures" (U.S. Department of Commerce, MA200) was the source of data for internal EP activities in manufacturing sectors. The data are disaggregated by media (air, water, and solid waste) and by type of cost (labor, depreciation, materials, and services. Using the same procedure as for 1977 and 1982, the data associated with each media were further disaggregated into the following components: (1) labor, (2) depreciation, (3) materials, and (4) services. The same distribution of materials expenditures was also used.

5.3.2. *Non-manufacturing Sectors*

Data for air and water pollution control for "electric utilities" (private and government) and "mining and other nonmanufacturing" were obtained from BEA Environmental Economics Division.[3] The "mining and other nonmanufacturing" data were allocated to "mining" and "other nonmanufacturing" using capital stock estimates provided by BEA. Further disaggregation of "other nonmanufacturing" was accomplished using data on capital expenditures for 1981-1985.

The procedure for disaggregating these expenditures into labor, depreciation, materials, and services is identical to the procedure used for the 1982 data. The same procedure applied to the 1982 data was used to generate estimates of operation and maintenance expenditures for solid waste.

Table 5.3 lists the updated values for internal EP activities by nonmanufacturing.

5.3.3. *Miscellaneous Internal Environmental Protection Activities*

5.3.3.1. Motor Vehicles

The *Survey of Current Business* provides data on business and household purchases of autos and trucks. As for 1982, these values were used as weights in distributing the fuel cost penalties and capital costs associated with automobile and truck pollution abatement between households and business.[4] Data on EP expenditures associated with automobiles and trucks were taken from EPA (1990).[5] The values assigned for motor vehicle EP expenditures by business associated with fuel economy and fuel price were $672.1 million in 1985, $750.6 million in 1988, and $94.9 million in 1991. Business motor vehicle maintenance expenditures are set equal to zero given its relatively small value (see endnote 5 for the list of household and business maintenance expenditures). EP expenditures for aircraft are assumed to be business purchases and EP expenditures for motorcycles are assigned to households.

5.3.3.2. Environmental Taxes

Belal (1987) was the source of environmental excise tax data for 1985. Due to the expiration of CERCLA, environmental excise tax data were collected for only the first three quarters of 1985. Mahler (1990) was the source of data for 1988 and Boroshok (1993) was the source for 1991 environmental excise taxes. Table 5.4 list the updated environmental tax data.

Table 5.3

Updated Values for Internal EP Activities by Nonmanufacturing

(Millions of Dollars)

	1985	1988	1991
Air			
Electric Utilities	1,036.0	1,156.6	1,151.6
Mining	217.5	279.1	273.9
Other Nonmanufacturing	465.4	532.2	527.0
Water			
Electric Utilities	207.8	241.6	248.1
Mining	717.9	982.3	1,077.1
Other Nonmanufacturing	570.6	737.0	814.1

Note: The air values for electric utilities excludes the fuel premium, which is $1,220.3 million for 1985, $874.5 million for 1988, and $673.1 million for 1991.

Table 5.4

Environmental Excise Taxes

(Millions of Dollars)

	1985	1988	1991
Petroleum	$29.3	$547.6	$825.0
Domestic		$250.1	$434.1
Imports		$297.5	$390.9
Chemicals	$175.8	$294.3	$299.6
Petrochemicals	$139.4	$241.3	$237.3
Inorganic chemicals	$36.4	$53.0	$50.4
Chemicals (imported)			$11.9

5.4. HOUSEHOLD ENVIRONMENTAL PROTECTION ACTIVITIES

5.4.1. *Purchases for the Operation and Maintenance of Septic Systems and Sewer Connections*

BEA (Rutledge and Vogan 1994) was the source of data for household operation and maintenance expenditures for septic systems and sewer connections. For 1985, 1988, and 1991, the values were $559 million, $642 million, and $749 million, respectively.

5.4.2. *Purchases for Operation and Maintenance of Motor Vehicles*

EPA (1990) reports data on EP operation and maintenance expenditures for motor vehicles. All EP operation and maintenance expenditures for motorcycles were assigned to households and all EP operation and maintenance expenditures for aircraft were assigned to business. EP operation and maintenance expenditures for autos and trucks were assigned to households and business using personal consumption expenditures and producer durable equipment purchases of autos and trucks as weights.

The amount assigned to personal consumption expenditures for I-O 13 was $868.3 million in 1985, $1,102.6 million in 1988, and $111.2 million in 1991.

5.4.3. *Purchases of Environmental Protection Equipment on Motor Vehicles*

Data on EP equipment (capital) expenditures on motor vehicles are reported by EPA (1990).[6] Table 5.5 lists the updated values for household expenditures on motor vehicle pollution abatement equipment. Household maintenance expenditures for motor vehicle EP operations are assigned to PCE of I-O 31.

5.5. INVESTMENT ACTIVITIES FOR ENVIRONMENTAL PROTECTION

5.5.1. *Households*

The BEA (see Rutledge and Vogan 1994) reports data on household investment expenditures for EP. As for the 1977 and 1982 EP I-O tables, one-third of these expenditures was assigned to I-O 3 and two-thirds were assigned to I-O 33. Table 5.6 lists the updated values for household investment in EP.

5.5.2. *Businesses*

5.5.2.1. Production Process

The BEA (see Rutledge and Vogan 1994) is the source of the data for business plant and equipment EP expenditures. The expenditure patterns used for the 1977 and 1982 EP I-O tables were used in the updates. Table 5.7 lists the values used in the updates.[7]

5.5.2.2. Motor vehicles and Aircraft

Table 5.8 lists the mobile source capital expenditure data for EP equipment on motor vehicles classified as gross private fixed investment in updating the EP I-O tables (see Section 5.4.2 for further detail).

Table 5.5

Updated Values for Household Expenditures on Motor Vehicle Pollution Abatement Equipment

(Millions of Dollars)

	1985	1988	1991
Automobiles	$3,617.7	$3,663.4	$3,352.8
Trucks	$550.8	$752.2	$1,107.3
Motorcycles	$91.1	$49.6	$61.7

Table 5.6

Updated Values for Household EP Investment Expenditures

(Millions of Dollars)

	1985	1988	1991
I-O 3	$672.7	$524.0	$360.3
I-O 33	$1,345.3	$1,048.0	$720.7
Total	$2,018.0	$1,572.0	$1,081.0

Table 5.7

Updates for EP Investment Activities (Production Process)

(Millions of Dollars)

	1985	1988	1991
Air	$3,635	$3,467	$5,581
Water	$2,802	$2,684	$4,380
Solid Waste	$1,611	$1,890	$2,520

Table 5.8

Updated Values for GPFI in EP Equipment on Motor Vehicles

(Millions of Dollars)

	1985	1988	1991
Automobiles	$1,769.5	$1,820.8	$2,522.0
Trucks	$787.3	$960.9	$945.2
Aircraft	$8.2	$13.7	$12.8

5.6. GOVERNMENT ENVIRONMENTAL PROTECTION ACTIVITIES

Table 5.9 reports the updated values for government EP activities. The benchmark I-O tables were the source for government purchases associated with sewerage (capital account), water (capital account), and sanitation. Therefore, sources external to the I-O table had to be used to generate totals for these activities.[8] BEA (see Rutledge and Vogan 1994) reports data for sewerage (government enterprise fixed capital, public sewer systems) and state and local plus federal highway erosion abatement expenditures. The EPA (1990, p. F-16, col. B) provides the 1985 data for government purchases for water and for 1988 and 1991, *Government Finances* is the source. "Environmental" water supply was estimated by multiplying the water supply total by 0.184. EPA (1990, p. F-7) reports data for government purchases for sanitation for 1985. For 1988 and 1991, *Government Finances* is the source. The EPA (1990, p. F-7) reports state and local expenditures for Natural Resources in 1985 and *Government Finances* is the source for 1988 and 1991. "Environmental" natural resources is obtained by multiplying state and local natural resource expenditures by 0.20.

Table 5.9

Updated Values for Government EP Activities

(Millions of Dollars)

	1985	1988	1991
Sanitation	$5,212	$7,350	$10,177
Sewerage	$7,765	$9,918	$10,653
EP Highways	$398	$493	$541
EP Water	$760.5	$1,113.6	$1,379.8
EP Nat. Resources	$1,671.4	$2,047.6	$2,515.0

5.7. IMPLEMENTATION OF THE UPDATE

To implement the update procedure it was assumed that the structure of the U.S. economy remained unchanged from 1982.[9] Equivalently, it was assumed that all final demand expenditure patterns and production technologies were constant. The only changes that occur are in the composition of EP expenditures. Even here, it was assumed that the expenditure patterns for air, water, and solid waste operation and maintenance materials as well as capital materials expenditures are unchanged.

5.8. EMPLOYMENT

5.8.1. *Employment in External EP Activities*

Table 5.10 lists employment in the external EP sectors for 1985, 1988, and 1991. Employment in private water supply (SIC 494) is reported in *County Business Patterns*. Employment in "environmental" water supply was estimated as 12.4 percent of private and public water supply employment. As for 1977 and 1982, all employment in sanitary services (SIC 495) was counted as employment in EP activities. These data were taken from *Employment, Hours, and Earnings* (U.S. Bureau of Labor Statistics). *Public Employment* (U.S. Department of Commerce, various issues) was the source for sewerage services and public water supply.

Table 5.10

Updated Employment Estimates for External EP Activities

(Number of Individuals)

	1985	1988	1991
"Environmental" Water Supply	20,095	21,398	22,164
Sanitary Services	65,600	94,000	123,000
Sewerage	107,000	116,000	127,000

5.8.2. *Employment in Internal EP* Activities

Employment for most sectors is from *Employment, Hours, and Earnings, United States, 1909-1990* (U.S. Bureau of Labor Statistics 1991) and *Employment and Earnings 1989-1992*, (U.S. Bureau of Labor Statistics, 1992). The *U.S. Statistical Abstract* was the source for "Agriculture, Forestry and Fisheries." Gross output and "compensation of employees" for each I-O sector for 1985, 1988, and 1991 was estimated by scaling gross output and "compensation of employees" in 1982 by the increase in GNP. This information, along with data on payments to labor used in internal EP activities, was used to update the employment figures using the same procedure as for 1977 and 1982.

5.8.3. *Employment to Support Household, Investment, and Government EP Activities*

The procedure for updating the employment estimates for household, investment, and government EP activities was essentially the same as for 1977 and 1982. The non-EP employment to output ratio was computed for each industry, using BLS employment and updated gross output estimates. The non-EP employment-output ratio was multiplied by the updated amount of each good and service purchased for EP final demand.

Public Employment was the source of employment data for sanitation, highways, and natural resources. All government employment in sanitation services was classified as EP employment. Employment in highway erosion abatement was estimated by multiplying the ratio of highway erosion abatement expenditures to total state and local government purchases for highways by total employment for highways. It was assumed that 20 percent of state and local government employment related to natural resource activities is for EP. Table 5.11 reports updated employment estimates for government EP activities.

5.8.4. *Summary of Updated Employment Figures*

Table 5.12 summarizes the updated values for total employment in EP activities.

Table 5.11

Updated Employment Estimates for Government EP Activities

(Number of Individuals)

	1985	1988	1991
Sanitation	113,000	114,000	114,000
Highways	4,853	4,899	4,699
Natural Resources	40,400	39,200	40,000

Table 5.12

Updated Estimates for Total Employment in EP Activities

(Number of Individuals)

EP Activity	1985	1988	1991
External	192,695	231,398	272,164
Internal	103,225	112,430	104,655
Household, Investment, and Government	204,894	196,421	205,668
Government Industry	158,253	158,099	158,699
Total EP	659,067	697,348	741,186
EP Employment as a Percent of Total Employment	.65	.64	.66

NOTES FOR CHAPTER 5

1. The 1987 benchmark table (U.S. Department of Commerce, BEA, 1994) was published as this report was being completed.

2. The BEA reports the following current account expenditures for solid waste: $8,452.5 million in 1985, $13,231 million in 1988, and $17,476 million in 1991.

3. The data on air and water pollution abatement operation and maintenance expenditures by nonmanufacturing sectors were provided by Gary Rutledge (letter June 6, 1994).

4. The following data on household and business purchases of trucks and automobiles (in millions of dollars) were used:

	1985	1988	1991
Automobiles	129.9	151.5	139.3
Personal Consumption Expenditures	87.2	101.2	79.5
Producers' Durable Equipment	42.7	50.3	59.8
Trucks	54.9	66.5	67.1
Personal Consumption Expenditures	22.6	29.2	36.2
Producers' Durable Equipment	32.3	37.3	30.9

Source: U.S. Department of Commerce (BEA), 1986, 1989, and 1992.

5. The following values (in millions of 1986 dollars) were taken from *Environmental Investments: The Cost of a Clean Environment* (U.S. EPA, 1990):

	Maintenance Exp.	Fuel Price Penalty	Fuel Economy Penalty
1985 (1986 dollars)			
Automobiles	-598	880	-679*
Trucks	22	335	288
Aircraft	3	NA	-10
Motorcycles	NA	NA	-41

	Maintenance Exp.	Fuel Price Penalty	Fuel Economy Penalty
1988 (1986 dollars)			
Automobiles	-425	1,195	-1,063*
Trucks	43	319	241
Aircraft	6	NA	-20
Motorcycles	NA	NA	-46
1991 (1986 dollars)			
Automobiles	-490	0	----*
Trucks	21	0	177
Aircraft	9	NA	-28
Motorcycles	NA	NA	-51

Note: The corrected values for the fuel economy penalty for light duty vehicles (*) were obtained from the Economic Analysis and Research Branch in EPA's Office of Policy, Planning and Evaluation.

The BEA price index for EP personal consumption (see Rutledge and Vogan 1994) was used to convert the values in 1986 dollars to current dollars. All negative values were treated as zero so that the following (in millions of dollars) were used in constructing values for EP expenditures for motor vehicles:

	Maintenance Exp.	Fuel Price Penalty	Fuel Economy Penalty
1985			
Automobiles	0.0	901.0	0.0
Trucks	22.5	343.0	294.9
Aircraft	3.1	0.0	0.0
Motorcycles	0.0	0.0	0.0
TOTAL	$25.6	$1,243.9	$294.9

	Maintenance Exp.	Fuel Price Penalty	Fuel Economy Penalty
1988			
Automobiles	0.0	1,260.6	0.0
Trucks	45.4	336.5	254.2
Aircraft	6.3	0.0	0.0
Motorcycles	0.0	0.0	0.0
TOTAL	$51.7	$1,597.1	$254.2
1991			
Automobiles	0.0	0.0	0.0
Trucks	24.4	0.0	206.0
Aircraft	10.5	0.0	0.0
Motorcycles	0.0	0.0	0.0
TOTAL	$35.0	$0.0	$206.0

6. The following table lists the EPA (1990, pp. C-9 to C-18) data that used to estimate expenditures on EP equipment on motor vehicles:

(1986 dollars)	1985	1988	1991
Automobiles	$5,258	$5,199	$5,049
Trucks	$1,307	$1,624	$1,764
Aircraft	$8	$13	$11
Motorcycles	$89	$47	$53

These were converted to current dollars using the price indexes for EP personal consumption expenditures (see Rutledge and Vogan 1994):

	1985	1988	1991
Automobiles	$5,383.2	$5,484.2	$5,874.8
Trucks	$1,338.1	$1,713.1	$2,052.5
Aircraft	$8.2	$13.7	$12.8
Motorcycles	$91.1	$49.6	$61.7

7. For 1988, it was necessary to modify the procedure used estimate the goods and services purchased as water EP capital expenditures. The amount of purchases of I-O 33 for all gross private fixed investment was revised in order to avoid having the amount of purchases of I-O 33 allocated to water EP capital expenditures exceeding the BEA total for water EP capital expenditures by business.

