LINKAGES BETWEEN THE ECONOMY AND THE ENVIRONMENT OF THE COASTAL ZONE OF MISSISSIPPI

PART II: ENVIRONMENTAL MODEL

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LINKAGES BETWEEN THE ECONOMY AND THE ENVIRONMENT OF THE COASTAL ZONE OF MISSISSIPPI

PART II: ENVIRONMENTAL MODEL

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by

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Any errors of fact, logic, or judgement remaining in the report are the responsibility of the authors.

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I. INTRODUCTION

This report is the middle link of three projects. The earlier part was published in March 1978 and was entitled "Linkages Between the Economy and the Environment of the Coastal Zone of Mississippi, Part I: Input-Output Model" [38]. The study was built primarily around techniques developed by Leontief [18], Carter [6] and Isard [15]. The third project will appear subsequent to this one in a year hence.

The motivation for this three year study is to supply an empirical investigation into the mutual impacts of economic activity and the environment in the coastal region of Mississippi. Such a study requires a considerable amount of data, both economic and environmental.

The economic data were furnished in the earlier report in the form of input-output tables. There the economic activity of the region was divided into 29 endogenous sectors, each producing output to be absorbed by the others and in return absorbing as inputs products produced by the other sectors. It is a fairly convenient approach to display the overall economic activity in an accounting framework.

The non-economic data, the environmental, are by far more difficult to obtain than the economic counterpart. In this report methods, sources and estimates of the magnitudes of non-economic data will be presented.

In order to estimate physical quantities of pollutants in the Mississippi coastal region, primary data published by the Mississippi Air and Water Pollution Control Commission (MAWPCC) were used when possible.

However, it was necessary in many instances to rely on secondary sources either from similar studies or from published findings of the Environmental Protection Agency (EPA). At times, reliance was strictly based upon estimation techniques obtained from engineering and scientific publications.

The primary endeavor was to allocate physical volumes of pollutants to the proper economic sectors as categorized by the Input-Output study [38]. Such allocation required a great deal of effort to systemize and analyze diverse aggregate data. In what follows, a schematic outline of the methods and procedures undertaken is discussed in detail. The analysis is focused on the three main categories of pollutants, which are:

A. Water Effluents
B. Air Pollution
C. Solid Wastes

The third phase of the study which is the linkage between the economy and the environment will follow techniques adopted by Isard [14] and many others in the area of regional economics.

It is necessary to point out that in order to conform the economic data which are for the year 1972 with the environmental data which are for the year 1977, it was necessary to update the economic data. This was done in order to compute values of pollutants per unit of sales as shown in Section IV.

II. TYPES OF POLLUTANTS AND THEIR POTENTIAL EFFECT ON THE ENVIRONMENT

Many different types of pollutants are discharged into the ecosystem as waste by-products of economic activity. These waste residues are frequently wholly or partially untreated for their harmful effects. Utimately diffused into water, air, and land, the qualitative impact upon human and animal life, as well as non-living inputs to the economic system, will be born largely by future generations. However, recent experiences with hazardous wastes suggest that proliferation of waste residues has already begun to adversely affect living and non-living resources. This section outlines the types and effects of pollutants found in water, air, and land regions of the Mississippi Coastal Zone.

It is important to propose a useful definition of waste for this particular study. In a study of a similar type in the state of Washington [9], waste was defined after posing the following questions:

> When is a material a waste and when is it a by-product? It was decided that if a "waste" material from an industry's main production process is recovered and made into some product in a plant, then this is a by-product. Also, if some material is rejected from the process, but is returned to the process as a new material, then it also is not a waste. However, if a material is rejected from a firm's process and it then is shipped off the premises for disposal or for use or recovery by another firm, this material is deemed a waste product.

This is a broad definition of waste and is perhaps inconsistent with the purpose of this study. It was then decided that waste be defined as the residual disposed into the environment after being treated at a waste treatment facility. That is, if part of the original waste has been treated and deemed unharmful to the environment, it will not be considered as part of the waste residual inventory.

Pollutants in this study can be classified into water effluents, air emissions, and solid waste. What follows is a brief outline and discussi of the major types encountered.

Water Pollution

Specialists in this area categorize water pollutants as chemical, physical, biological and physiological. Water pollutants considered in the study are:

Waste Water	Heavy Metals	Fecal Coliform
PH (Abnormal)	Zinc	BOD (Abnormal)
Temperature (Elevated)	Cadmium	COD (Abnormal)
Chlorine	Iron	Suspended Solids
Nitrogen	Chromium	Settleable Solids
Sulfides	Aluminum	Oil and Grease
Flouride	Copper	Phenols
Phosphate	Nickel	Organic Carbon
	Lead	

Benarde [3] gives a lucid description of the chemical, physical, biological and physiological water pollution as follows:

> The chemical pollutants include both inorganic and organic compounds, such as dairy, textile, cannery, brewery, and paper-mill wastes, ensilage, laundry wastes, manure, and slaughterhouse wastes. These essentially contain proteins, carbohydrates, fats, oils, resins, tars and soaps. If the pollutants are not excessive, they will be stabilized by the self-purification process. If they are excessive, death of fish and offensive odors can result. In addition, such plant nutrients as phosphates, nitrates, and potassium have the ability to aid weed growth and promote algae blooms which further deplete oxygen. Inorganic salts, particularly toxic heavy metals not removed by the standard sewage-treatment process, can produce water unsuitable for industry, irrigation, and drinking.
>
> Biological pollutants include the many types of microscopic animal and plant forms, such as bacteria, protozoa, and viruses that are associated with disease transmission. These come from domestic sewage, farms, and tanneries.
>
> Physiological pollution manifests itself as objectionable tastes and odors. These may be imparted to the flesh of fish, making them inedible, or water itself may become unfit to drink owing to its odor and taste. Odors and tastes occur in water as a

consequence of the presence of inorganic chemicals, and as hydrogen sulfide, or the extensive growth of certain species of algae. Some impart musty odors, while others give fishy, pigpen, spicy, or chemical tastes to it.