8. This introduces a discrepancy since all other sectors are scaled in the same proportion during the update procedure.

9. No RAS update of the original 1982 benchmark input-output table was attempted.

6. APPLICATIONS

This chapter demonstrates presents measures of the size of the EP "industry" and a modified Leontief multiplier for calculating indirect EP employment. These measures and indirect employment are computed for the U.S. for 1977, 1982, 1985, 1988, and 1991. The chapter concludes with a simplified numerical illustration.

6.1. DECOMPOSITION OF GROSS OUTPUT INTO EP AND NON-EP ACTIVITIES

Using I-O concepts and the I-O matrix adjusted for environmental protection activities, it is possible to derive a matrix of inputs to EP activities, which is independent of the matrix of inputs to traditional economic activities. This is the first step in developing measures for the size of the EP industry and estimating indirect employment attributable to EP activities.

In matrix notation, the basic I-O model is described by

$$q = Aq + Y \tag{6.1}$$

where

$$A = X \hat{q}^{-1} \tag{6.2}$$

q is the vector of gross output, **X** is the matrix of inter-industry flows, and Y is the vector of final demand. A is the matrix of direct intermediate input requirements. The $\hat{q}^{-1}$ matrix is a diagonal matrix whose elements consist of the reciprocal of industry gross output.

The vector of gross output requirements for producing any vector of final demand is obtained by solving (1) for q^1,

$$q = [I - A]^{-1} Y = BY \tag{6.3}$$

I is, of course, the identity matrix.

The vector of total primary factor demands is

$$P = \Pi q \tag{6.4}$$

where

$$\Pi = V \hat{q}^{-1} \tag{6.5}$$

V is the matrix of primary inputs and Π is the matrix of primary input coefficients.

Schäfer and Stahmer (1989) and more recently, Nestor and Pasurka (1995) have shown that q can be disaggregated into EP and non-EP components as follows:

$$(6.6) \qquad q = [I - A]^{-1}Y = BY = BY_e + B_{ne}Y_{ne} + BA_eB_{ne}Y_{ne}$$

where $B_{ne} = I - A_{ne}$, with A_{ne} being the matrix non-EP input-output coefficients, A_e is the matrix of EP input-output coefficients, and Y_e and Y_{ne} are EP and non-EP final demand respectively. Equation (6.6) indicates that gross output (q = BY) has three components. The first component, BY_e, is the gross output required to support final demand associated with EP activities. This output is produced with intermediate inputs used for both EP and non-EP activities. The second component, $B_{ne}Y_{ne}$, consists of the gross output required to support non-EP final demand. The output is produced with intermediate inputs used for non-environmental protection activities. The third component, $BA_eB_{ne}Y_{ne}$, measures the output required to support intermediate inputs used for environmental protection activities. This output includes EP inputs required indirectly to support non-EP intermediate inputs and final demand.

6.2. MEASUREMENT OF THE SIZE OF THE EP "INDUSTRY"

Nestor and Pasurka (1995) propose two alternatives for measuring the size of the EP "industry." One possible measure is value-added associated with EP activities relative to value-added for the economy (which is equal to GNP). This comparison is analogous to using value-added for a specific industry to compute its contribution to GNP or measure its size relative to the national economy. The (direct) value-added for EP activities is simply the sum of value-added for external, internal, household, investment, and government EP activities. Using Π_e, and Π_{ne} to denote the matrices of EP primary inputs, and non-EP primary inputs, respectively, Nestor and Pasurka (1995) show that direct EP value-added (P_e^d) this is given by the expression

$$(6.7) \qquad P_e^d = \left[\Pi Y_{(n+1)} + \Pi A_e^{ext} BY\right] + \left[\Pi_e Y_e^* + \Pi_e Y_{ne} + \Pi_e A_e^{int} BY + \Pi_e A_{ne} BY\right] + \Pi_{ne} Y_e^*$$

where Y_e^* denotes EP final demand excluding purchases of external EP activities while $Y_{(n+1)}$ denotes external EP activities purchased as final demand. A_e^{ext} and A_e^{int} represent the matrix of direct intermediate input requirements relevant to the external and internal EP sectors, respectively. Note that (6.7) is composed of seven components. The first component represents final demand purchases of external EP activities. The second component represents the use of external EP activities as an intermediate input. The first and second components, then, are the value-added associated with external EP activities. The third through sixth components are the

value-added associated with internal EP activities. The third and fourth components represent EP value-added associated with EP and non-EP final demand. The fifth and sixth components represent EP value-added associated with intermediate inputs used for internal EP activities and non-EP activities. The seventh component is the non-EP value-added required to support household, investment and government EP activities.

As an alternative measure, one might want to compute the total share of GNP required to support EP activities. Nestor and Pasurka (1995) derive such a measure. This measures is the primary inputs (value-added) used directly and indirectly in EP activities ($P_e^{(d+I)}$) and is given as

$$P_e^{(d+i)} = \Pi BY_e + \Pi BA_e B_{ne} Y_{ne} + \Pi_e B_{ne} Y_{ne} \tag{6.8}$$

6.3. INDIRECT EMPLOYMENT REQUIRED TO SUPPORT EP ACTIVITIES

It is also possible to use the EP I-O tables to compute indirect employment in EP activities. Using (6.7), the formula for computing direct employment associated with EP activities ($\mathbf{L}_e^d$) is

$$L_e^d = \left[l' Y_e^{ext} + l' A_e^{ext} BY \right] + \left[l_e' Y_e^* + l_e' Y_{ne} + l_e' A_e^{int} BY + l_e' A_{ne} BY \right] + l_{ne}' Y_e^* \tag{6.9}$$

l denotes the vector of labor-output ratios, with l_e being for EP activities and l_{ne} being for non-EP activities.

Using (6.8), the formula for computing direct plus indirect employment associated with EP activities ($\mathbf{L}_e^{(d+I)}$) is

$$L_e^{(d+i)} = l' BY_e + l' BA_e B_{ne} Y_{ne} + l_e' B_{ne} Y_{ne} \tag{6.10}$$

6.4. ESTIMATES OF THE SIZE OF THE EP INDUSTRY AND INDIRECT EMPLOYMENT ASSOCIATED WITH EP ACTIVITIES

Equations 6.7, 6.8, 6.9 and 6.10 were used to measure EP activities relative to GNP well as well as compute direct employment and direct plus indirect employment for 1982, 1985, 1988, and 1991. The results of these computations are presented in Table 6.1.

Table 6.1

Measures of EP Employment and the Size of the EP Industry

Measure	1977	1982	1985	1988	1991
Direct Employment (Number of Individuals)	678,359	640,181	659,067	698,348	741,186
As a Percent of Total Employment	0.79	0.69	0.65	0.64	0.66
Direct + Indirect Employment (Number of Individuals)	1,267,082	1,433,502	1,591,940	1,796,027	1,965,818
As a Percent of Total Employment	1.48	1.54	1.58	1.65	1.76
Direct Value-Added (Millions of Dollars)	14,124.9	20,593.1	28,692.2	37,754.5	46,646.6
As a Percent of GNP	0.71	0.64	0.68	0.74	0.80
Direct + Indirect Value-Added (Millions of Dollars)	30,436.4	50,802.5	72,404.1	96,766.0	121,625.2
As a Percent of GNP	1.53	1.58	1.74	1.93	2.12

6.5. NUMERICAL EXAMPLE

To illustrate the EP I-O concepts, this section works through a numerical example using a hypothetical three sector I-O table. Sectors 1 and 2 undertake internal EP activities and purchase external EP services from the third sector, which is the external EP services sector. For simplicity of exposition, we assume: (1) the external EP services sector does not undertake internal EP activities, (2) the external EP services sector does not use its own output as an intermediate input in its production process, and (3) there are no environmental excise taxes. Also, to make the hypothetical I-O table comparable to the U.S. I-O table, intermediate inputs and domestic absorption (consumption + investment + government expenditures, or C+I+G) consist of both domestically produced and imported products. Table 6.2 is the total I-O table which embodies EP activities and corresponds to Figure 2.4a in Chapter 2. Note that $X_{3,3}$ ($X_{(n+1)(n+1)}$ in Figure 2.4a) equals zero, reflecting the assumption that the external EP services sector does not use its own output as an intermediate input in its production process. In this example, GNP is 295.

Table 6.2

Total I-O Table

	1	2	3	Int. Inputs	C+I+G	Exports	Imports	Total Uses
1	95	70	60	225	171	70	66	400
2	80	30	20	130	90	40	60	200
3	40	10	0	50	50	0	0	100
Int. Inputs	215	110	80					
Labor	115	50	10					
Capital	55	25	10					
IBT	15	15	0					
Output	400	200	100					

Table 6.3, which corresponds to Figure 2.3b in Chapter 2, shows the purchases of all products used in EP activities for the example. Table 6.3 excludes the inputs purchased by the external EP services sector since these inputs represent do not represent direct purchases for EP. Internal EP activities are represented by sector 1 and 2 purchases from sectors 1 and 2 and the use of primary inputs for EP. External EP activities are represented by sector 1 and 2 purchases from sector 3. Household, government, and investment activities for EP are all represented by the entries in the C+I+G column. Total EP expenditures in this economy are 300 and are greater than GNP.

Table 6.4 corresponds to Figure 2.5 in Chapter 2 and shows the total I-O table with internal EP activities externalized to the external EP sector. Table 6.4 is constructed by subtracting inputs associated with internal EP activities from the corresponding I-O cell values of Table 6.1. Both the row and column sum associated with each sector's internal EP activities are added to the external EP sector. Equivalently, the cost of a sector's internal EP activities is added to the cost of purchased external EP services. Also, the amount of each intermediate input plus primary inputs used in internal activities is added to the inputs purchased by the external EP services sector. Note that the externalization procedure results in an increase in gross output in the external EP sector but leaves GNP unaffected.

Table 6.3

EP Expenditures I-O Table

	1	2	3	Int. Inputs	C+I+G	Exports	Imports	Total Uses
1	40	40	0	80	20	0	10	90
2	50	10	0	60	10	0	5	65
3	40	10	0	50	50	0	0	100
Int. Inputs	130	60	0					
Labor	11.5	5	0					
Capital	3.5	10	0					
IBT	0	0	0					
Output	145	75	0					

Table 6.4

Total I-O Table with Internal EP Activities Externalized

	1	2	3	Int. Inputs	C+I+G	Exports	Imports	Total Uses
1	55	30	140	225	171	70	66	400
2	30	20	80	130	90	40	60	200
3	145	75	0	220	50	0	0	270
Int. Inputs	230	125	220					
Labor	103.5	45	26.5					
Capital	51.5	15	23.5					
IBT	15	15	0					
Output	400	200	270					

It is relatively easy to obtain the matrix of total direct intermediate input requirements (**A**),the matrix of direct EP input requirements ($\mathbf{A_e}$), the matrix of direct non-EP input requirements ($\mathbf{A_{ne}}$), the matrix of total primary input coefficients (Π), the matrix of EP primary input coefficients (Π_e), and the matrix of non-EP primary input coefficients (Π_{ne}) as shown below.

$$A = \begin{bmatrix} 0.2375 & 0.35 & 0.6 \\ 0.2 & 0.15 & 0.2 \\ 0.1 & 0.05 & 0.0 \end{bmatrix}$$

$$A_e = \begin{bmatrix} 0.1 & 0.2 & 0.0 \\ 0.125 & 0.05 & 0.0 \\ 0.1 & 0.05 & 0.0 \end{bmatrix}$$

$A_{ne} = A - A_e =$

0.1375	0.15	0.6
0.075	0.1	0.2
0	0	0

$\Pi =$

0.2875	0.25	0.1
0.1375	0.125	0.1
0.0375	0.075	0

$\Pi_e =$

0.02875	0.025	0.0
0.00875	0.05	0.0
0.0	0.0	0.0

$\Pi_{ne} = \Pi - \Pi_e =$

0.25875	0.225	0.1
0.12875	0.075	0.1
0.0375	0.075	0

Furthermore, it is possible to disaggregate A_e into input coefficients pertaining to external EP activities (A_e^{ext}) and input coefficients pertaining to internal EP activities (A_e^{int}).

$A_e = A_e^{ext} + A_e^{int} =$

0.0	0.0	0.0
0.0	0.0	0.0
0.1	0.05	0.0

+

0.1	0.2	0.0
0.125	0.05	0.0
0.0	0.0	0.0

It follows that

$$B = [I - A]^{-1} = \begin{bmatrix} 1.6584 & 0.7502 & 1.1451 \\ 0.4344 & 1.3870 & 0.5380 \\ 0.1876 & 0.1444 & 1.1414 \end{bmatrix}$$

and

$$B_{ne} = [I - A_{ne}]^{-1} = \begin{bmatrix} 1.1765 & 0.1961 & 0.7451 \\ 0.0980 & 1.1275 & 0.2843 \\ 0.0 & 0.0 & 1.0 \end{bmatrix}$$

Final demand (Y) is equal to domestic absorption (C+I+G) plus exports (X) less imports (M). Y can be disaggregated into the component that pertains directly to EP (Y_e) and the component that does not pertain to EP (Y_{ne}). For this example,

$$Y = Y_e + Y_{ne} = \begin{bmatrix} 10 \\ 5 \\ 50 \end{bmatrix} + \begin{bmatrix} 165 \\ 65 \\ 0 \end{bmatrix}$$

Y_e can be further disaggregated into final purchases of external EP activities ($Y_{(n+1)}$) and final purchases of products other than external EP activities for purposes of EP (Y_e^*).

$$Y_e = Y_{(n+1)} + Y_e^* = \begin{bmatrix} 0 \\ 0 \\ 50 \end{bmatrix} + \begin{bmatrix} 10 \\ 5 \\ 0 \end{bmatrix}$$

Using equation 6.6, gross output in the hypothetical economy is disaggregated into EP and non-EP components as follows.

$$X = [I - A]^{-1}Y = BY = BY_e + B_{ne}Y_{ne} + BA_eB_{ne}Y_{ne}$$

$$= \begin{bmatrix} 77.5913 \\ 38.1787 \\ 59.6681 \end{bmatrix} + \begin{bmatrix} 206.8627 \\ 89.4608 \\ 0 \end{bmatrix} + \begin{bmatrix} 115.5459 \\ 72.3605 \\ 40.3319 \end{bmatrix}$$

The seven components of direct value-added are (see equation 6.7):

$$P_e^d = [\Pi Y_{(n+1)}\, \Pi A_e^{ext} BY] + [\Pi_e Y_e^* + \Pi_e Y_{ne} + \Pi_e A_e^{int} BY] + \Pi_e A_{ne} BY] + \Pi_{ne} Y_e^*$$

$$= \begin{bmatrix} 5 \\ 5 \\ 0 \end{bmatrix} + \begin{bmatrix} 5 \\ 5 \\ 0 \end{bmatrix} + \begin{bmatrix} 0.4125 \\ 0.3375 \\ 0.0 \end{bmatrix} + \begin{bmatrix} 6.3688 \\ 4.6938 \\ 0.0 \end{bmatrix}$$

$$+ \begin{bmatrix} 3.8000 \\ 3.7000 \\ 0.0 \end{bmatrix} + \begin{bmatrix} 5.9188 \\ 4.7688 \\ 0.0 \end{bmatrix} + \begin{bmatrix} 3.7125 \\ 1.6625 \\ 0.7500 \end{bmatrix}$$

The first component represents final demand purchases of external EP activities. The second component represents the use of external EP activities as an intermediate input. The first and second components, then, are the value-added associated with external EP activities. The third through sixth components are the value-added associated with internal EP activities. The third and fourth components represent EP value-added associated with EP and non-EP final demand. The fifth and sixth components represent EP value-added associated with intermediate inputs used for internal EP activities and non-EP activities. The seventh component is the non-EP value-added required to support household, investment and government EP activities.