Various physical effects, such as foaming, color, turbidity, and increased temperature are also considered forms of pollution.

Elevated temperature also plays a part in water pollution. Water from a nearby stream or river is pumped into a plant to cool a machine or process that normally generates heat. The transfer of heat to the cooling water raises its temperature several degrees. When this heated water is discharged back into the stream or river whence it came, it can disrupt ecological relationships within it. A rise in temperature of only a few degrees can be lethal to a variety of aquatic plant and animal forms, which, like most living things, are sustained only within a narrow temperature range. The death of certain species removes the food supply of species which prey on them; without this food supply they in turn will die or be forced to move downstream. Furthermore, the warmer the water, the less oxygen it will contain; oxygen, as has been pointed out, is vital for the prevention of deterioration. At elevated temperatures all chemical and biological activity proceeds at a more rapid rate than would normally prevail, and this in turn depletes the sensitive oxygen balance of the stream. This series of events can result in the loss of self-purification capacity by altering the stream community.

Air Pollution

In this study, air pollutants considered are:

Nitrogen oxide	Particulates
Sulfur oxides	Aldehydes
Carbon Monoxide	Hydrocarbons

By weight, these substances account for the major discharges of air pollution. In the United States carbon monoxide represents about half, followed by sulfur oxides and hydrocarbons, with particulates and nitrogen oxides representing smaller amounts[22].

Mills [22] gives a description of the major airborne discharges as follows:

Particulates: are small pieces of materials discharged to the air by burning fuel, and by industrial processes. When fuel is burned, small pieces of unburned material pass to the atmosphere. Large particulate discharges result from the burning of a ton of coal or wood, whereas petroleum products and, especially, natural gas generate only small amounts of particulates per ton. Any coal-fired combustion system, whether for space heating or thermal electric generation, discharges particulates. Diesel engines in large trucks, buses, and some cars discharge small amounts of particulates, but internal-combustion engines discharge almost none. After discharge to the atmosphere, particulates disperse according to the wind pattern. Eventually, they fall to earth, mostly within a few miles of the point of discharge. Particulates vary greatly in size, which strongly effect their dispersion, the speed with which they settle out of the atmosphere, and the harm they do to people and property.

Sulfur oxides: most sulfur in the air over urban areas results from human activities, particularly the burning of coal and oil, but also from a variety of industrial processes, especially smelting and refining. Some kinds of coal and oil contain much more sulfur than others. All the sulfur in the fuel at the time of combustion is released during combustion and enters the atmosphere unless captured beforehand. Sulfur oxidizes in the atmosphere and most washes back to earth as dilute sulfuric acid during precipitation. Heating oil used for space heating is a major source of sulfur discharges, as is the heavy oil used in thermal electric generation and in large space-heating units in apartment houses and other large buildings.

Carbon Monoxide: virtually all the carbon monoxide in the atmosphere is discharged by human activities. Most results from burning gasoline in internal-combustion engines, but some results from many industrial processes. Carbon monoxide results from incomplete combustion in internal-combustion engines, and less is discharged the more complete the combustion. Carbon monoxide is an apparently inert gast in the atmosphere; it does not react with other substances there. Yet much of the massive discharge of carbon monoxide in metropolitan areas disappears within a few hours, at a rate apparently not explainable by the circulation of air. It is still something of a mystery what happens to it.

Hydrocarbons: they are discharged from the combustion of fossil fuels, from industrial processes, and from a variety of miscellaneous sources. Among the later are evaporation of industrial solvents and the wearing of motor vehicle tires from driving. Like carbon monoxide, hydrocarbons are the products of incomplete combustion in internal-combustion engines, the largest single source of hydrocarbons. Important natural processes also discharge hydrocarbons, and in much larger quantities than human activities on a worldwide basis. As with sulfur oxides, human activities account for most hydrocarbons in the atmosphere over urban areas. Hydrocarbons are reactive in the atmosphere. Along with nitrogen oxides, they result in the formation of photochemical smog in appropriate climatic conditions.

Nitrogen oxides: they are naturally present in the atmosphere in large volumes. Most nitrogen discharges from human activity are converted to nitrogen dioxide, but human activity accounts for only a minor part of all atmospheric nitrogen dioxide. Virtually all nitrogen discharges from human activity result from combustion of fossil fuels in motor vehicles, space heating systems, and thermal electric plants. Whereas carbon monoxide and hydrocarbons are the products of incomplete combustion, nitrogen oxides are the natural products of combustion. Therefore, procedures to improve the efficiency of combustion reduce carbon monoxide and hydrocarbon discharges, but increase nitrogen oxide discharges. In the atmosphere, nitrogen dioxide is an ingredient in the formation of photochemical smog. Photochemical reactions take place within a few hours of discharge. Nitrogen dioxide that does not take part in photochemical reactions is removed from the atmosphere as aerosols by settling onto the earth and by rain, mostly within three days of discharge.

Solid Waste

Solid wastes include rubbish, refuse, garbage and others. The American Public Works Association [3] classifies these as follows:

Rubbish: Includes combustible items, such as cartons, boxes, paper, grass, plastics, bedding and clothing and non-combustibles, such as ashes, cans, crockery, metal furniture, glass, and bathtubs.

Garbage: Waste resulting from growing, preparing, cooking, and serving food. Included in this category are market wastes. Together they account for approximately 10 percent of the volume of solid waste collected [3].

Refuse: The term has been used to denote all types of waste.

Other types of waste include demolition waste such as bricks, masonry, piping, and lumber and sewage-treatment residue such as septic-tank sludge and solids from the coarse screening of domestic sewage.

For more information regarding water and air pollution and solid waste, the reader is referred to Bell [2], Benarde [3], Dolan [10], Mills [22], and Zwick and Benstock [53].

III. METHODOLOGIES FOR ESTIMATING PHYSICAL QUANTITIES OF POLLUTANTS MISSISSIPPI COASTAL REGION

A. Water Effluents

Water effluent loadings were derived basically from 1977 waste water treatment facility printouts provided by the Mississippi Air and Water Pollution Control Commission (MAWPCC)[23]. For estimation purposes the 30 endogenous and exogenous sectors of the updated input-output model were divided into the four categories listed below to conform with printout classifications and effluent type. The data were the primary source for all categories except Agriculture. To estimate household and commercial water wastes, the use of secondary data was necessary.

Water Effluent Categories
Effluent Type and Data Sources
Mississippi Coastal Region

Category	Sector	Major Effluent Type	Source(s)
Agricultural	1-5	Irrigation	U.S. Census of Agriculture
Industrial	6-17; 20	Industrial Process Waste	MAWPCC
Commercial	18-19; 21-29	Waste Water Sewage	MAWPCC & Secondary
Households	30	Waste Water Sewage	MAWPCC & Secondary

A waste water treatment facility is classified as industrial, municipal, or private. The industrial facilities, also called "package plants," process waste water from specific firms which hold state permits. Under 1977 permit stipulations, effluents produced by firms as consequences of their production processes were identified and monitored periodically at "discharge points" to determine compliance with the standards. However, some manufacturers utilize city facilities which are neither municipal nor private and as such are not monitored. This is a particular problem for large, privately-owned industrial parks. Thus, it was necessary to provide estimating procedures of water effluents for such firms. The municipal and private facilities, on the other hand, process waste water sewage of commercial establishments, shopping centers, apartment complexes, schools, and private households. A few monitored municipal facilities, however, do receive wastes from manufacturing firms, usually because of geographical proximity. Such instances required a knowledge of specific loadings by the firm since facilities rather than firms usually hold the necessary permits.

Industrial Water Effluents

Factory printouts for manufacturing firms in the Mississippi coastal region were classified by product into SIC categories corresponding to their respective input-output sector groupings, a sector being one or more industries [29]. Three sectors not conventionally classified as manufacturing --Mining, Construction, and Communications/Public Utilities-- were included with manufacturing simply because they were monitored in the same fashion.

The level of information obtained from the printouts for each firm in the coastal region was gathered as illustrated in the following to yield net estimates of effluent weights in pounds and million gallons of waste water entering the environment after treatment. In addition, data on PH and temperature were recorded. Monthly sample observations per discharge point in units of weight (pounds) or concentration (milligrams per liter) were converted to yearly estimates, assuming a 300 day industrial year [39]. Sample data were published as a range from minimum to maximum with the average reading taken where possible [8]. The weights in pounds were obtained directly as daily averages and were then converted to an annual basis. Measurements that were given as milligrams per liter (MG/L) required an indirect conversion to pounds by the following formula for a given effluent and firm:

(1) Pounds/day = MG/L x 8.34 x Flow Rate

where:
MG/L = Milligrams per liter
8.34 = Conversion factor
Flow Rate = Million gallons water per day

The technique followed is illustrated by the following example for a hypothetical firm A. Assume that the BOD discharge is given in pounds and suspended solids are recorded as 29.98 MG/L for all months at the discharge point. Further assume that only three months are sampled for this hypothetical firm. Biological oxygen demand (BOD) and flow rate (waste water) are averaged and converted to yield 33,000 pounds and 150 million gallons per year, respectively, as follows:

$$\left(\frac{100 + 110 + 120}{3}\right) \text{ lbs. x 300 days = 33,000 lbs./year}$$

and

$$\left(\frac{.5 + .4 + .6}{3}\right) \text{ MGY x 300 days = 150 MGY.}$$

To convert suspended solid concentration to pounds, Equation 1 is applied to 29.98 MG/L and each corresponding flow rate to yield an average of 125 pounds per day as shown in the computations below. The daily average is then converted to an annual quantity of 37,500 pounds.

Suspended solids = (29.98) (8.34) (.5) + (29.98) (8.34) (.4) + (29.98) (8.34) (.6)
Total per day = 125 + 100 + 150 = 375
Average per day = 375 ÷ 3 = 125

and hence,

The total is 125 x 300 = 37,500 lbs.

Hypothetical Firm Worksheet
Water Effluents

Firm A

Water Effluent and Other:	Month 1	2	. . .	12	Average Per Day	Total Per Year
BOD-5 day (lbs)	100.00	110.00	. . .	120.00	110 lbs.	33,000 lbs.
Sus. Solids (MG/L)	29.98	29.98	. . .	29.98	125 lbs.	37,500 lbs.
PH	7.00	6.00	. . .	8.00	7 SU	7 SU*
Flow Rate (MGD)	.50	.40	. . .	.60	.5 MGD	150 MGY

*SU = Scientific units

If a firm had more than one discharge point, all discharge points were summed to give total firm loadings. Total firm outputs of water effluents were then compiled on sector worksheets such as shown in the following figure. For example, BOD discharges by Firm A added to all other firms in Sector 1 total 183,000 pounds.

Hypothetical Sector Worksheet
Water Effluents
Sector 1

Firm	Employment	BOD (lbs)	Suspended Solids (lbs)	PH(SU)*	Flow Rate (MGY)
A	50	33,000	37,500	7	150
B	100	60,000	60,000	6	100
C	150	100,000	80,000	8	150
Total	300	183,000	170,000	7	300

*SU = Scientific units

For manufacturing firms which dump their wastes into monitored municipal facilities rather than their own it was necessary to identify and allocate their proper effluent loadings from the total commercial and household wastes of the facility. The resulting effluent quantities were then entered on manufacturing worksheets and processed as if monitored separately. Facility worksheets then consisted of purely non-manufacturing wastes, that is, commercial and household. This procedure was particularly essential in the Food Processing sector, requiring primary data collected in the field.