It follows that

$$P_e^{d} = \begin{bmatrix} \text{Labor} \\ \text{Capital} \\ \text{IBT} \end{bmatrix} = \begin{bmatrix} 30.2125 \\ 25.1625 \\ 0.7500 \end{bmatrix}$$

According to equation 6.8, total value-added (direct plus indirect) for EP consists of three components

$$P_e^{(d+I)} = \Pi B Y_e + \Pi B A_e B_{ne} Y_{ne} + \Pi_e B_{ne} Y_{ne}$$

$$= \begin{bmatrix} 37.8190 \\ 21.4079 \\ 5.7731 \end{bmatrix} + \begin{bmatrix} 55.3428 \\ 28.9658 \\ 9.7600 \end{bmatrix} + \begin{bmatrix} 8.1838 \\ 6.2831 \\ 0.0 \end{bmatrix}$$

Thus, for the example

$$P_e^{d+I} = \begin{bmatrix} \text{Labor} \\ \text{Capital} \\ \text{IBT} \end{bmatrix} = \begin{bmatrix} 101.3456 \\ 56.6569 \\ 15.5331 \end{bmatrix}$$

Table 6.5 gives employment and the employment-output ratio for each of the three sectors in the economy. Table 6.6 corresponds to equation 6.9 and shows how direct EP employment is computed. Table 6.7, which corresponds to equation 6.10, shows how direct plus indirect employment is calculated. In Table 6.6, the sum of the first two components is the employment associated with external EP activities. The sum of the second through sixth components is the employment associated with internal EP activities, and the seventh component is the employment requirement for household, government, and investment EP activities.

Table 6.5

Employment and Employment-Output Ratios for the Example

Industry	Total Employment	Employment in Internal EP	Non-EP Employment	l	l_e	l_{ne}
1	20	2	18	0.050	0.005	0.045
2	5	0.5	4.5	0.025	0.0025	0.0225
3	1	0	1	0.010	0.000	0.0100

Table 6.6

Components of Direct Employment

Component	Amount of Employment
$l'Y_{(n+1)}$	0.5000
$l'A_e^{ext}BY$	0.5000
$l_e'Y_e^*$	0.0625
$l_e'Y_{ne}$	0.9875
$l_e'A_e^{int}BY$	0.5500
$l_e'A_{ne}BY$	0.9000
$l_{ne}'Y_e^*$	0.5625
Total (L_e^d)	4.0625

Table 6.7

Components of Direct plus Indirect Employment

Component	Amount of Employment
$l'BY_e$	5.4307
$l'BA_eB_{ne}Y_{ne}$	7.9896
$l'_eB_{ne}Y_{ne}$	1.2580
Total ($L_e^{(d+I)}$)	14.6783

NOTES FOR CHAPTER 6

1. See Appendix D for a discussion of the derivation of the total requirements matrix.

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APPENDIX A. CONCORDANCE OF INPUT-OUTPUT SECTORS

Concordance Between Environmental Protection Industry and BEA Input-Output Sectors

EP Industry I-O Sector	BEA I-O Sector[1]	Description
1		**Agriculture, forestry, and fisheries**
	01	Livestock and livestock products
	02	Other agricultural products
	03	Forestry and fishery products
	04	Agricultural, forestry and fishery services
2		**Mining**
	05	Iron and feroalloy mining
	06	Nonferrous metal mining
	07	Coal mining
	08	Crude petroleum and natural gas
	09	Stone and clay mining
	10	Chemical and fertilizer mining
3		**Construction**
	11	New construction (exclude: 11.0307--New sewer system facilities)
	12	Maintenance and repair construction (exclude: 12.0209--Maintenance and repair of sewer system facilities)
4		**Food and kindred products**
	14	Food and kindred products

Concordance Between Environmental Protection Industry and BEA Input-Output Sectors (Continued)

EP Industry I-O Sector	BEA I-O Sector[1]	Description
5		**Tobacco manufactures**
	15	Tobacco manufactures
6		**Textile mill products**
	16	Broad and narrow fabrics, yarn and thread mills
	17	Miscellaneous textiles and floor coverings
7		**Apparel and other textile products**
	18	Apparel
	19	Miscellaneous fabricated textile products
8		**Lumber and wood products**
	20	Lumber and wood products, except containers
	21	Wood containers
9		**Furniture and fixtures**
	22	Household furniture
	23	Other furniture and fixtures
10		**Paper and allied products**
	24	Paper and allied products, except containers
	25	Paperboard containers and boxes
11		**Printing and publishing**
	26	Printing and publishing

Concordance Between Environmental Protection Industry and BEA Input-Output Sectors (Continued)

EP Industry I-O Sector	BEA I-O Sector[1]	Description
12		**Chemicals and allied products**
	27	Chemicals and selected chemical products
	29	Drugs, cleaning and toilet preparations
	30	Paints and allied products
13		**Petroleum refining**
	31	Petroleum refining
14		**Rubber and plastic products**
	28	Plastics and synthetic materials
	32	Rubber and miscellaneous plastic products
15		**Leather and leather products**
	33	Leather tanning and finishing
	34	Footwear and other leather products
16		**Stone, clay and glass products**
	35	Glass and glass products
	36	Stone and clay products
17		**Primary metals**
	37	Primary iron and steel
	38	Primary nonferrous metals
18		**Fabricated metal products**
	39	Metal containers
	40	Heating, plumbing and fabricated structural metal
	41	Screw machine products and stampings
	42	Other fabricated metal products

Concordance Between Environmental Protection Industry and BEA Input-Output Sectors (Continued)

EP Industry I-O Sector	BEA I-O Sector[1]	Description
19		**Machinery, except electrical**
	43	Engines and turbines
	44	Farm and garden machinery
	45	Construction and mining equipment
	46	Materials and handling machinery
	47	Metal working machinery
	48	Special industry machinery
	49	General industry machinery (exclude "environmental" component of 49.0300--Blowers and Fans)
	50	Miscellaneous machinery, except electrical
	51	Office, computing and accounting machines
	52	Service industry machines
20		**Electrical machinery**
	53	Electrical industrial equipment
	54	Household appliances
	55	Electrical lighting and wiring equipment
	56	Radio, TV and communication equipment
	57	Electronic components and accessories
	58	Miscellaneous electrical machinery and supplies
21		**Motor vehicles**
	59	Motor vehicles and equipment

Concordance Between Environmental Protection Industry and BEA Input-Output Sectors (Continued)

EP Industry I-O Sector	BEA I-O Sector[1]	Description
22		**Other transportation equipment**
	13	Ordnance and accessories
	60	Aircraft and parts
	61	Other transportation equipment
23		**Instruments**
	62	Scientific and controlling instruments
	63	Optical, ophthalmic and photographic equipment
24		**Miscellaneous manufacturing**
	64	Miscellaneous manufacturing
25		**Transportation and warehousing**
	65	Transportation and warehousing
26		**Communication**
	66	Communications, except radio and TV
	67	Radio and TV broadcasting
27		**Electric utilities**
	68.0100	Electric utilities
	78.0200	Federal electric utilities
	79.0200	State and local electric utilities
28		**Gas utilities**
	68.0200	Gas production and distribution utilities
29		**Trade**
	69	Wholesale trade
	74	Eating and drinking places

Concordance Between Environmental Protection Industry and BEA Input-Output Sectors (Continued)

EP Industry I-O Sector	BEA I-O Sector[1]	Description
30		**Finance, insurance and real estate**
	70	Finance and insurance
	71	Real estate and rental
31		**Other services**
	68.0301	Water supply and sewerage systems ("nonenvironmental")
	68.0302	Steam supply and irrigation systems ("nonenvironmental")
	72	Hotels, personal and repair services
	73	Business services
	75	Automobile repair and services
	76	Amusements
	77	Health, education, social services, nonprofit organizations
32		**Government enterprises**
	78.0100	U.S. postal services
	78.0300	Commodity credit corporation
	78.0400	Other federal government enterprises
	79.0100	Local government passenger transit
	79.0300	Other state and local government services ("nonenvironmental")
33		**New sewer system facilities**
	11.0307	New sewer system facilities
34		**Maintenance and repair of sewer system facilities**
	12.0210	Maintenance and repair of sewer system facilities

Concordance Between Environmental Protection Industry and BEA Input-Output Sectors
(Continued)

EP Industry I-O Sector	BEA I-O Sector[1]	Description
35		**Water supply ("environmental")**
	68.0301	Water supply and sewerage systems ("environmental")
36		**Sewerage systems**
	79.0300	Other state and local government services ("environmental")
37		**Solid Waste Management**
	68.0302	Sanitary services ("environmental")
38		**Selected industrial air pollution control equipment**
	49.0300	Blowers and fans ("environmental")
39		**Noncomparable imports and scrap**
	80	Noncomparable imports
	81	Scrap, used and secondhand goods
40		**Government industry**
	82	Government industry
41		**Other industry**
	83	Rest of the world industry
	84	Household industry
	85	Inventory valuation adjustment

[1] From "The Use of Commodities by Industries" table.

APPENDIX B. CONSTRUCTION OF EXPENDITURE PATTERNS

This appendix outlines, in detail, the procedure for constructing the expenditure patterns for air, water, and solid waste pollution abatement. More specifically, it derives the proportions that were applied to the "materials and supplies" component of both operation and maintenance and capital costs and in order to allocate these components to specific I-O categories. First, the derivation of the expenditure patterns for the materials component of operation and maintenance costs is presented for air, water, and solid waste, respectively. Second, the expenditure patterns for the materials component of capital expenditures for air, water, and solid waste pollution abatement are derived.

MATERIALS COMPONENT OF OPERATION AND MAINTENANCE EXPENDITURES

Air

"Materials and supplies" expenditure patterns for five types of air pollution control equipment (thermal incinerators, fluid-bed catalytic incinerators fabric, filter systems, electrostatic precipitators, and flue gas desulfurization systems) were estimated on the basis of available engineering studies. For thermal incinerators, fluid-bed catalytic incinerators fabric, filter systems, electrostatic precipitators, the *OAQPS Control Cost Manual* (U.S. EPA, 1990) was the source. For flue gas desulfurization systems, information assembled by the Radian Corporation (1982a, 1982b) was the source. Tables B.1 through B.5 present the expenditure patterns obtained from these studies.

The five expenditure patterns were aggregated to form an overall expenditure pattern for the materials component of operating costs. To aggregate across the specific abatement technologies, weights were assigned to each technology according to the proportion of the value of each type of technology in total shipments of air pollution control equipment. The data on the value shipments of air pollution control equipment were taken from the Department of Commerce publication, "Selected Industrial Air Pollution Control Equipment (MA-35J)." The MA-35J gives values for shipments of technologies other than the five that were used for constructing the air expenditure pattern. These other types of technologies were ignored for the purposes of computing the weights. Thermal incinerators, fluid-bed catalytic incinerators, fabric filters, electrostatic precipitators, and flue gas desulfurization equipment represent about 84 percent of the total value of shipments of air pollution control equipment in 1977 and about 85 percent in 1982. Table B.6 presents the weights that were used in the aggregation of the specific expenditure patterns.

Table B.1

Distribution of Materials and Supplies Operating Expenditures
for Thermal Incinerators

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Maintenance material	$ 7,130	3	0.023
Utilities - natural gas	264,500	28	0.849
Utilities - electricity	35,000	27	0.112
Insurance	4,830	30	0.016

Source: *OAQPS Control Cost Manual* (U.S. EPA, 1990)
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.2

Distribution of Materials and Supplies Operating Expenditures
for Fluid-bed Catalytic Incinerators

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Maintenance material	$ 7,130	3	0.052
Catalyst replacement	14,600	12	0.107
Utilities - natural gas	63,400	28	0.465
Utilities - electricity	42,300	27	0.311
Insurance	8,900	30	0.065

Source: *OAQPS Control Cost Manual* (U.S. EPA, 1990)
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.3

Distribution of Materials and Supplies Operating Expenditures
for Filter Systems

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Maintenance material	$ 14,256	3	0.168
Replacement parts, bags	9,845	6	0.116
Electricity	48,223	27	0.569
Compressed air	8,294	19	0.098
Insurance	4,123	30	0.049

Source: *OAQPS Control Cost Manual* (U.S. EPA, 1990)
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.4

Distribution of Materials and Supplies Operating Expenditures
for Electrostatic Precipitators

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Maintenance material	$ 4,320	3	0.055
Electricity (fan)	21,018	27	0.266
Electricity (operating)	35,344	27	0.447
Insurance	18,447	30	0.233

Source: *OAQPS Control Cost Manual* (U.S. EPA, 1990)
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.5

Distribution of Materials and Supplies Operating Expenditures
for Lime FGD Systems

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Raw Material			
Lime	$ 3,219,000	16	0.398
Fixation Chemical	527,000	12	0.065
Utilities			
Water	32,000	31	0.005
Electricity	1,903,000	27	0.235
Reheat (steam)	524,000	31	0.065
Maintenance			
Material (½ Radian value)	1,444,500	3	0.179
Supplies	433,000	3	0.053
Sludge Handling	528,000	[2]	

Source: Radian Corporation (1982)
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.
[2]The costs associated with sludge handling were assumed to be included in solid waste operation and maintenance expenditures.

Table B.6

Weights Assigned to Air Pollution Control Expenditure Patterns

Technology	1977 Total ($1000)*	1977 Weight	1982 Total ($1000)*	1982 Weight
Thermal Incinerators	22,801	0.044	15,170	0.02
Fluid-bed Catalytic Incinerators	5,162	0.01	11,494	0.015
Filter Systems	141,881	0.274	224,839	0.292
Electrostatic Precipitators	291,538	0.564	236,078	0.306
FGD Systems	55,734	0.108	282,437	0.367
Total	517,116	1.000	770,018	1.000
Total Shipments of Air Pollution Control Equipment	617,331	**	905,162	**
Percentage of Total Included in Expenditure Pattern Construction	0.838	**	0.851	**

*Source: *Selected Industrial Air Pollution Control Equipment* (MA-35J) (Department of Commerce, 1978 and 1983)

Water

To assign the materials component of operation and maintenance expenditures to specific I-O categories, expenditure patterns for primary settling, biological oxidation, neutralization, filtration, coagulation, and chlorination were taken from Gumerman, Burris, Hansen (1986) and DeRenzo (1978). Tables B.7 through B.12 provide these patterns as well as the assigned I-O sectors.

Similar to the case for air pollution control materials expenses, the processes were weighted and aggregated. The weights were derived from data for 1978 on the number of gallons of discharged water treated by ten methods for manufacturing and mineral industries. These data were obtained from the "Water Use in Manufacturing" survey from the *1977 Census of Manufactures* and the "Water Use in Mineral Industries" from the *1977 Census of Mineral*

Industries. Table B.13 provides the data used to construct the weights and the weights assigned to the specific abatement processes. The values for the five processes that were not used in the construction of the aggregate expenditure pattern were not used in the construction of the weights.

Solid Waste

To assign "materials and supplies" to specific I-O sectors, it was assumed that the expenditure pattern for sludge removal is representative of the expenditure pattern for all materials purchased for solid waste disposal. Expenditure patterns for wash-water recovery, alum sludge disposal, and lime sludge disposal were taken from the American Society of Civil Engineers and American Water Works Association (1990, pp. 340-343). Due to the lack of information on the number of each type of disposal technique in operation, the aggregate expenditure pattern was formed by simply taking an average of the three example expenditure patterns. The expenditure patterns for wash-water recovery, alum sludge disposal, and lime sludge disposal are presented in Tables B.15-B.17.