Many data problems were encountered when processing the printouts, often necessitating less than optimal solutions. Missing or incomplete data were handled in a variety of ways. For example, many firms with a permit printout had no effluent sample results but did list maximum allowable permit conditions. Unpublished data provided by the MAWPCC and regional research and development center often determined whether to base estimation of the unknown firm's pollution upon allowable permit ranges or to omit the firm and estimate later. Estimations based upon permit conditions were generated with Equation 2. Maximum conditions were used because few average permit conditions were listed.

(2) $$E_e = \frac{A_k}{M_k} \times M_u$$

where:

E_e = Effluent estimation based on allowable permit conditions
A_k = Actual reported effluent value of known firms
M_k = Maximum allowable permit value of known firms
M_u = Maximum permit value of unknown firm

Some firms contained extensive effluent concentrations (MG/L) but no flow rate to convert to pounds. In such instances an average flow rate per employee was developed from similar firms in the sector and applied to known average annual employment. Some firms not listed in the manufacturer's directory were monitored. These firms were processed if employment data and SIC products were available. The inclusion of these firms tended to balance out those listed firms which were not monitored.

After the data in all sectors were processed, a measure of the adequacy of the regional samples was undertaken as shown in Table 1. The percent of total firms and total employment covered in each manufacturing sector suggested that data supplementation was needed. Although 76 percent of employment was covered, one particular firm in the Transportation Equipment Sector accounted for over 60 percent of total regional manufacturing employment. Omitting this one firm resulted in only 16 percent of employment being covered.

On a sector-by-sector basis half had less than 50 percent coverage and three had no coverage. Thus, two types of supplementation were needed: sector and product. Sector supplementation was required for extremely low coverage of all products such as the Apparel sector. Product supplementation sought to give coverage to specific categories of products produced in the region but not by firms in the regional sample, for example, Food Processing.

The idea is to simulate the unaccounted region with data of similar firms producing similar products in other parts of Mississippi and monitored with a common sampling procedure. In using the non-regional supplementary data, the assumption is made that similar firms have similar patterns of waste loadings [25].

To select the supplementary data, lists of all Mississippi coastal firms in each sector and their respective SIC products were compared to the firms and products of the regional sample. Using firm employment and product coverage, the degree of supplementation was ascertained. For example, the Apparel sector required total sector supplementation. The Food

TABLE 1

PERCENT COVERAGE OF MAWPCC REGIONAL SAMPLE
INDUSTRIAL CLASSIFICATION SECTORS
Mississippi Coastal Region
1977

Sector	Sector Number	Firms in Regional Sample[a]	Total Regional Firms[b]	Percent Firms Sampled	Employment In Regional Sample[a]	Total Regional Employment[b]	Percent of Coverage
Manufacturing:							
Food Processing	8	20	35	57	1,591	2,153	62
Apparel	9	0	12	0	0	1,745	0
Lumber-Wood	10	2	9	22	129	398	32
Paper-Allied	11	1	1	100	1,326	1,326	100
Printing-Publ.	12	0	11	0	0	433	0
Chemicals Petro.	13	7	14	50	1,834	2,023	91
Stone, Clay, Glass	14	2	13	15	460	762	60
Prim.-Fab. Metals	15	3	33	9	267	3,351	13
Transp. Equip.	16	1	19	5	22,000	23,033	96
Misc. Mfg.	17	0	34	0	0	1,090	0
Total Mfg.		36	181	20	27,607	36,314	76
Non-Manufacturing:							
Mining	6	1	7	14	5	220[c]	2
Construction	7	1	NA	-	NA		-
Comm. Pub. Util.[d]	20	1	2	50	NA	NA	-

[a] [23]
[b] [29]
[c] [27]
[d] Includes power generating plants only.

Processing sector, though with over 50 percent coverage in the regional sample, contained effluent data only from seafood processors. In order to give a more accurate sector profile, firms with categories such as beverages and bread were needed. Thus, bottlers and bakeries in other areas of Mississippi were added to the regional sample as supplementary data. The regional research and development office and engineering experts as well as the manufacturer's directory were instrumental in selecting non-regional firms to include in the supplementary sample.

Selected non-regional firms were then processed on worksheets in the same manner as regional firms. Total sector poundage of water effluents was estimated by adjusting the regional quantities to correspond to total area employment, utilizing both regional and selected non-regional data when necessary. The computational procedure summarized in Equation 3 implies a proportion of the mean taken from the regional and non-regional samples for the supplementary data. Average effluent per employee $\bar{X}$ of the supplementary sample was weighted by the factor $\frac{n_1}{n_1 + n_2}$ corresponding to regional sample employment and a factor $\frac{n_2}{n_1 + n_2}$ corresponding to non-regional sample employment.

$$\bar{X} = \frac{\sum_{i=1}^{n_1} X_{1i} + \sum_{i=1}^{n_2} X_{2i}}{n_1 + n_2} = \frac{n_1}{n_1 + n_2}\bar{X}_1 + \frac{n_2}{n_1 + n_2}\bar{X}_2 \qquad (3)$$

where:

$\bar{X}$ = Average effluent/employee, supplemental sample (lbs/emp)
n_1= Regional sample employment
n_2= Non-regional sample employment
$\bar{X}_1$= Regional effluent/employee, supplemental sample (lbs/yr)
$\bar{X}_2$= Non-regional effluent/employee, supplemental sample lbs/yr)

Total industrial sector water pollution X was computed as shown in Equation 4. Estimated tonnage of the uncovered sector is equal to $N\bar{X}$. Thus, the actual tonnage of effluent A obtained from the regional sample was added to the estimated tonnage of the uncovered sector $N\bar{X}$ obtained in Equation 3.

(4) $$X = A + N\bar{X}$$

where:

A = Actual tonnage from regional MAWPCC sample
N = Sector employment not covered by regional sample
$\bar{X}$ = Average effluent/employee, supplementary sample

Agricultural Water Effluents

Important water effluents for the agricultural sectors should include fertilizers, irrigation residues, pesticides, and sediment [44]. However, there is little data available on area source pollution (agriculture) in a useable, quantifiable form at the national or state level, and almost none at the county level. Similar studies, even in agricultural-intensive regions, also encountered severe data problems [4], [16], [17]. The usual practice was to enter zeros even if it was known that some quantity is generated.

It was discovered that agricultural pollution in the Mississippi Coastal Zone is relatively insignificant [25]. Small quantities of pesticides and toxic chemicals run off, especially in the upper Pascagoula River in Jackson County. There is also some murkiness of water caused by the sandy soil. Agricultural activity in the coastal area, including fisheries, comprised only one percent of total estimated output in 1977 (see Appendix A) and is not in close proximity to urban centers. The potential for natural absorption by the environment is somewhat enhanced. Thus, it was felt that little accuracy is sacrificed by omitting some categories of agricultural water pollution. However, total irrigation water in acre feet was converted to gallons and entered as waste water flow for the Crops Sector.

Commercial and Household Water Effluents

Commercial and household effluents are primarily waste water sewage and were provided on municipal and private printouts [23]. Effluent loadings for 24 available printouts were processed and compiled on worksheets in a similar manner as the industrial sectors. However, 71 smaller facilities had no available printout and required indirect estimation of annual waste water flow with unpublished data. Hence, published and unpublished data were the source of information to estimate in millions of gallons total commercial and household waste water flow. Total household waste water flow was then estimated using average per capita data. Subtracting this total from the combined commercial and household flow, the remaining amount gives an estimate of the total annual commercial sector waste water, as shown below:

9,623.635 MGY	Printout and non printout facility water flows[a]
-5,205.740 MGY	Household water based on per capita data[b]
=4,417.895 MGY	Commercial waste water flow

[a] [23], [24]
[b] See Households, Appendix B

Total commercial waste water flow of 4,417.895 million gallons per year was allocated among its respective eleven sectors (18-19, 21-29) based on engineering factors such as those shown in Table 2. The final column of Table 2 is based on the assumption that approximately 80 percent of total water usage is waste water and 20 percent is either consumed or recycled [25]. When specific engineering units were not available, for instance, store frontage feet, other measures such as per capita waste water were applied to sector employment.

After allocating all quantities of commercial waste water among the commercial sectors, effluent quantities per commercial sector were derived by applying Equation 1 to domestic sewage concentration factors as shown in Table 3. These particular effluents were chosen because they appeared consistently on the printouts for sewage treatment faciltiies. The final column shows the ultimate load to the environment by subtracting the 85 percent of effluent that is cleaned at the treatment facility before entering the environment. Medium concentration was chosen because the Mississippi Coastal Zone is between medium and weak levels, but more toward the medium range [25]. Chlorine and fecal coliform were not listed in the engineering

TABLE 2

SELECTED ESTIMATED WATER CONSUMPTION
AT COMMERCIAL ESTABLISHMENTS
MEDIUM CONCENTRATIONS
(Gallons per day)

Type of Establishment	Unit	Total Water Flow Rate: gpd/unit[a]	Waste Water Flow Rate: gpd/unit[b]
Service Stations	Pump	500	400
Restaurants (avg.)	Person	7-10	5.6-8
Stores	25 Ft. Front	450	360
Hotels	Room	50-100	40-80
Motels	Room	100-150	50-120
Hospitals	Room	150-250	120-200
Schools	Pupil	15-20	12-16
Institutions (avg.)	Room	75-125	60-100
Offices	Office	10-15	8-12

[a] [20]
[b] [25]

TABLE 3

TYPICAL EFFLUENT COMPOSITION OF DOMESTIC SEWAGE
SELECTED VALUES
(Concentrations in Milligrams Per Liter)

Effluent	Medium Concentration[a]	Net Concentration After Treatment[b]
BOD	200	30
Suspended Solids	200	30
Nitrogen	40	6
Oil and Grease	100	15
Chlorine[c] (lbs)	---	3.478 /MGY
Fecal Coliform (#/ML)[c]	---	2.80 /MGY

[a] [20]
[b] [25]
[c] Chlorine and fecal coliform were estimated in pounds and number per milliliter (#/ML) per million gallons of waste water, respectively, from available MAWPCC sewage facility printouts.

table and had to be estimated from facility printouts in pounds and number per milliliter (#/ML) per gallon of waste water, respectively, by dividing total facility water flow by total facility effluent.

At this point we have quantities of effluent loadings and waste water for all commercial sectors and waste water flow for the Household sector. To identify effluent loadings of households, total printout and non-printout estimates of facility loadings were summed to yield combined effluent magnitudes for commercial and household sectors. Categories of effluents for all commercial sectors were then summed and subtracted from their corresponding regional effluent control totals to allocate household effluent quantities.

B. Air Emissions

Quantities of air pollutants were derived from national data and from studies of similar areas because localized data were unavailable. For estimation purposes the 30 economic sectors of the Mississippi coastal model were divided into non-household and household categories to best utilize available data within time and budgetary constraints. The household category, consisting of sector 30, was estimated with emission factors published by the Environmental Protection Agency [50], [51]. The non-household category includes sectors 1-29 and was estimated by adapting to the Mississippi coastal region the air pollution coefficients derived in regions of South Carolina [16]. Adjustments using engineering and technical information were necessary at times to complement the estimates obtained.