Table B.7

Distribution of Materials and Supplies Operating Expenditures for Settling (Primary and Secondary – Example 1)[1]

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[2]
Maintenance	$ 46,000	3	0.152
Lime	14,000	16	0.046
Electricity	105,000	27	0.348
Ammonia	60,000	12	0.199
Phosphoric Acid	54,000	12	0.179
Taxes and Insurance	23,000	3	0.076

Source: DeRenzo, 1978, p.214.
[1]Aerated lagoons served as the example for settling.
[2] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.8

Distribution of Materials and Supplies Operating Expenditures for Settling (Primary and Secondary--Example 2)[1,2]

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[3]
Maintenance	$ 5,600	3	0.229
Chemicals	12,600	12	0.517
Electrical Energy	3,400	27	0.139
Taxes and Insurance	2,800	3	0.115

Source: DeRenzo, 1978, p. 326.
[1]The centrifugation system with throughput of 36,000 gallons per day (i.e. 6 tons of solid per day) served as an example of settling.
[2]The expenditure patterns for aerated lagoons and centrifugation were averaged to get one expenditure patterns for primary and secondary settling.
[3] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.9

Distribution of Materials and Supplies Operating Expenditures for Biological Oxidation[1]

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[2]
Maintenance	$ 50,000	3	0.549
Lime	7,000	16	0.077
Electricity	9,000	27	0.275
Taxes and Insurance	25,000	3	0.099

Source: DeRenzo, 1978, p. 227.
[1]Anaerobic digestion served as the example for biological oxidation.
[2] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.10

Distribution of Materials and Supplies Operating Expenditures for Neutralization

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Maintenance	$ 42,000	3	0.067
Lime	539,000	16	0.867
Electricity	13,500	27	0.022
Coagulant Aids	6,000	12	0.010
Taxes and Insurance	21,000	3	0.034

Source: DeRenzo, 1978, p. 736.
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.11

Distribution of Materials and Supplies Operating Expenditures for Coagulation[1]

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[2]
Maintenance	$ 12,000	3	0.384
Lime	2,000	16	0.065
Coagulant Acid	4,800	12	0.156
Sulfuric Acid	3,000	12	0.097
Taxes and Insurance	6,000	3	0.195
Electrical Energy	3,000	27	0.098

Source: DeRenzo, 1978, p. 526.
[1]The precipitation, flocculation, and sedimentation system (with a wastewater flowrate of 410,000 gallons per day) served as the example for coagulation.
[2] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.12

Distribution of Materials and Supplies Expenditures for Chlorination[1]

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[2]
Process Energy	$ 15.12	27	0.098
Maintenance Material	14	3	0.016
Chlorine	835	12	0.996

Source: American Society of Civil Engineers and the American Water Works Association, 1990, p.249.
[1]An erosion feed chlorinator with a chlorine feed rate of 1 lb/day served as the example for chlorination of industrial waste water.
[2] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.13

Distribution of Materials and Supplies Expenditures for Filtration[1]

Maintenance	6,000	3	0.428
Hydrated Lime	75	16	0.005
Ferric Chloride	840	12	0.060
Electrical Energy	3,100	27	0.221
Taxes and Insurance	4,000	3	0.286

Source: DeRenzo, 1978, p. 736.
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.14

Weights Assigned to Water Pollution Control Expenditure Patterns

Technology	1978 Total (Billions of Gallons)[1]	Weight
Settling (Primary and Secondary)	4656.5	0.494
Biological Oxidation	1654.6	0.176
Neutralization	1554.1	0.165
Coagulation	715.3	0.076
Chlorination	485.8	0.052
Filtration	351.5	0.037
TOTAL[2]	9417.8	1.000

[1]Derived from the 1978 "Water Use in Manufacturing" survey from the *1977 Census of Manufactures* and the "Water Use in Mineral Industries" from the *1977 Census of Mineral Industries*.
[2]Because wastewater may be treated by more than one process, the sum of the of the water treated by category will not be equal to the total amount of wastewater treated. Thus, it is not possible to determine the percentage of wastewater treatment accounted for in the determination of the expenditure pattern.

Table B.15

Distribution of Materials and Supplies Operating Expenditures for Wash-Water Recovery

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Power	$ 1,250	27	0.124
Misc. Supplies	800	3	0.080
Polymer	8,000	12	0.796

Source: American Society of Civil Engineers and American Water Works Association, 1990, pp. 340-343.
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.16

Distribution of Materials and Supplies Component of Operating Expenditures for Alum Sludge Disposal

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Power	$ 9,150	27	0.528
Misc. Supplies	4,970	3	0.287
Polymer	3,200	12	0.185

Source: American Society of Civil Engineers and American Water Works Association, 1990, pp. 340-343.
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.17

Distribution of Materials and Supplies Component of Operating Expenditures for Lime Sludge Disposal

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Power	$ 47,000	27	0.439
Misc. Supplies	60,000	3	0.561

Source: American Society of Civil Engineers and American Water Works Association, 1990, pp. 340-343.
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

MATERIALS COMPONENT OF CAPITAL EXPENDITURES

Air

The pattern for the materials and supplies component for capital expenditures for five types of air pollution control equipment (thermal incinerators, fluid-bed catalytic incinerators fabric, filter systems, electrostatic precipitators, and flue gas desulfurization systems) was

obtained from engineering studies. For thermal incinerators, fluid-bed catalytic incinerators fabric, filter systems, electrostatic precipitators, the *OAQPS Control Cost Manual* (U.S. EPA, 1990) was the source. For flue gas desulfurization systems, information assembled by the Radian Corporation (1982a, 1982b) was the source. Tables B.18 through B.23 document the values reported in these studies.

As in the case of operation and maintenance expenditures, the five expenditure patterns were aggregated to form an overall expenditure pattern. Weights were assigned to each technology according to the proportion of the value of each type of technology in total shipments of air pollution control equipment.

For the purposes of this study, both the BEA and the Commerce (MA-35J) data were accepted "as truth." The MA-35J estimates of shipments of industrial air pollution control equipment served as cost estimates for mechanical devices. Using this information, the aggregate the expenditure patterns for 1977 and 1982 were adjusted in order to maintain the ratio of shipments of industrial air pollution control equipment to total capital expenditures for air pollution abatement. Table B.24 provides both original expenditure patterns and the expenditures patterns adjusted to maintain consistency with the BEA and the Commerce data. The adjusted patterns were used in this study.

Water

The values for the materials and supplies component of capital expenditures were derived using information from the *Development Document for Effluent Guidelines and Standards for the Nonferrous Metals Forming and Iron and Steel/Copper/Aluminum Metal Powder Production and Powder Metallurgy Point Source Category*. The proportion of expenditures accounted for by each I-O category was computed using the cost equations for recommended treatment and control technologies. The midpoint for the range of validity for each equation, when substituted into the cost equation, gave an estimate of the costs for each item. These cost estimates, distribution values, and assigned I-O sector are presented for each item of the materials component of capital expenditures for water pollution abatement are presented in Table B.25.

Solid Waste

As in the case of operating costs for solid waste, capital expenditures are allocated on the assumption that the expenditures for sludge removal are representative of the expenditure pattern for all capital expenditures for solid waste disposal. Cost estimates for wash-water recovery, alum sludge disposal, and lime sludge disposal reported by the American Society of Civil Engineers and American Water Works Association (1990) were used. These values, assigned I-O sectors, distribution values are presented in Tables B.26-B.28. The simple average of the values for the three technologies gave the aggregate expenditure pattern.

Table B.18

Distribution of Materials and Supplies Capital Expenditures for Fabric Filters

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
DIRECT COSTS			
Purchased equipment costs			
Fabric Filter	$80,231	38	0.195
Bags and cages	18,092	6	0.044
Auxiliary equipment	62,700	[2]	0.152
Instrumentation	16,102	23	0.039
Sales taxes	4,831	3	0.012
Freight	8,051	25	0.020
Direct Installation Costs			
Foundation and supports	7,600	3	0.018
Handling and erection	95,004	3	0.230
Electrical	15,201	3	0.037
Piping	1,900	3	0.005
Insulation for ductwork	13,300	3	0.032
Painting	3,800	3	0.009
INDIRECT COSTS (INSTALLATION)			
Engineering	19,001	3	0.046
Construction and field experiments	38,001	3	0.092
Contractor fees	19,001	3	0.046
Start-up	1,900	3	0.005
Performance test	1,900	3	0.005
Contingencies	5,700	3	0.013

Source: *OAQPS Control Cost Manual* (U.S. EPA, 1990)
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services, site preparation, and facilities and buildings.
[2]The distribution of costs for auxiliary equipment is presented in Table B.20.

Table B.19

Distribution of Materials and Supplies Capital Expenditures
for Electrostatic Precipitators

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
DIRECT COSTS			
Purchased equipment costs			
Absorber vessels and carbon	635,189	38	0.344
Auxiliary equipment	62,700	[2]	0.034
Instrumentation	69,789	23	0.038
Sales taxes	20,937	3	0.012
Freight	34,894	25	0.019
Direct installation costs			
Foundation and supports	32,940	3	0.018
Handling and erection	411,755	3	0.223
Electrical	65,881	3	0.036
Piping	8,235	3	0.004
Insulation for ductwork	16,470	3	0.009
Painting	16,470	3	0.009
INDIRECT COSTS			
Engineering	164,702	3	0.089
Construction and Field Experiments	164,702	3	0.089
Contractor fees	82,351	3	0.045
Start-up	8,235	3	0.004
Performance test	8,235	3	0.004
Model study	16,470	3	0.009
Contingencies	24,705	3	0.014

Source: *OAQPS Control Cost Manual* (U.S. EPA, 1990)
[1] "Total Cost" excludes expenditures for labor, capital recovery, (depreciation), and site preparation, and facilities and buildings.
[2] The distribution of costs for auxiliary equipment is presented in Table B.20.

Table B.20

Distribution of Auxiliary Equipment Costs
for Fabric Filters and Electrostatic Precipitators

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Ductwork	$14,000	18	0.034
Fan	14,000	19	0.034
Motor	7,000	20	0.017
Starter	3,500	20	0.008
Dampers	7,200	18	0.017
Compressor	6,000	19	0.015
Screw conveyor	4,000	19	0.010
Stack	7,000	3	0.017

Source: *OAQPS Control Cost Manual* (U.S. EPA, 1990)
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services, site preparation, and facilities and buildings.

Table B.21

Distribution and Classification of Materials and Supplies Capital Expenditures for Thermal Incinerators

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
DIRECT COSTS			
Purchased equipment costs			
Incinerator	$254,000	38	0.526
Instrumentation	25,400	23	0.053
Sales taxes	7,630	3	0.016
Freight	12,700	25	0.025
Direct installation costs			
Foundation and supports	24,000	3	0.050
Handling and erection	42,000	3	0.087
Electrical	12,000	3	0.025
Piping	6,000	3	0.012
Insulation (for ductwork)	3,000	3	0.006
Painting	3,000	3	0.006
INDIRECT COSTS			
Engineering	30,000	3	0.062
Construction and Field Experiments	15,000	3	0.031
Contractor fees	30,000	3	0.062
Start-up	6,0000	3	0.012
Performance test	3,000	3	0.006
Contingencies	9,000	3	0.020

Source: *OAQPS Control Cost Manual* (U.S. EPA, 1990)

[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services, site preparation, and facilities and buildings.

Table B.22

Distribution and Classification of Materials and Supplies Capital Expenditures for Catalytic Incinerators

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
DIRECT COSTS			
Purchased equipment costs			
Incinerator	$468,200	38	0.527
Instrumentation	46,800	23	0.053
Sales taxes	14,000	3	0.016
Freight	23,400	25	0.026
Direct installation costs			
Foundation and supports	44,200	3	0.050
Handling and erection	77,300	3	0.087
Electrical	22,100	3	0.025
Piping	11,000	3	0.012
Insulation (for ductwork)	5,520	3	0.006
Painting	5,520	3	0.006
INDIRECT COSTS			
Engineering	55,200	3	0.062
Construction and Field Experiments	27,600	3	0.031
Contractor fees	55,200	3	0.062
Start-up	11,0000	3	0.012
Performance test	5,200	3	0.006
Contingencies	16,600	3	0.019

Source: *OAQPS Control Cost Manual* (U.S. EPA, 1990)
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services, site preparation, and facilities and buildings.

Table B.23

Distribution of Materials and Supplies Capital Expenditures for Lime FGD Systems

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
DIRECT COSTS			
Lime Preparation			
Conveyors	$546,000	19	0.009
Slakers and pumps	161,000	20	0.003
Storage silos	1,249,000	18	0.021
Storage tanks	261,000	18	0.004
Pumps and motors	36,000	20	0.001
SO2 Scrubbing			
Absorbers	15,973,000	38	0.266
Fans and motors	2,040,000	19	0.034
Heat exchangers	3,100,000	19	0.052
Soot blowers	1,196,000	19	0.020
Valves and ducting	1,617,000	18	0.027
Mold tanks	1,037,000	18	0.017
Pumps and motors	2,982,000	20	0.050
INDIRECT COSTS			
Interest during construction	3,962,000	3	0.066
Field overhead	3,962,000	3	0.066
Engineering	3,163,000	25	0.053
Freight	395,000	3	0.007
Offsite	1,188,000	3	0.020
Taxes	474,000	3	0.008

Table B.23 (Continued)

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Spares	158,000	3	0.002
Allowance for shakedown	1,996,000	3	0.033
Contingency	11,044,000	3	0.184
Contractor Fee	3,313,000	3	0.055
Land cost	154,000	3	0.002

Source: DeRenzo, 1978, p. 736.
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.24

Original and Adjusted[1] Expenditure Patterns for Materials Component of Capital Expenditures for Air Pollution Control

I-O Sector	1977 Original	1977 Adjusted	1982 Original	1982 Adjusted
3	0.545	0.656	0.516	0.587
6	0.012	0.014	0.013	0.015
18	0.028	0.034	0.044	0.050
19	0.036	0.044	0.063	0.072
20	0.016	0.019	0.029	0.033
23	0.035	0.042	0.025	0.028
25	0.024	0.029	0.032	0.037
38	0.304	0.162	0.278	0.178

[1]To adjust the original expenditure patterns, the proportion of total expenditure for sector 38 was set equal to the ratio of shipments of industrial air pollution control equipment to total capital expenditures for air pollution abatement observed in 1977 and 1982. Proportions for sectors other than 38 were adjusted so that all proportions summed to one.

Table B.25

Distribution of Materials and Supplies Capital Expenditures
for Water Pollution Abatement

Item	Estimate of Item Cost ($)[1]	Assigned I-O Sector	Share in Total Cost[2]
Agitators, C-clamp	1,009	18	0.001
Agitators, Top Entry	1,896	18	0.001
Clarifier, Concrete	279,519	16	0.168
Clarifier, Steel	165,571	18	0.100
Cooling Tower System	55,563	18	0.03
Equalization Tanks, Steel	52,187	18	0.031
Feed System, Alum	39,961,345	19	[3]
Feed System, Batch Lime	2,193	19	0.001
Feed System, Lime	175,552	19	0.106
Feed System, Polymer	30,502	19	0.018
Feed System, Sulfuric Acid	64,304	19	0.039
Multimedia Filter	60,528	19	0.036
Oil/Water Separator	24,913	18	0.015
Pumps, Centrifugal	9,605	19	0.006
Pumps, Sludge	7,332	19	0.004
Sulfonator	16,193	18	0.010
Tank, Batch Reactor	15,089	18	0.009
Tank, Concrete	17,800	16	0.011

Table B.25 (Continued)

Item	Estimate of Item Cost ($)[1]	Assigned I-O Sector	Share in Total Cost[2]
Tank, Fiberglass	15,089	16	0.009
Tank, Large Steel	2,187	18	0.001
Vacuum Filter	184,251	19	0.111
Vacuum Filter Housing	28,166	18	0.017
Engineer	120,945	3	0.073
Contingency	199,559	3	0.120
Contractor's Fee	133,039	3	0.080

Source: Derived from the *Development Document for Effluent Guidelines and Standards for the Nonferrous Metals Forming and Iron and Steel/Copper/Aluminum Metal Powder Production and Powder Metallurgy Point Source Category*.