The South Carolina data were based on a pioneering study by Peter Victor, which, in turn, was derived from the EPA emission factor study [52]. Thus, both household and non-household data were based utimately upon EPA emission factors.

Household Category

Household air pollution is composed primarily of emissions from privately-owned automobiles and trucks. The Mississippi State Motor Vehicle Comptroller's Office provided automobile registrations and other data which allowed EPA emission factors to be applied to the Mississippi Coastal Zone [32].

Other regional data such as average ambient coastal temperature and vehicle model year distribution were obtained from a variety of secondary sources and applied to EPA emission factor tables to compute the parameters of the emission formula shown in Equation 5. Every effort was made to obtain data which simulated actual conditions of the Mississippi coastal region. Of course, when no regional data were available, documented national data had to be substituted. Total pollutant in grams per mile was converted to tons per year based upon miles traveled per vehicle model year using the estimated parameters of Equation 5.

(5) $$E_{npstu} = \sum_{i=1}^{n} C_{ipn} \times M_{in} \times V_{ips} \times Z_{ipt} \times R_{iptw}$$

where:

E_{npstu} = Composite emission factor in grams per miles traveled for calendar year n, pollutant p, average speed s, ambient temperature t, and percent of cold operation u,

C_{ipn} = Mean emission factor for the i^{th} model year, during calendar year n, and pollutant p,

M_{in} = Fraction of annual travel by i^{th} model year during calendar year n,

V_{ips} = Speed correction factor for i^{th} model year vehicle, pollutant p, and average speed s,

Z_{ipt} = Temperature correction factor for i^{th} model year vehicle, pollutant p, and ambient temperature t,

R_{iptw} = Hot-cold vehicle operation factor for i^{th} model year vehicle, pollutant p, ambient temperature t, and percentage of cold operation w.

Non-Household Categories

Non-household air pollution includes industrial and commercial process pollution as well as vehicle emissions. Sectors in the South Carolina study were compared and grouped to correspond with the 29 Mississippi sectors. When sectors correspond exactly, e.g., Mining, the South Carolina coefficients were incorporated directly into the Mississippi model.

When the Mississippi input-output study contained more sectors than corresponding South Carolina categories, the latter's coefficients were multiplied by each Mississippi sector's proportion of total output in the sector category. The estimated Mississippi air coefficient thus derived in weight per dollar was then converted to tons by multiplying tons per dollar by total Mississippi sector output.

When the South Carolina study contained more sectors in a given sector category than the Mississippi coastal model, total tonnage of pollutant was estimated as shown in Equation 6. Total tonnage per each South Carolina sector in the Mississippi category was found by multiplying tons per dollar of output by South Carolina sector output. Total tonnages per South Carolina sector thus derived were summed to give total tons of pollutant (T_s) for South Carolina sectors in the Mississippi input-output category. Total dollar output per South Carolina sector was summed to yield total output (O_s). The product of South Carolina tonnage and 1977 Mississippi sector dollar output (O_m) was divided by total South Carolina sector output (O_s) to give estimated Mississippi tonnage.

(6)
$$X = \frac{T_s O_m}{O_s}$$

where:

X = Estimated tons of pollutant in Mississippi
T_s = Tonnage of South Carolina sectors
O_m = Dollar output of Mississippi sector
O_s = Dollar output of South Carolina sectors

Comparisons with unpublished data indicate a fair level of accuracy using this procedure. Some minor adjustments were made, however, and some known pollutant quantities not previously listed were added.

C. Solid Waste

Solid waste was estimated primarily from per-capita solid waste factors published in a detailed engineering study [42]. Examples of the types of data used are given in Table 4. Appropriate solid waste factors in pounds were multiplied by corresponding units, many of which were the same types used in estimating waste water flows.

TABLE 4

APPROXIMATE SOLID WASTE GENERATION RATES
SELECTED CATEGORIES[a]

Source of Waste	Unit	Pounds per day/ Unit
Schools, general	Pupil	2.1
Hospital	Bed	8.0
Hotel, medium class	Room	1.5
Restaurant	Meal	2.0
Food Processing[b]	Employee	131.73
Lumber and Wood[b]	Employee	534.33
Paper and Allied	Employee	13.33
Transportation Equip.	Employee	8.67

[a] [42]
[b] Average of sub-categories.

For sectors in which listed waste factors were not practically available, more general factors such as those shown in Table 5 were used. Agricultural waste factors (Livestock) in wet tons per year were adjusted for dry weight. Household solid waste was derived by applying waste factors of the appropriate coastal population density to estimated 1977 Mississippi coastal population.

TABLE 5

AVERAGE SOLID WASTE COLLECTED
SELECTED CATEGORIES
(Pounds per day per person)

Solid Waste Type	Urban	Rural	National
Commercial	.46	.11	.38
Industrial	.65	.37	.59
Construction	.23	.02	.18
Miscellaneous	.38	.08	.31

Source: [42]

IV. THE ENVIRONMENTAL MODEL
MISSISSIPPI COASTAL REGION

The basic structure of the environmental matrix for the coastal region of Mississippi is shown in Table 1. It contains 29 rows representing the endogenous sectors, that is, the economic producing sectors of the region. Households, the last row, is the exogeneous sector representing pollutants by non-producers. It also contains thirty columns. The first column headed Waste Water is water partially treated or non-treated which is dumped into the environment as a consequence of the economic process. The other 29 columns are net unpriced loadings of water effluents, air emissions, and solid waste from the area's economy into the environment. The units of measurement differ but, when appropriate, were given in tons per year. The coefficients in the table represent values estimated for the year 1977.

The data used to compile the coefficients in the matrix were obtained from various sources. The primary source of data for water pollution was computer printouts provided by the Mississippi Air and Water Pollution Control Commission. Other coefficients were obtained from several sources. For instance, air pollution tonnages were primarily obtained, after adjustments, from work obtained from unpublished sources, telephone surveys and engineering information.