[1]Computed by substituting the midpoint for the range of validity into the corresponding cost equation.

[2] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

[3]The cost for feed system, alum was omitted from the computation of distribution values since the estimated cost of this item was so much higher than for any other component.

Table B.26

Distribution of Materials and Supplies Capital Expenditures for Wash-Water Recovery

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Recovery Ponds	$ 20,000	3	0.088
Land	25,000	3	0.108
Polymer Feed	20,000	12	0.088
Return Pumps	80,000	19	0.349
Site Work	20,000	3	0.088
General Contractor Overhead and Profit	25,000	3	0.108
Engineering	20,000	3	0.088
Legal, Fiscal, and Administrative	2,000	3	0.008
Interest During Construction	17,000	3	0.075

Source: American Society of Civil Engineers and American Water Works Association, 1990, pp. 340-343.
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.27

Distribution of Materials and Supplies Capital Expenditures
for Alum Sludge Disposal

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Centrifuge	$ 230,000	19	0.526
Polymer	20,000	12	0.046
Haul Truck	29,000	21	0.066
Site Work	39,000	3	0.089
General Contractor Overhead and Profit	48,000	3	0.110
Engineering	37,000	3	0.085
Legal, Fiscal, and Administrative	4,000	3	0.009
Interest During Construction	30,000	3	0.069

Source: American Society of Civil Engineers and American Water Works Association, 1990, pp. 340-343.
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

Table B.28

Distribution of Materials and Supplies Capital Expenditures
for Lime Sludge Disposal

Item	Item Cost	Assigned I-O Sector	Share in Total Cost[1]
Vacuum Filter	$ 650,000	19	0.589
Haul Truck	58,000	21	0.052
Site Work	99,000	3	0.090
General Contractor Overhead and Profit	113,000	3	0.102
Engineering	92,000	3	0.083
Legal, Fiscal, and Administrative	1000	3	0.009
Interest During Construction	82,000	3	0.075

Source: American Society of Civil Engineers and American Water Works Association, 1990, pp. 340-343.
[1] "Total Cost" excludes expenditures for labor, capital recovery (depreciation), and services.

APPENDIX C. USE OF COMMODITIES BY INDUSTRIES INPUT-OUTPUT TABLES: 1977 AND 1982

September 1995

Table C.1
1977 "Use" Input-Output Table

	01	02	03	04	05	06	07	08	09	10
01	31871.1	7.9	655.2	53245.8	2612.7	2072.6	261.7	3801.3	0.2	21.3
02	162.8	5561.8	1993.9	110.2	6.5	33.7	6.0	5.8	4.6	334.8
03	1390.7	2928.7	328.5	962.2	20.3	221.8	172.7	233.2	120.6	560.7
04	11358.3	6.9	9.3	33222.1	4.2	8.9	13.3	3.4	32.1	233.1
05	0.0	0.0	0.0	0.0	2627.9	0.0	0.0	0.0	0.0	0.0
06	202.6	28.4	1322.3	10.9	0.0	11090.1	11808.4	76.4	978.6	671.5
07	80.5	23.9	108.8	60.2	1.5	140.8	9547.9	12.0	79.0	12.5
08	195.9	99.8	18305.8	77.7	4.9	3.9	11.3	12111.0	1708.9	2688.4
09	0.0	0.0	569.5	0.0	0.0	0.0	0.0	0.0	73.8	1.2
10	273.9	46.4	826.4	5659.9	232.2	327.4	402.1	123.4	227.1	13420.2
11	27.6	22.0	4.8	921.4	125.4	20.2	58.7	17.8	25.7	51.3
12	7734.9	927.3	3540.3	2056.7	26.9	958.1	197.3	632.6	237.5	1682.7
13	3580.1	957.3	7339.2	739.9	40.5	258.9	204.0	437.2	91.5	1260.4
14	638.5	306.3	2987.0	1850.7	257.7	6576.4	1810.6	250.3	813.0	1980.9
15	25.7	1.6	2.4	1.4	0.0	6.5	256.4	8.5	39.4	0.9
16	75.1	120.7	15826.2	3032.4	1.7	115.0	7.5	237.8	127.0	81.2
17	12.1	778.3	8891.9	10.0	1.4	42.8	0.7	45.6	1127.0	160.7
18	278.5	804.6	23157.5	6760.9	63.6	5.2	25.8	1216.5	964.1	346.6
19	946.4	2572.0	5148.3	302.1	8.1	328.5	129.8	275.4	89.5	341.4
20	408.2	427.7	7144.0	16.2	0.7	11.0	38.0	50.0	23.2	8.1
21	119.6	95.9	115.6	7.3	0.6	1.5	2.9	46.6	1.8	6.1
22	171.9	3.2	13.0	0.0	0.4	0.1	0.2	1.7	0.0	0.0
23	5.1	35.5	711.0	33.3	1.6	11.2	11.9	14.2	9.2	27.4
24	19.0	38.9	516.7	19.4	1.1	7.3	607.1	14.0	13.4	8.6
25	1929.0	516.3	5753.4	4454.9	88.4	468.6	441.9	911.3	363.9	1945.2
26	322.3	94.4	995.1	364.7	8.3	141.4	375.8	54.1	87.8	121.2
27	1168.4	1411.7	501.9	1077.9	34.3	575.2	302.7	370.3	127.3	948.5
28	212.6	479.1	239.0	796.0	4.6	120.1	65.6	120.4	37.4	602.6
29	5689.0	1567.3	23232.4	10692.3	153.8	1671.3	2182.2	1918.4	950.5	2672.4
30	8250.2	5659.3	2795.6	1312.7	112.8	214.8	636.8	351.5	362.5	396.8
31	2890.4	2111.2	15718.0	5693.3	671.2	1151.6	1306.9	748.9	876.9	1467.2
32	52.8	50.5	132.3	242.2	30.4	57.1	187.2	32.0	48.8	63.7
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	1.5	6.1	0.7	19.3	0.2	5.9	1.3	3.1	1.6	12.4
36	5.7	8.6	26.9	101.2	2.3	16.2	5.5	1.8	2.2	33.5
37	0.0	27.7	41.2	48.9	1.0	8.7	1.3	10.9	6.1	36.1
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	7.4	183.5	32.4	4504.3	1.0	217.4	74.1	5.4	16.8	540.5
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	80107.8	27910.7	148986.4	138408.4	7148.3	26890.2	31155.6	24142.9	9669.0	32740.1
Labor	11618.8	12790.8	87504.5	25371.6	1118.2	7621.9	14056.1	8799.8	5270.7	11780.9
IBTs	2815.2	3021.2	2699.5	6401.7	2423.0	325.7	193.1	343.2	114.4	783.7
Other	35213.0	34308.3	19029.4	19018.4	2163.1	2874.2	4119.8	5692.5	1638.6	6255.3
Total VA	49647.0	50120.3	109233.4	50791.7	5704.3	10821.8	18369.0	14835.5	7023.7	18819.9
Output	129754.8	78031.0	258219.8	189200.1	12852.6	37712.0	49524.6	38978.4	16692.7	51560.0

Table C.1 (cont.)
1977 "Use" Input-Output Table

	11	12	13	14	15	16	17	18	19	20
01	0.2	399.1	0.4	0.8	0.0	3.7	1.4	1.1	1.1	1.7
02	2.6	3725.4	60277.4	511.6	2.9	1996.7	9131.0	48.3	29.8	26.1
03	193.6	774.5	910.5	461.5	30.9	558.2	1718.7	912.1	591.5	464.3
04	15.1	1139.5	35.2	54.6	530.0	21.1	11.1	9.8	16.9	11.1
05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
06	85.6	10.1	19.6	1611.2	471.7	119.0	22.8	1.5	76.5	54.3
07	6.0	31.7	0.8	21.7	17.2	11.4	21.4	45.8	20.4	29.8
08	1.0	56.8	22.7	116.6	38.2	286.9	194.9	287.4	198.8	157.4
09	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	1.9	350.7
10	8171.8	1769.6	489.1	1408.9	133.0	878.7	146.3	605.3	540.4	837.9
11	4838.9	224.3	12.1	42.6	14.3	42.5	48.9	199.6	142.1	242.9
12	1024.7	21874.9	3335.8	9435.4	220.0	1080.7	2566.8	1202.2	436.3	973.7
13	248.9	1955.9	8310.2	940.4	26.3	649.0	1276.3	337.2	578.2	322.6
14	328.7	2468.1	171.5	10611.1	453.4	401.1	783.7	1131.9	2090.6	3521.9
15	5.0	6.3	4.2	6.4	1436.8	3.5	4.7	0.0	1.2	1.0
16	14.1	641.6	197.0	370.1	6.5	4123.2	642.8	435.5	705.8	1089.5
17	48.9	1426.1	44.5	509.8	2.6	370.8	30726.0	23636.6	15078.3	7771.8
18	83.8	1982.8	550.3	474.1	72.2	357.0	1109.6	5222.7	4267.1	3216.2
19	251.6	935.9	167.1	379.9	24.9	391.5	2307.0	1909.9	17059.6	1289.6
20	13.7	33.9	7.3	56.5	0.9	55.8	581.3	430.8	5211.7	12964.4
21	8.7	6.0	102.3	28.7	0.1	61.5	5.0	61.6	567.3	30.6
22	0.0	0.1	0.0	0.3	0.0	20.8	15.3	0.0	21.5	25.1
23	461.4	97.8	24.6	48.7	2.3	36.2	109.4	83.3	286.9	447.2
24	130.3	30.3	2.6	20.7	70.7	32.3	21.7	33.1	64.8	84.4
25	1309.6	3367.7	3202.6	1616.7	107.6	2134.1	4043.9	1438.8	1494.3	1281.2
26	602.4	277.3	173.0	140.1	33.5	117.5	136.5	375.9	520.9	363.5
27	320.2	1747.2	627.3	1021.3	47.8	778.6	2914.4	710.7	823.3	745.5
28	65.8	1764.0	1572.1	338.7	11.7	939.4	1683.3	315.5	265.4	177.6
29	2858.6	4521.6	1789.5	2268.4	325.1	1294.7	5675.8	3652.6	6477.6	5116.3
30	1141.7	1387.1	817.7	713.2	110.8	511.6	848.0	972.2	1270.0	1794.0
31	3329.8	6956.9	1954.4	1925.3	299.6	1130.8	1947.4	2430.8	3585.3	3472.9
32	854.6	143.9	94.5	59.0	48.9	56.1	100.5	99.8	171.3	218.5
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.1	42.0	17.1	9.5	0.3	3.1	14.1	4.4	6.0	6.4
36	4.5	35.0	4.1	9.6	5.0	6.4	19.7	21.5	19.4	17.0
37	9.7	93.3	21.6	33.6	2.4	20.7	73.8	21.0	27.8	22.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	22.3	581.8	184.9	571.0	0.9	151.4	3759.4	101.9	0.0	254.8
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.8	0.0
Total	26453.9	60508.4	85144.0	35818.0	4548.5	18646.0	72664.7	46740.8	62674.6	47383.8
Labor	16660.8	16360.2	5204.6	15234.4	2355.3	10505.3	25951.9	23665.0	38158.7	31521.7
IBTs	576.3	1253.0	5272.8	1577.0	30.7	604.8	1532.1	746.8	1120.8	755.7
Other	6293.3	14435.4	3273.6	6662.5	721.3	4857.3	6464.7	10619.3	15791.0	9358.4
Total VA	23530.4	32048.6	13751.0	23473.9	3107.3	15967.4	33948.7	35031.1	55070.4	41635.8
Output	49984.3	92557.0	98895.0	59291.9	7655.8	34613.4	106613.4	81771.9	117745.1	89019.6

Table C.1 (cont.)
1977 "Use" Input-Output Table

	21	22	23	24	25	26	27	28	29	30
01	0.7	1.1	0.4	26.1	8.3	0.9	6.3	0.7	2512.5	1480.3
02	44.3	10.1	6.8	27.9	82.4	0.0	7255.4	13147.6	0.0	5.4
03	299.9	253.1	101.6	117.3	3254.3	1973.9	3518.9	342.0	3437.3	15143.8
04	2.5	6.4	41.6	29.1	72.6	3.5	3.3	1.0	25119.7	7.9
05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
06	271.7	311.5	228.6	378.3	64.0	0.0	2.1	0.0	75.3	0.0
07	2313.0	162.3	19.7	79.5	165.8	36.5	4.0	0.7	157.5	83.4
08	140.0	885.1	25.0	437.3	17.2	0.0	0.0	0.0	446.8	2.7
09	231.3	162.8	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	204.3	64.8	566.6	687.1	111.5	48.4	34.4	7.3	3870.0	440.9
11	41.7	81.0	59.6	47.0	262.2	154.4	56.3	10.9	1639.8	1943.2
12	635.5	277.3	867.0	454.1	142.6	81.3	160.8	3.5	322.9	194.2
13	259.6	308.9	141.2	146.3	8700.6	131.2	8258.0	180.2	5378.8	765.1
14	5226.2	621.7	1036.4	1104.9	957.5	67.2	54.8	5.1	1732.5	285.3
15	5.1	0.8	8.0	93.7	3.6	1.1	0.7	0.1	88.1	10.3
16	1453.6	373.4	225.1	81.3	73.2	13.9	7.2	1.1	406.3	23.0
17	11547.7	4719.7	1070.0	1458.5	385.4	62.6	19.1	0.0	19.2	0.9
18	10871.8	2109.5	779.7	367.0	484.5	96.3	67.9	4.2	745.0	108.8
19	4163.9	2605.2	268.7	122.9	655.4	150.5	716.2	7.6	1059.0	121.8
20	3404.3	3452.9	1311.7	227.4	367.2	1731.5	239.0	7.9	314.5	227.2
21	31779.8	604.9	2.7	1.6	328.7	146.0	11.6	3.1	348.7	33.5
22	33.1	6202.7	0.0	8.4	1742.3	4.6	3.8	1.7	3.8	19.0
23	210.7	431.8	1020.0	16.9	67.3	128.3	77.8	13.6	235.1	146.0
24	29.9	41.3	51.8	1106.6	114.4	52.9	17.8	4.5	747.1	288.4
25	1156.9	863.0	368.3	473.6	16543.2	334.3	2272.9	64.8	8109.6	1157.9
26	65.0	264.2	154.0	160.8	989.1	1059.8	240.3	40.0	6032.8	3034.4
27	538.6	408.6	156.2	132.4	819.1	278.7	-3421.4	3421.4	7075.5	1725.9
28	200.8	100.4	41.9	34.3	170.0	150.1	3784.7	17028.1	1571.2	1119.0
29	4969.5	2477.1	1240.6	1348.2	3571.7	573.6	1152.0	43.7	16598.1	3043.5
30	514.5	873.3	316.4	432.7	3014.6	1690.1	745.7	470.3	22900.2	53566.9
31	2729.3	2141.1	1263.7	1109.6	6830.0	3878.7	1104.3	302.3	43164.2	16266.4
32	135.5	114.9	52.8	78.2	200.0	201.8	198.2	114.5	1978.8	2784.3
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	3.9	5.8	0.9	0.4	4.8	2.4	5.0	1.3	5.7	20.0
36	18.8	7.7	4.9	2.5	53.9	23.7	4.8	3.5	137.4	32.0
37	25.5	13.4	8.0	5.4	22.7	40.4	30.7	0.9	438.8	176.7
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	522.9	35.4	70.4	526.9	3112.4	931.8	0.2	3.2	464.0	276.3
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	84051.8	30993.2	11513.1	11324.2	53392.1	14050.3	26632.7	35236.7	157136.3	104534.4
Labor	23069.1	21679.1	8376.5	5416.6	49315.3	21109.3	8370.3	3905.9	188068.0	59352.7
IBTs	1648.6	445.7	222.7	210.6	4322.4	5744.9	3129.1	1545.5	56509.5	52961.5
Other	8915.6	3777.7	4957.4	2793.3	18542.6	20611.8	22382.2	7614.6	68555.5	184380.8
Total VA	33633.3	25902.5	13556.6	8420.5	72180.3	47466.0	33881.6	13066.0	313133.0	296695.0
Output	117685.1	56895.7	25069.7	19744.7	125572.4	61516.3	60514.2	48302.7	470269.3	401229.4

Table C.1 (cont.)
1977 "Use" Input-Output Table

	31	32	33	34	35	36	37	38	39	40	41	Total Int.
01	1112.4	159.5	1.9	0.8	0.6	2.1	0.3	0.0	0.0	0.0	0.0	100274.2
02	16.8	6.2	39.0	10.6	0.4	1.0	4.1	0.0	0.0	0.0	0.0	104629.8
03	4324.8	2322.8	7.0	1.8	133.7	425.2	71.6	3.0	0.0	0.0	0.0	49287.2
04	2678.6	490.6	0.2	0.0	0.1	0.0	0.6	0.1	0.0	0.0	0.0	75193.9
05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2627.9
06	266.9	7.3	0.4	0.6	0.0	0.0	0.1	17.2	0.0	0.0	0.0	30285.6
07	1615.2	63.8	2.0	0.9	0.5	1.9	0.5	0.1	0.0	0.0	0.0	14980.6
08	188.3	0.0	18.5	7.3	0.0	0.0	29.7	2.0	0.0	0.0	0.0	38768.2
09	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1400.3
10	1638.6	70.5	4.0	0.9	2.3	2.4	1.1	3.2	0.0	0.0	0.0	44278.3
11	5120.9	207.8	0.2	0.0	1.6	5.2	2.1	0.7	0.0	0.0	0.0	16717.7
12	6895.7	212.2	16.2	18.0	13.4	37.9	68.2	1.8	0.0	0.0	0.0	70547.4
13	3888.8	403.6	87.5	25.1	9.1	29.7	187.1	5.3	0.0	0.0	0.0	58460.3
14	2157.7	63.8	19.3	14.8	0.3	0.8	10.3	2.2	0.0	0.0	0.0	52794.1
15	72.6	9.9	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	2106.0
16	1025.1	50.9	472.4	77.3	2.5	9.5	0.5	1.8	0.0	0.0	0.0	32148.8
17	19.6	6.7	297.6	12.9	0.0	0.0	0.0	106.0	0.0	0.0	0.0	110411.8
18	3285.6	53.6	646.1	177.2	4.8	1.1	15.8	38.4	0.0	0.0	0.0	70816.3
19	2445.4	194.8	254.1	11.9	7.3	27.5	2.4	57.9	0.0	0.0	0.0	47731.0
20	2801.8	236.8	82.8	5.9	1.8	5.7	1.9	24.4	0.0	0.0	0.0	41928.0
21	5201.8	81.3	1.7	1.5	1.0	1.1	3.5	0.0	0.0	0.0	0.0	39822.1
22	323.0	62.7	0.3	0.0	0.8	3.1	0.0	0.0	0.0	0.0	0.0	8682.9
23	3241.5	22.4	3.5	0.7	2.3	2.3	1.9	2.2	0.0	0.0	0.0	8082.3
24	1517.1	55.4	1.2	1.1	0.9	3.3	4.6	0.1	0.0	0.0	0.0	5774.9
25	5589.4	1343.5	109.3	21.5	6.4	20.1	110.6	8.4	0.0	0.0	0.0	75423.2
26	5943.5	172.7	22.0	35.2	2.7	10.4	30.0	3.3	0.0	0.0	0.0	23566.0
27	4303.6	1493.0	11.9	3.1	80.1	278.4	6.7	3.9	0.0	0.0	0.0	33570.3
28	1508.8	973.6	5.6	1.5	41.3	156.8	3.5	1.5	0.0	0.0	0.0	36704.0
29	13802.5	643.5	267.4	53.2	15.0	44.0	86.5	34.1	0.0	0.0	0.0	134673.9
30	24083.8	565.1	66.4	5.9	14.6	34.3	28.0	11.6	0.0	0.0	0.0	138993.6
31	36372.0	1201.8	996.5	36.9	27.5	83.8	141.3	16.8	0.0	0.0	0.0	177334.8
32	2139.4	333.5	5.3	0.8	3.6	8.9	4.7	0.9	0.0	0.0	-0.5	11099.3
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	26.1	1214.3	0.0	0.0	66.0	241.2	0.5	0.0	0.0	0.0	0.0	1548.1
35	37.7	11.0	0.0	0.0	0.5	1.8	0.0	0.0	0.0	0.0	0.0	256.2
36	104.9	7.1	1.0	0.1	0.0	0.0	0.4	0.1	0.0	0.5	0.0	749.7
37	369.6	16.6	1.0	0.3	0.9	1.8	65.6	0.1	0.0	0.0	0.0	1726.2
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.0	0.4	0.0	0.0	0.1	0.1	0.2	0.3	0.0	0.0	0.0	17155.8
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.1
Total	144123.8	12773.1	3442.3	527.8	442.2	1441.5	884.7	347.4	0.0	0.5	-0.5	1680589.7
Labor	171285.0	19694.6	1880.6	986.6	181.2	627.8	662.7	191.4	0.0	213794.2	5889.8	1175408.0
IBTs	6186.9	0.0	84.6	6.4	8.1	1.6	83.3	5.7	0.0	0.0	0.0	165707.9
Other	91673.4	-1023.5	333.5	27.3	160.8	466.1	563.4	72.7	0.0	0.0	6517.5	650112.0
Total VA	269145.4	18671.2	2298.7	1020.3	350.1	1095.5	1309.4	269.9	0.0	213794.2	12407.3	1991227.9
Output	413269.2	31444.2	5741.0	1548.1	792.3	2537.0	2194.0	617.3	0.0	213794.7	12406.8	3671817.5

Table C.1 (cont.)
1977 "Use" Input-Output Table

	PCE	GPFI	Inventory	Exports	Imports	Non-Environ. Gov't.	Sanit.	Sewer.	Hwy	Water	Nat. R.	Final Demand	Output
01	11377.4	0.0	712.2	12959.7	-2712.4	3340.3	0.0	0.0	0.2	0.0	12.1	25689.5	125963.7
02	236.6	489.9	588.8	3235.4	-37565.4	221.5	0.0	0.0	0.5	0.0	0.4	-32792.3	71837.5
03	0.0	158491.6	0.0	26.4	0.0	49654.9	0.0	0.0	143.9	333.0	282.9	208932.7	258219.9
04	113507.8	0.0	1616.6	7307.8	-8358.0	3586.0	0.0	0.0	0.0	0.0	0.9	117661.1	192855.0
05	8437.4	0.0	364.8	1664.3	-271.7	-0.1	0.0	0.0	0.0	0.0	0.0	10194.7	12822.6
06	2926.4	892.4	1268.5	1490.8	-1476.5	146.0	0.0	4.4	0.0	0.0	0.1	5252.2	35537.8
07	37261.7	0.0	2694.5	1077.0	-6120.4	875.9	0.0	2.7	0.1	0.0	2.0	35793.5	50774.1
08	547.6	11.0	1336.2	1937.7	-3576.8	100.2	0.0	0.0	0.0	0.0	0.1	356.0	39124.2
09	9208.1	5049.9	490.8	294.3	-743.4	870.4	3.6	1.6	0.1	0.0	3.3	15178.6	16578.9
10	5498.9	0.0	919.5	2328.4	-3737.7	1433.5	0.0	2.1	0.2	0.8	6.2	6451.8	50730.1
11	10237.0	0.0	595.6	701.9	-360.0	3941.9	0.0	0.0	0.2	0.0	14.5	15131.1	31848.8
12	19330.9	541.2	1831.0	8137.9	-5715.6	3480.5	0.0	16.4	1.2	0.0	10.9	27634.5	98181.9
13	37593.0	0.0	2996.2	2837.3	-11591.1	5592.1	0.0	207.3	0.8	0.0	18.1	37653.7	96114.0
14	6443.8	57.7	1625.1	3266.2	-3022.0	934.6	0.0	2.1	0.1	0.0	1.8	9309.4	62103.5
15	7609.5	0.0	227.3	310.3	-2667.4	52.1	0.0	0.0	0.0	0.0	0.0	5531.8	7637.8
16	1952.4	0.0	880.0	1106.6	-1713.6	449.7	0.0	0.0	0.0	0.0	0.7	2675.9	34824.7
17	59.3	110.8	2280.6	3092.0	-12003.0	373.3	0.0	0.0	0.0	0.0	0.0	-6086.9	104324.9
18	3210.0	4674.6	2263.2	3730.2	-2680.5	1808.0	0.0	6.5	0.2	0.0	1.1	13013.3	83829.6
19	1576.8	49891.9	3950.7	18524.0	-7509.6	4236.8	56.4	39.4	1.6	11.0	8.1	70787.0	118518.0
20	19283.4	19703.8	2694.6	9014.1	-11398.8	7395.6	0.0	0.0	0.2	0.2	4.6	46697.8	88625.8
21	46124.2	30854.1	4368.3	10993.6	-18252.5	2883.0	36.9	47.5	3.0	16.2	9.4	77083.6	116905.7
22	8119.4	11122.1	898.0	10102.6	-2143.3	18626.4	0.0	0.0	0.1	0.3	2.6	46728.2	55411.1
23	4306.0	8757.6	661.3	3491.6	-3107.7	3116.8	9.6	9.2	0.1	0.4	3.2	17248.1	25330.4
24	12684.3	1283.2	913.3	1295.3	-3832.5	912.2	0.0	0.0	0.3	0.0	6.6	13262.6	19037.5
25	33063.3	1978.6	1019.5	10168.9	-591.9	7151.0	2.3	34.4	1.2	0.6	12.6	52840.5	128263.7
26	22917.5	3385.1	0.0	985.4	0.0	2708.7	0.0	2.1	0.3	0.0	8.7	30007.7	53573.7
27	25816.3	0.0	0.0	62.7	-352.6	4843.6	0.0	0.0	2.7	0.0	4.2	30376.9	63947.2
28	11828.7	0.0	0.0	205.8	-1847.1	871.7	0.0	0.0	0.7	0.0	6.6	11066.4	47770.4
29	289847.0	24699.8	3117.0	12611.2	5375.6	3416.2	21.2	33.1	1.4	3.0	24.5	339150.0	473823.9
30	240622.5	10747.0	0.4	5949.1	-532.8	8065.9	0.0	30.8	0.1	0.0	13.8	264896.8	403890.4
31	245181.6	0.0	151.5	4076.6	-148.4	19665.4	0.0	27.8	0.0	0.0	4.0	268958.5	446293.3
32	4480.4	0.0	0.0	193.7	0.0	760.4	0.0	18.3	0.0	0.0	0.3	5453.1	16552.4
33	0.0	314.0	0.0	0.0	0.0	53.0	5295.0	79.0	0.0	0.0	0.0	5741.0	5741.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1548.1
35	479.7	0.0	0.0	0.8	0.0	55.4	0.0	0.0	0.0	0.0	0.2	536.1	792.3
36	1787.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1787.3	2537.0
37	467.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	467.8	2194.0
38	0.0	617.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	617.3	617.3
39	14595.3	-10279.6	-203.5	1589.8	-27223.5	4669.8	0.0	0.0	2.9	6.1	497.4	-16345.3	810.5
40	0.0	0.0	0.0	0.0	0.0	212264.1	0.0	1498.7	31.4	0.0	0.0	213794.2	213794.2
41	-1290.7	0.0	-18992.0	43915.2	-10908.4	-316.8	0.0	0.0	0.0	0.0	0.0	12407.3	12446.4
													1175408.0
													165707.9
													650112.0
	1257328.6	323394.0	21270.0	188684.6	-186789.0	378240.2	5425.0	2063.4	193.4	371.7	961.7	1991143.4	

Table C.2
1982 "Use" Input-Output Table

	01	02	03	04	05	06	07	08	09	10
01	55652.3	5.8	484.1	76728.6	3131.2	1759.5	126.2	4326.7	0.4	63.8
02	253.6	8956.2	2500.9	180.0	12.7	49.5	12.7	18.3	7.0	568.6
03	1811.9	4748.5	442.5	508.1	15.8	141.0	102.8	229.5	180.8	270.8
04	11954.8	6.9	1.7	49044.4	0.9	4.5	5.4	2.6	25.8	295.6
05	0.0	0.0	0.0	0.0	3365.4	0.0	0.0	0.0	0.0	0.0
06	232.6	27.6	1486.0	25.8	0.0	11537.6	14348.4	15.0	1254.9	843.2
07	175.0	15.2	172.4	47.1	1.0	27.3	12804.1	5.5	70.3	6.9
08	404.9	120.6	16465.1	110.4	0.5	7.3	14.4	13077.9	2226.1	4541.0
09	0.0	0.0	709.0	0.0	0.0	0.0	0.0	0.0	147.7	2.2
10	667.2	31.6	868.6	7285.4	696.1	337.3	380.4	156.7	286.8	19015.1
11	78.6	123.1	219.3	2073.3	266.9	34.9	101.6	28.5	35.5	78.4
12	9937.8	1382.6	5425.2	3590.0	57.0	1455.5	497.5	929.9	439.4	3748.4
13	8294.0	2374.9	15797.5	1240.6	120.6	457.9	548.5	744.7	217.2	2333.0
14	453.2	505.8	3869.6	4157.1	89.6	8187.0	2212.1	337.9	795.4	2857.2
15	26.6	1.1	6.9	1.4	0.0	4.5	347.9	7.1	73.6	1.1
16	34.1	165.4	20939.8	4214.5	3.8	195.6	5.0	152.7	185.4	91.3
17	0.0	223.7	13597.8	7.5	0.5	6.6	1.3	37.6	1482.8	89.5
18	449.4	1813.9	32863.3	9995.7	99.3	2.6	14.1	1345.8	1256.6	626.1
19	1506.9	4191.4	9499.0	473.0	24.9	482.9	182.7	449.6	129.6	340.2
20	187.8	565.6	13109.4	14.4	1.0	18.0	10.4	49.1	25.4	9.8
21	337.4	41.3	247.9	22.3	4.0	7.1	16.9	19.4	6.7	30.2
22	409.4	4.6	19.0	0.0	0.0	0.1	0.1	2.3	0.0	0.0
23	18.3	49.5	1328.5	68.8	5.4	22.1	26.8	17.1	28.1	55.6
24	46.3	32.4	604.3	29.1	1.2	10.9	546.3	10.1	28.1	13.0
25	3766.3	905.1	8246.1	7435.5	123.3	530.6	506.8	1148.0	420.7	3300.3
26	410.5	316.3	1455.8	664.5	25.8	92.4	331.7	127.1	92.9	270.8
27	2087.9	3534.9	955.3	2524.4	71.5	987.8	600.9	693.5	248.0	2217.0
28	365.9	1057.8	300.3	2190.0	23.7	360.8	193.2	190.8	84.1	1784.0
29	6820.3	2077.8	33239.6	15041.7	440.7	1899.3	2778.8	1989.3	1590.7	3344.7
30	11504.4	26081.3	4473.1	2196.5	196.4	396.5	1067.6	449.4	573.7	593.2
31	5001.8	4930.0	36376.5	11545.8	628.4	2017.7	2379.8	1147.4	1557.6	2319.9
32	114.0	50.5	218.0	470.3	54.2	111.9	330.3	57.0	79.1	139.3
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	11.6	20.9	3.3	9.4	0.1	1.6	0.4	2.2	0.5	24.0
36	36.8	10.0	41.7	175.1	3.0	17.2	6.3	3.5	5.8	61.7
37	227.0	177.0	103.4	63.9	1.3	7.0	1.0	13.6	8.1	53.1
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	18.8	438.1	8.4	4189.8	4.2	263.5	103.5	3.8	22.7	731.6
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	123297.4	64987.4	226079.3	206324.4	9470.4	31435.9	40605.9	27789.6	13587.5	50720.5
Labor	14248.8	25883.4	140808.6	37576.3	2393.9	9107.7	18970.0	10490.6	7766.6	17654.4
IBTs	3680.8	26549.3	2006.1	6688.5	2554.7	328.1	293.2	463.6	138.9	830.8
Other	54163.3	75194.4	58284.3	26806.6	5235.9	-29.7	4266.6	2286.9	2169.4	9376.9
Total VA	72092.9	127627.1	201099.0	71071.4	10184.5	9406.1	23529.8	13241.1	10074.9	27862.1
Output	195390.3	192614.5	427178.3	277395.8	19654.9	40842.0	64135.7	41030.7	23662.4	78582.6