Methodologies and techniques by which these values were obtained are given in Section III. A full description of actual calculations based upon the methodology is detailed in Appendix B. Hence, every value that appears in Table 1 has its justification in that appendix.

By weight, there were approximately 16,000 tons of water pollutants, 114,000 tons of air emissions, and 407,000 tons of solid waste dumped into the environment totalling 537,000 tons. Also included was approximately 369 billion gallons of waste water. Portions of these pollutants were contributed directly as by-products of the economic activities and other portions by households as part of the consumption process, as shown in Table 1.

It should be pointed out that the coefficients for PH, temperature, and fecal coliform which appear in Table 1 are measurements of concentration, and hence meaningless if aggregated. They were provided for completeness and should be interpreted with special care.

An examination of Table 1 reveals that some producing sectors have no environmental data. The reason for these omissions is the unavailability of data either in published form or the impossibility of obtaining information directly, or it might be that the sector does not contribute much of some particular pollutant. Such omissions will cause bias when the linkage of the economic and environmental models is executed, resulting in an underestimation of the economic impact upon the environment.

A ranking of pollutants according to economic criteria as represented by the producing sectors is presented in Table 2. The information in this table provides a basis for identifying and comparing the sectors in terms of their relative importance in generating volumes of pollutants. For instance, in the ranking for nitrogen, Food Processing (Sector 8) is ranked highest among the producing sectors in its contribution. The lowest contributor is Finance, Insurance and Real Estate (Sector 24).

Table 3 gives the volume of pollutants per $10,000 of production.

Each entry in the table represents the magnitude of pollutants per each $10,000 produced. For instance, the Food Processing sector contributes .706 million gallons of waste water, .001 tons of chlorine, .023 tons of nitrogen, .044 tons of BOD, .076 tons of suspended solids, .04 tons of settleable solids, .02 tons of oil and grease., .015 tons of nitrogen oxide, .076 tons of sulfur oxides, .001 tons of carbon monoxide, .008 tons of particulates, .001 tons of aldehydes, .001 tons of hydrocarbons, and 3.988 tons of solid waste for each $10,000 produced during one year.

In this manner, a comparison can be made among sectors in terms of the production of pollutants per unit of sales, a unit being defined as $10,000 of output. It is necessary to mention here that the values given in the table represent the "direct" environmental effect of $10,000 of sectoral sales. The "secondary" environmental effects resulting from the interindustry sales and purchases will be given in the subsequent report.

Table 4 ranks the producing sectors in terms of the environmental factors for each $10,000 of sales. For instance, Sector 8 produces more nitrogen per $10,000 of sales than Sector 10, and Sector 10 in turn produces more nitrogen per $10,000 of sales than Sector 28, and so on.

A cursory look at Table 2 and Table 4 will reveal that the two types of ranking give different results. In Table 2, the ranking is based upon total magnitudes, while in Table 4 it is based upon a unit of production, $10,000 of output.

Table 5 gives a review of each pollutant separately. For each pollutant, the five top sectors that contributed the highest direct loadings are specified and the results displayed as percentages. For each of the residuals, the top five contributors accounted for the majority.

Some residuals, as indicated in Table 5, are shown to be contributed by one sector, for instance, flouride, having the sole contributor as

Chemicals and Petroleum, and similarly for heavy metals and sulfides. The proper interpretation is that in these cases, either data were available only for that particular sector or it is in fact the only or major contributor of that residual.

TABLE 1

PHYSICAL QUANTITIES OF WATER EFFLUENTS,
AIR POLLUTION, AND SOLID WASTE
MISSISSIPPI COASTAL REGION
1977

Sector Number	Sector Name	Waste Water (MGY)	PH (Scientific Unit)	Temperature (°Farenheit)	Chlorine (Tons/yr)	Nitrogen (Tons/yr)	Sulfides (Tons/yr)	Flouride (Tons/yr)	Phosphate (Tons/yr)
1.	Fisheries								
2.	Forestry								
3.	Livestock Products								
4.	Crops & Agricultural	175.634							
5.	Ag, Forestry, Fish Svc.								
6.	Mining	633.600							
7.	Construction	759.000	7.1						
8.	Food Processing	7,534.839	7.5	74.9	4.372	245.560			
9.	Apparel & Finished	328.634	7.5	74.0	.135	2.246			
10.	Lumber & Wood	311.268	6.9	63.3		12.979			
11.	Paper & Allied	7,245.000	7.1	82.0					
12.	Printing & Publishing	6.495							
13.	Chemical & Petro. & Other	12,874.239	7.8	69.8		153.936	1.811	256.363	
14.	Stone, Clay & Glass	3,240.408	8.5	76.5	.010				
15.	Primary & Fab. Metals	1,458.868	7.9	80.0	.777	17.983			7.004
16.	Transportation Equip.	324,804.460	7.6	82.7	1.586				.271
17.	Miscellaneous Equip.	86.848	7.9	71.2	.028	.919			
18.	Water Transportation	17.500			.031	.438			
19.	Other Transportation	10.335			.018	.259			
20.	Communication & Pu.Utl.	44.832	7.8		.002				
21.	Eating and Drinking	298.636			.519	7.472			
22.	Service Stations	102.600			.179	2.568			
23.	Wholesale & Retail	212.670			.370	5.321			
24.	Finance, Ins.& Real Est.	5.685			.010	.142			
25.	Hotel, Motel, Lodging	61.628			.107	1.542			
26.	Medical Services	120.421			.210	3.013			
27.	Educational Services	173.364			.302	4.317			
28.	Other Services	3,385.135			5.887	84.696			
29.	State & Local Gov't.	29.910			.053	.749			
30.	Households	5,205.740			8.943	136.383			
	TOTAL	369,127.735			23.539	680.523	1.811	256.363	7.275

MGY = Million gallons per year.