Table C.2 (cont.)
1982 "Use" Input-Output Table

	11	12	13	14	15	16	17	18	19	20
01	2.3	280.8	1.9	2.9	0.2	2.4	3.2	2.4	7.3	8.5
02	11.7	4830.8	131800.8	408.5	5.2	2879.1	6518.8	71.4	64.1	157.1
03	201.8	541.9	489.3	288.2	19.3	333.4	1469.1	1182.9	1141.4	744.2
04	6.5	921.4	25.8	50.7	619.2	17.2	8.2	7.4	12.8	9.8
05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
06	104.1	19.5	33.2	1514.4	497.0	96.0	21.4	1.3	138.8	51.2
07	4.7	30.9	0.5	16.0	7.1	5.4	8.8	89.9	12.3	27.2
08	1.5	71.2	46.7	128.8	72.4	287.8	219.8	354.3	259.5	241.3
09	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0	30.3	388.2
10	13971.9	2004.9	364.6	1751.8	108.2	1172.6	136.1	669.9	826.6	1098.8
11	7098.4	609.4	23.0	87.4	12.1	65.6	70.3	335.1	299.3	383.7
12	2018.9	27792.6	3119.7	14799.4	429.0	2364.1	3549.1	1907.1	820.3	2584.6
13	1121.4	3267.6	17493.8	844.2	39.5	629.4	1555.5	757.4	1044.8	751.9
14	874.0	4204.5	370.5	14112.4	387.4	517.3	1225.6	1210.2	3439.6	5880.8
15	9.2	2.9	3.3	3.2	1614.1	2.5	2.6	0.4	2.4	1.9
16	19.5	885.0	361.7	421.8	10.0	4657.7	587.7	641.9	1213.7	1488.5
17	202.9	698.3	47.8	252.0	1.8	254.2	28741.4	28537.2	17728.1	9930.8
18	166.1	2938.8	479.9	795.3	80.0	437.9	1267.5	7814.9	6357.6	5266.4
19	458.6	939.9	64.3	543.3	33.0	387.1	2624.9	2515.6	24527.8	2032.6
20	15.9	42.9	12.2	104.1	2.1	68.1	725.3	388.1	10226.3	25554.5
21	43.9	16.3	35.8	10.8	0.2	11.1	20.1	39.1	114.2	18.1
22	0.0	0.0	0.0	0.2	0.0	101.9	43.3	0.0	35.0	40.7
23	855.4	167.8	27.3	61.1	5.8	48.6	63.7	103.2	352.6	552.3
24	210.6	32.2	4.6	20.5	104.4	28.3	19.0	40.6	98.8	132.0
25	2148.1	3941.8	8110.8	2198.6	157.6	2979.1	4661.3	1906.6	2427.6	2110.2
26	1097.4	505.7	204.4	657.5	29.8	440.9	631.3	1481.1	1193.4	1640.1
27	721.7	4084.4	1822.8	2229.0	83.9	1483.2	5247.0	1435.1	1911.6	1871.2
28	191.3	3431.1	3584.8	1045.3	34.1	1799.7	3025.1	675.6	630.9	505.4
29	4088.5	6813.9	4673.3	4205.9	526.2	1671.6	6174.2	6560.0	12395.3	10707.8
30	1966.0	1539.4	1894.0	812.9	181.5	560.5	910.7	1327.1	2551.0	2400.6
31	5224.6	9606.2	2174.3	2999.1	486.8	1741.9	4642.1	3905.7	7191.3	7056.9
32	1370.2	273.7	97.1	110.5	88.2	97.6	191.3	185.6	307.4	389.3
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.7	36.5	10.4	6.7	0.3	2.3	34.4	1.7	3.8	4.3
36	7.8	67.4	7.6	16.2	6.3	7.4	28.3	27.7	22.6	27.7
37	11.3	193.9	85.0	55.2	2.4	39.4	105.1	33.0	45.7	56.4
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	54.0	920.6	310.0	944.6	1.1	243.5	5202.4	140.9	807.9	626.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	44280.9	81714.2	177781.2	51498.5	5646.3	25434.8	79739.8	64350.5	98242.1	84741.0
Labor	29068.6	28146.3	8116.9	21934.5	2872.1	14359.9	31680.7	34332.4	63834.1	58148.4
IBTs	730.1	1777.3	4767.0	1621.8	37.0	633.5	1183.7	1055.9	1760.4	1481.8
Other	12723.8	22792.8	16040.7	7775.0	543.7	4117.4	-6472.4	6882.5	14474.7	4305.1
Total VA	42522.5	52716.4	28924.6	31331.3	3452.8	19110.8	26392.0	42270.8	80069.2	63935.3
Output	86803.4	134430.6	206705.8	82829.8	9099.1	44545.6	106131.8	106621.3	178311.3	148676.3

Table C.2 (cont.)
1982 "Use" Input-Output Table

	21	22	23	24	25	26	27	28	29	30
01	3.8	4.7	2.5	35.0	18.0	4.3	19.2	2.1	2808.7	3023.2
02	38.8	17.2	47.4	41.1	221.0	0.0	15843.1	38713.8	34.1	0.4
03	498.4	950.9	141.1	165.0	5361.5	4024.9	8234.9	781.6	4373.4	25685.7
04	0.7	7.6	52.1	49.1	249.3	3.4	0.9	0.2	39803.4	9.0
05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
06	240.8	309.3	513.1	492.5	53.9	0.0	5.3	0.0	65.7	0.3
07	1665.1	355.3	6.7	126.6	187.7	29.1	2.9	0.2	186.1	102.8
08	119.6	971.3	103.9	778.9	27.5	0.0	0.0	0.0	870.5	10.2
09	113.2	407.0	2.8	21.5	0.0	0.0	0.0	0.0	8.3	1.3
10	153.6	108.1	684.5	777.3	161.0	86.4	41.5	6.3	8359.0	897.5
11	53.4	122.0	106.3	137.3	473.4	508.8	124.1	25.2	2369.9	4218.7
12	743.3	466.8	910.5	701.7	230.6	149.6	336.4	10.1	458.3	347.1
13	610.6	597.3	366.9	314.3	26315.2	317.4	8370.9	384.5	12331.2	2036.6
14	4671.3	1170.3	1552.1	1516.2	1062.9	191.9	94.7	11.6	2376.1	402.8
15	2.7	1.2	6.0	93.1	7.8	2.9	0.8	0.3	83.9	25.7
16	1001.3	565.0	374.9	171.4	77.1	7.8	1.0	0.4	689.5	54.2
17	8194.5	5914.8	1798.1	2135.0	246.5	34.0	56.7	0.7	29.9	1.2
18	8111.5	2915.9	1260.7	565.7	938.2	325.6	118.6	3.0	1149.8	128.7
19	6858.4	3721.8	354.5	302.0	1884.4	442.4	1496.4	13.6	1550.8	461.6
20	2557.3	4765.9	3089.6	592.6	371.4	4435.6	360.4	19.3	337.4	343.6
21	25308.1	607.3	11.4	10.0	353.8	10.3	10.6	6.5	472.6	83.8
22	39.3	13162.2	0.0	5.4	2491.9	7.9	5.2	2.7	3.4	29.1
23	413.4	1569.6	1597.4	36.7	85.6	210.3	98.4	27.5	400.5	979.9
24	27.2	62.4	37.4	1339.3	130.1	88.9	30.9	9.1	838.4	508.3
25	2249.4	1429.5	468.2	546.0	26535.7	416.5	5785.6	139.0	8081.2	5721.0
26	224.3	567.8	330.6	104.5	2280.7	1985.6	173.0	31.7	9669.2	7153.9
27	923.2	932.6	381.3	244.8	1853.5	377.8	0.0	205.5	14306.8	1047.7
28	375.0	274.6	112.2	79.7	65.2	17.4	13430.7	48191.4	2877.8	88.5
29	8564.8	3648.2	2122.0	2274.2	6252.6	1321.5	1939.0	116.0	27868.5	9610.6
30	543.1	1857.9	683.9	526.7	6371.7	3545.8	2292.2	755.9	36657.3	101008.2
31	3771.0	5085.3	2470.1	2266.8	9610.6	8809.3	1961.7	628.0	69575.7	32183.6
32	250.0	207.3	93.8	134.2	276.1	257.2	344.4	198.8	3027.2	5246.9
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.8	1.4	0.6	0.2	5.8	3.5	7.2	1.8	77.7	6.6
36	27.0	12.1	5.5	3.1	71.2	15.3	6.7	5.0	392.8	45.8
37	39.7	26.5	8.8	5.5	114.9	354.2	131.4	7.0	273.9	259.4
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	698.7	110.2	258.5	668.1	5411.1	1934.8	1.9	9.5	1485.8	1430.8
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	79093.4	52927.3	19955.4	17261.5	99797.8	29920.4	61326.8	90308.3	253894.9	203154.7
Labor	23647.9	40529.4	15463.9	7262.7	73322.6	42502.6	14601.4	6793.5	294051.7	118240.6
IBTs	1657.8	749.6	352.7	202.1	5744.8	6334.2	6528.4	2864.9	77689.2	82237.2
Other	6841.7	8605.4	8119.1	3266.9	16456.6	33068.4	38866.3	10704.5	94602.1	312198.1
Total VA	32147.4	49884.4	23935.7	10731.7	95524.0	81905.2	59996.0	20362.9	466343.0	512675.9
Output	111240.8	102811.7	43891.1	27993.2	195321.8	111825.6	121322.8	110671.2	720237.9	715830.6

Table C.2 (cont.)
1982 "Use" Input-Output Table

	31	32	33	34	35	36	37	38	39	40	41	Total Int.
01	1165.2	2110.6	1.2	0.7	3.5	5.9	1.5	0.0	0.0	0.0	0.0	151800.6
02	41.0	25.0	57.3	19.7	1.1	2.0	12.6	0.0	0.0	0.0	0.0	214422.5
03	12437.2	5206.9	7.0	2.3	275.9	416.3	90.0	7.5	0.0	0.0	0.0	83523.7
04	4589.9	1343.8	0.0	0.0	0.2	0.2	0.7	0.1	0.0	0.0	0.0	109132.2
05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3365.4
06	263.8	8.4	0.4	1.3	0.0	0.0	0.1	25.2	0.0	0.0	0.0	34228.1
07	1564.7	57.3	4.2	2.1	1.0	1.8	0.4	0.0	0.0	0.0	0.0	17821.7
08	300.7	0.0	24.5	11.5	0.0	0.0	65.6	3.2	0.0	0.0	0.0	41938.9
09	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1846.6
10	4089.1	54.3	7.8	2.5	9.2	4.5	3.8	4.3	0.0	0.0	0.0	67281.2
11	11124.2	269.9	6.3	1.0	2.8	3.6	8.0	1.6	0.0	0.0	0.0	31580.9
12	11017.6	812.2	23.0	38.0	47.0	73.3	177.1	4.2	0.0	0.0	0.0	103394.9
13	7441.4	1450.0	210.3	74.8	20.9	37.0	381.2	5.8	0.0	0.0	0.0	120900.7
14	6019.6	138.7	30.8	29.9	20.1	6.2	12.1	5.6	0.0	0.0	0.0	75000.2
15	288.1	6.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	2631.4
16	1806.3	91.7	688.0	146.1	10.8	9.8	1.6	6.3	0.0	0.0	0.0	41978.2
17	46.2	0.4	343.2	18.7	0.0	0.0	0.0	196.2	0.0	0.0	0.0	120857.9
18	5690.0	55.3	804.4	288.2	14.7	4.4	87.3	87.9	0.0	0.0	0.0	96621.1
19	5654.5	688.2	392.0	32.0	30.1	53.4	9.8	149.0	0.0	0.0	0.0	75502.1
20	5516.7	830.3	118.3	12.7	5.9	8.3	3.3	42.8	0.0	0.0	0.0	74541.9
21	9184.8	264.0	4.6	5.2	0.9	0.9	227.9	0.1	0.0	0.0	0.0	37605.5
22	491.1	105.0	0.4	0.0	1.0	1.9	0.2	0.0	0.0	0.0	0.0	17003.3
23	4990.4	30.1	10.8	3.0	2.1	1.4	147.2	7.5	0.0	0.0	0.0	14469.9
24	2509.0	49.3	0.9	1.5	1.4	1.9	1.2	0.1	0.0	0.0	0.0	7649.9
25	7003.3	2355.6	180.2	39.0	14.4	21.1	255.4	15.6	0.0	0.0	0.0	118281.0
26	10678.1	253.2	29.1	58.9	14.8	17.1	21.3	5.7	0.0	0.0	0.0	45268.8
27	7449.9	3225.2	20.5	6.7	133.8	238.6	31.5	8.9	0.0	0.0	0.0	66199.4
28	2853.1	3990.6	6.6	2.3	195.8	352.7	276.7	3.8	0.0	0.0	0.0	94668.0
29	20939.3	1268.8	430.4	111.2	41.7	51.1	173.5	79.4	0.0	0.0	0.0	213852.4
30	44036.2	1111.6	99.8	15.4	71.9	75.2	222.4	12.2	0.0	0.0	0.0	261563.1
31	75641.3	1612.1	2142.3	118.7	62.1	83.6	210.8	30.1	0.0	0.0	0.0	329196.9
32	4464.1	660.2	9.2	1.7	2.2	3.3	3.3	1.4	0.0	0.0	0.0	19916.9
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	3088.1	0.0	0.0	0.0	0.0	0.0	3088.1
35	63.7	16.6	0.0	0.0	0.7	1.2	3.1	0.0	0.0	0.0	0.0	366.0
36	283.5	9.3	1.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1459.5
37	423.5	22.8	2.6	0.9	1.0	0.7	156.1	0.4	0.0	0.0	0.0	3112.4
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	2306.1	731.5	0.0	0.0	0.0	0.1	14.6	0.6	0.0	0.0	0.0	30097.8
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	272383.5	28854.6	5657.8	1046.3	987.1	4565.5	2600.7	705.6	0.0	0.0	0.0	
Labor	321735.4	30223.9	1942.7	1724.0	250.7	386.2	1286.7	330.1	0.0	337369.5	7640.3	1916700.0
IBTs	9319.8	13.7	64.1	6.2	17.9	5.8	122.6	6.6	0.0	0.0	0.0	252500.0
Other	150488.8	-5049.7	860.1	311.6	80.9	201.5	228.3	-136.3	0.0	0.0	37745.0	1038397.1
Total VA	481544.0	25187.9	2866.9	2041.8	349.5	593.5	1637.5	200.4	0.0	337369.5	45385.3	
Output	753927.5	54042.5	8524.7	3088.1	1336.5	5159.0	4238.2	906.0	0.0	337369.5	45385.3	

Table C.2 (cont.)
1982 "Use" Input-Output Table

	PCE	GPFI	Inventory	Exports	Imports	Non-Environ. Gov't.	Sanit.	Sewer.	Hwy	Water	Nat. R.	Final Demand	Output
01	15998.0	0.0	-1513.0	19448.3	-4153.0	8505.7	3.0	0.0	0.0	0.0	14.5	38303.6	190104.2
02	251.4	1137.0	943.9	8388.9	-46481.4	727.2	0.0	0.0	0.6	0.0	0.5	-35031.9	179390.6
03	0.0	267631.4	0.0	82.3	0.0	74717.9	100.0	0.0	226.5	614.2	282.3	343654.6	427178.3
04	166401.5	0.0	865.3	10933.1	-12416.4	6333.7	0.0	0.0	0.0	0.0	1.5	172118.7	281250.9
05	14249.0	0.0	363.7	2666.1	-972.5	-1.7	0.0	0.0	0.0	0.0	0.0	16304.6	19670.0
06	3425.2	1390.8	-632.9	1815.2	-2208.4	254.2	8.4	0.0	0.0	0.0	0.2	4052.7	38280.8
07	56918.7	0.0	-193.5	1413.1	-11623.5	1447.4	5.1	0.0	0.1	0.0	2.9	47970.3	65792.0
08	820.8	3.5	-1037.0	2537.8	-3182.7	125.7	0.0	0.0	0.0	0.0	0.1	-731.8	41207.1
09	12492.7	9354.9	-247.0	604.6	-1542.6	1087.4	2.4	5.5	0.1	1.2	4.4	21763.6	23610.2
10	9260.3	0.0	321.7	4072.1	-5635.3	2061.8	2.2	0.0	0.1	0.0	6.8	10089.7	77370.9
11	17388.0	0.0	104.9	1403.4	-638.4	4547.4	1.8	0.0	0.0	0.0	15.0	22822.1	54403.0
12	31960.1	1457.8	-984.5	14694.3	-9954.2	6502.9	29.5	0.0	0.0	0.0	21.3	43727.2	147122.1
13	78469.4	0.0	-2310.1	9387.9	-19488.6	14550.9	401.9	0.0	0.7	0.0	31.1	81043.2	201943.9
14	8597.1	45.1	-749.6	6463.9	-4871.8	1674.2	0.0	0.0	0.0	0.0	2.0	11160.9	86161.1
15	10390.5	0.0	117.7	512.2	-4628.3	104.4	0.0	0.0	0.0	0.0	0.0	6496.5	9127.9
16	3053.0	0.0	-75.3	1710.6	-2788.5	491.0	0.8	0.0	0.0	0.0	2.7	2394.3	44372.5
17	50.0	68.4	-4890.2	4855.5	-17599.0	981.8	0.0	0.0	0.0	0.0	0.1	-16533.4	104324.5
18	4610.6	5969.6	-1287.3	5668.3	-5230.5	2227.6	11.5	0.0	0.3	0.0	6.5	11976.6	108597.7
19	2497.0	78679.6	-1617.5	33371.7	-17084.1	8208.2	73.2	102.7	2.8	18.4	9.8	104261.8	179763.9
20	24308.8	37204.3	-112.1	17478.5	-22304.2	18376.9	0.3	0.0	0.4	0.5	6.8	74960.1	149502.0
21	51624.1	37215.5	-1336.8	12304.7	-31997.9	4650.7	83.8	65.3	4.6	26.5	12.6	72653.1	110258.6
22	9142.7	15337.7	3911.7	19331.9	-5270.2	40244.9	0.0	0.0	0.0	0.5	3.5	82702.7	99706.0
23	6266.1	15866.8	-90.5	6722.7	-5790.2	6459.7	19.0	19.1	0.2	0.7	6.6	29480.2	43950.1
24	18844.9	4347.6	-42.3	1904.8	-7526.8	1572.5	0.2	0.0	0.0	0.0	13.2	19114.1	26764.0
25	49682.0	3068.2	-539.6	19706.0	-902.1	10571.8	65.0	4.9	1.7	1.3	19.5	81678.7	199959.7
26	40287.0	4705.1	0.0	1490.0	0.0	5442.5	4.4	0.0	0.1	0.0	14.1	51943.2	97212.0
27	47066.0	0.0	0.0	82.9	-910.0	8828.2	0.0	0.0	4.8	0.0	6.9	55078.8	121278.2
28	25567.7	0.0	0.0	149.9	-4671.1	2396.4	0.0	0.0	0.0	0.0	6.7	23449.7	118117.7
29	438312.1	35304.5	-494.2	21941.5	8609.0	6776.2	71.0	37.5	1.3	5.5	43.2	510607.6	724460.0
30	426033.4	9535.0	0.0	12151.0	-1075.9	11846.2	29.5	0.0	0.0	0.0	10.4	458529.6	720092.7
31	431610.3	4360.9	-83.5	5850.6	-124.1	41064.4	-36.1	0.0	-0.5	0.0	57.6	482699.7	811896.6
32	7709.7	0.0	0.0	101.4	0.0	1183.0	38.6	0.0	0.0	0.0	4.2	9036.9	28953.8
33	0.0	2454.2	0.0	0.0	0.0	470.7	122.0	5477.8	0.0	0.0	0.0	8524.7	8524.7
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3088.1
35	832.6	0.0	0.0	2.2	0.0	133.6	0.0	0.0	0.0	0.0	2.2	970.5	1336.5
36	3699.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3699.5	5159.0
37	1125.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1125.8	4238.2
38	0.0	906.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	906.0	906.0
39	23831.4	-15590.2	-148.0	2280.2	-47284.0	9223.9	0.0	0.0	3.9	8.3	0.0	-27674.5	2423.3
40	0.0	0.0	0.0	0.0	0.0	334546.9	2093.0	0.0	36.2	0.0	693.4	337369.5	337369.5
41	-6587.9	0.0	-11299.0	106000.1	-42165.9	-562.0	0.0	0.0	0.0	0.0	0.0	45385.3	45385.3
Total													
Labor													1916700.0
IBTs													252500.0
Other													1038397.1
Total VA													
Output	2036189.5	520453.7	-23055.0	357527.7	-331912.6	637774.2	3130.5	5712.8	284.0	677.1	1302.6	3208084.5	3208084.5

APPENDIX D. DERIVATION OF THE TOTAL REQUIREMENT MATRIX

Due to problem of secondary production (i.e. most industries produce more than one commodity), it is necessary to introduce the modified form of the total requirements matrix. To obtain the modified total requirements matrix, both the "Use" and the "Make" Tables are required. The "Make" table is BEA's "The Make of Commodities by Industry" table and the "Use" table is BEA's "The Use of Commodities by Industry" table. The rows of the "Make" table are industry sectors and the columns are commodity sectors. Hence, a row shows the amount of each commodity produced by an industry, while a column shows the amount of a commodity produced by each industry. Similarly, in the "Use" table, the rows are commodity sectors, while the columns are industry sectors. A row shows the amount of a commodity used by each industry and purchased as final demand, while a column shows the amount of each commodity and the amount of primary factors used by an industry.

Industry output (q) is given by:

$$q = [I-A]^{-1} = BY$$

where

Y	=	the final demand (commodity)vector
A	=	"Use" table (divide I-O ccells of column by industry output associated with that column)
$B = W[I-AW]^{-1}$	=	industry by commodity total requirements matrix

and

W	=	"Make" table (divide I-O cells of a column by commodity output associated with that column)
AW	=	commodity by commodity direct requirements matrix
$[I-AW]^{-1}$	=	commodity by commodity total requirements matrix

The "Use" table, or the commodity by industry direct requirements table, is the table that is adjusted to isolate EP activities. Thus, the industry by commodity matrix total requirements matrix, $W[I-AW]^{-1}$, is used in this study. This matrix shows direct and indirect requirements of the output of industry I per dollar of final demand of commodity j. When estimating equations 14, 18, 19, and 20, B and B_{ne} are calculated in the manner shown above.

For simplicity of calculation, the adjustment for the "scrap sector" is ignored. Given the relatively small size of the "scrap sector," this probably has an insignificant impact on the results.

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APPENDIX E. DOCUMENTATION OF PEER REVIEW

E.1. Description of Review Process

Drafts of the reports *The U.S. Environmental Protection Industry: The Technical Document* and *The U.S. Environmental Protection Industry: A Proposed Framework for Assessment* were subjected to both an inter- and intra-agency reviewed. Representatives from the following Agencies were contacted for comment: Bureau of Economic Analysis, Congressional Budget Office, Department of Commerce, Office of Technology Assessment, and the U.S. International Trade Commission. Within EPA, representatives from the following offices were contacted: Office of Air and Radiation, Office of International Activities, Office of Prevention, Pesticides and Toxic Substances, Office of Solid Waste and Emergency Response, and Office of Water. Upon receipt of comments, EPA staff made an attempt to address and incorporate all comments, to the maximum extent possible. Specific comments and responses are listed below.

In addition, the analytical methods used were documented in an academic paper, which was submitted for peer review to the journal, *The Review of Income and Wealth*, a journal specializing in national income accounting and input-output concepts. The paper, "Environment-Economic Accounting and Indicators of the Economic Importance of Environmental Protection Activities," was accepted for publication after two revisions.

E.2. Specific Comments and Responses

Comment: [The report should] note (or footnote) additional complications and idiosyncracies of various estimates [of the size of the EP industry] beyond the discussion definitions and the example of water supply.

Response: Endnote 3 in Chapter 2 of *The U.S. Environmental Protection Industry: The Technical Document* and endnote 6 in *The U.S. Environmental Protection Industry: A Proposed Framework for Assessment* were added.

Comment: The point that data is the limiting factor [to measuring the size of the EP industry] should be made explicit for policymakers.

Response: Although data are a potential source of the discrepancy in different estimates of the size of the EP industry, it is not the primary source of the discrepancy. Rather, the report points out that it is the lack of a consistent definition of the economic activities that constitute environmental protection activities that is the primary source of the different estimates.

Comment: In addition to internal corporate activities and purchase of nonenvironmental commodities, environmental costs in the form of fees, taxes, and penalties paid to government do not count as EP industry revenues.

Response: Endnote 2 in Chapter 2 of *The U.S. Environmental Protection Industry: The Technical Document* and endnote 5 in *The U.S. Environmental Protection Industry: A Proposed Framework for Assessment* were added.

Comment: While disentangling [revenues from] environmental goods and services from nonenvironmental goods and services can be difficult and may in practice account for some discrepancy between cost and revenue based estimates of the EP industry, it is not a theoretical reason for such a discrepancy.

Response: The report does not claim that the difficulty in acquiring such data is a "theoretical reason for such a discrepancy." The report discusses the difficulties of actually measuring the size of the environmental protection industry.

Comment: In distinguishing value-added from revenues or costs of EP, it might be useful to have a more concrete example of how value-added is only a component of total costs in [*The U.S. Environmental Protection Industry: A Proposed Framework for Assessment*].

Response: Endnote 7 was added to *The U.S. Environmental Protection Industry: A Proposed Framework for Assessment*.

Comment: Perhaps a more important example than adding the value of game animals can be found to illustrate the SEEA's modification of national income accounting.

Response: The example was changed to the value of wetlands in mitigating floods, filtering water for drinking, and serving as a nursery for commercial fish.

Comment: Are government expenditures on vehicle emissions control and other environmental activities (e.g., precipitators at a municipal utility or military base clean-up or environmental monitoring) treated somewhere or are data not available?

Response: As stated in the report(s), this study uses the BEA definition of environmental protection expenditures with some modifications in order to accommodate EPA's definition of environmental protection costs. Some of BEA's expenditure information is excluded due to lack of information regarding which goods and services are purchased as a consequence of these expenditures. For example, regulation and monitoring expenditures are excluded from this report.

Comment: The report may benefit from a comparative assessment that clearly indicates why one approach [to measuring the EP industry] may be better over others.

Response: The preferred approach depends on the type of question that is being asked so it is not possible to compare approaches without reference to the research issue. Section 2 of *The U.S. Environmental Protection Industry: A Proposed Framework for Assessment* details the reasons that input-output framework is appropriate for this study.

Comment: The discussion of Table 1 [in *The U.S. Environmental Protection Industry: A Proposed Framework for Assessment*] is insufficient.

Response: The text describing the table was revised.

Comment: [The report] needs to clarify that water related EP expenditures include drinking water.

Response: The text under 3.3.1 in *The U.S. Environmental Protection Industry: A Proposed Framework for Assessment* was altered to make this point.

Comment: The format of the reports [should be] described in a preface or other appropriate introductory material.

Response: The acknowledgments section of the reports describes the relationship between the two reports.

Comment: The report could be improved by collection of primary data.

Response: Such data would have been useful in constructing the EP input-output tables for this report. However, the cost collecting primary data was not within the EPA budget allocated for this project.

Comment: The reports could be improved by more clearly describing the objective of the analysis.

Response: Section 1.1 of *The U.S. Environmental Protection Industry: A Proposed Framework for Assessment* was revised to address this comment.

Comment: The report [should] highlight all assumptions in a list or table.

Response: Appendix G, "List of Important Assumptions" was added to *The U.S. Environmental Protection Industry: The Technical Document*.

Comment: Are any air pollution services provided by the [external] EP industry?

Response: As indicated by the detailed discussions of what is included in the external EP sectors in Chapters 2 and 3 of *The U.S. Environmental Protection Industry: The Technical Document* no air pollution control services are provided by the external EP services sectors.

Comment: (Regarding Table 1 in *The U.S. Environmental Protection Industry: A Proposed Framework for Assessment*) The table needs a discussion of units and whether the information is based on a revenue, cost or value-added approach.

Response: The text describing the table was revised and the omitted units (millions of dollars) were added to the table.

Comment: The report needs a more complete discussion of the model to accompany derivation of the mathematical formulae.

Response: The derivation of the input-output multipliers is presented in "Environment-Economic Accounting and Indicators of the Economic Importance of Environmental Protection Activities" which will appear in the September 1995 issue of *The Review of Income and Wealth*.

Comment: The report needs to make clear that there are two parts to disaggregating the input-output tables: 1) identifying environmental protection expenditures which reduce pollution and 2) identifying defensive expenditures to reduce the effects of pollution.

Response: Endnote 5 in Chapter 2 of *The U.S. Environmental Protection Industry: The Technical Document* was added.

Comment: How are federal contributions to SRFs treated?

Response: Federal state revolving fund (SRF) subsidies do not appear to be counted as environmental protection expenditures by the Bureau of Economic Analysis. Hence, there is no explicit accounting of SRFs in the input-output tables in this report.