TABLE 1 (Cont)

PHYSICAL QUANTITIES OF WATER EFFLUENTS,
AIR POLLUTION, AND SOLID WASTE
MISSISSIPPI COASTAL REGION
1977

Sector Number	Heavy Metals (Tons/yr)	Zinc (Tons/yr)	Cadmium (Tons/yr)	Iron (Tons/yr)	Chromium (Tons/yr)	Aluminum (Tons/yr)	Copper (Tons/yr)	Nickel (Tons/yr)	Lead (Tons/yr)	Fecal Coliform (#/ML)
1										
2										
3										
4										
5										
6										
7										
8										1,926,425.279
9		.671			.671					
10										
11										
12										
13	13.081		.576	46.498	.626					7,069.778
14										
15		.869	1.508	2.907	.431	7.429	.778	1.736		
16		2.168			.109					24,041.845
17		.009		.006	.013				.077	5,752.584
18										49.000
19										28.938
20				.003			.001			4,440.405
21										836.181
22										287.280
23										595.476
24										15.918
25										172.559
26										337.179
27										485.419
28										9,476.378
29										83.748
30										14,417.008
TOTAL	13.081	3.717	2.084	49.414	1.850	7.429	.779	1.736	.077	

ML = Milliliter

TABLE 1 (Cont)

PHYSICAL QUANTITIES OF WATER EFFLUENTS,
AIR POLLUTION, AND SOLID WASTE
MISSISSIPPI COASTAL REGION
1977

Sector Number	BOD (Tons/yr)	COD (Tons/yr)	Suspended Solids (Tons/yr)	Settleable Solids (Tons/yr)	Oil & Grease (Tons/yr)	Phenols (Tons/yr)	Organic Carbon (Tons/yr)	Nitrogen Oxide (Tons/yr)	Sulfur Oxides (Tons/yr)
1									
2									
3									
4									
5									
6			113.302						189.[illegible]
7			143.290						
8	467.941		812.232	423.188	209.382			160.014	810.204
9	6.760		20.885					188.576	143.200
10	41.284		68.110		7.727	.160		8.394	54.393
11	473.000		1,383.000					83.874	543.504
12									.273
13	230.190	665.498	607.011		116.628	.314	52.836	3,526.913	1,600.000
14	36.655		632.101		12.902			117.970	203.310
15	.051		34.469		16.951			77.500	77.702
16	36.655		47.370		.703			2,306.791	116.658
17	2.117		5.613		1.161	.002		191.053	148.027
18	2.190		2.190		1.095			91.599	
19	1.293		1.293		.647			128.768	
20	.019		7.965		.170			9.083	40,000.000
21	37.359		37.359		18.680				
22	12.836		12.836		6.418			8,813.096	427.640
23	26.606		26.606		13.303				
24	.711		.711		.356				
25	7.710		7.710		3.855				
26	15.065		15.065		7.533				
27	21.689		21.689		10.844				
28	423.480		423.480		211.740				
29	3.742		3.742		1.871				
30	664.920		5,367.271		320.961				
TOTAL	2,512.273	665.498	9,795.300	423.188	962.927	.476	52.836	15,703.631	44,313.917

TABLE 1 (Cont)

PHYSICAL QUANTITIES OF WATER EFFLUENTS, AIR POLLUTION, AND SOLID WASTE MISSISSIPPI COASTAL REGION 1977

Sector Number	Carbon Monoxide (Tons/yr)	Particulates (Tons/yr)	Aldehydes (Tons/yr)	Total Hydrocarbons (Tons/yr)	Solid Waste (Tons/yr)
1					
2		27.133			
3		73.680			23,919.900
4		221.037			
5					
6	14.450	16.762	14.450	14.450	21.450
7					223.500
8	6.934	80.007	6.934	6.934	42,543.280
9	1.179	14.143	1.179	1.179	540.950
10	.448	672.758	.448	.448	3,428.700
11	4.474	500.000	4.474	4.474	2,652.000
12				250.000	212.170
13	7.622	82.567	7.623	381.077	17,148.971
14	1.632	1,091.850	1.632	1.632	1,828.800
15	.698	300.000	.698	.698	43,060.350
16					29,942.900
17	11.246	31.014	1.225	1.275	1,100.900
18	140.921	133.874	21.138	28.184	80.523
19	198.104	188.199	29.716	39.621	47.541
20	7.445	2,500.000	74.450	223.349	292.695
21					57,854.160
22	40,160.945	1,115.582		4,834.188	82.524
23		20.000			1,977.570
24					261.441
25					903.870
26					3,010.520
27					13,002.297
28					907.764
29					687.930
30					161,377.920
TOTAL	40,556.098	7,068.606	163.967	5,787.459	407,110.626

TABLE 2

RANKING OF PHYSICAL QUANTITIES OF POLLUTION
CATEGORY BY SECTOR
Mississippi Coastal Region
1977

Rank	Waste Water	Chlorine	Nitrogen	Sulfides	Flouride	Phosphate	Heavy Metals	Zinc	Cadmium	Iron	Chromium	Aluminum	Copper	Nickel
1	16	30	8	13	13	15	13	16	15	13	9	15	15	15
2	13	28	13			16		15	13	15	13			
3	8	8	30					9		17	15			
4	11	16	28					17		20	16			
5	30	15	15								17			
6	28	21	10											
7	7	23	21											
8	6	27	23											
9	15	26	27											
10	9	22	26											
11	10	9	22											
12	21	25	9											
13	14	29	25											
14	23	18	17											
15	4	17	29											
16	27	19	18											
17	26	14,24	19											
18	22	20	24											
19	17													
20	25													
21	20													
22	29													
23	18													
24	19													
25	12													
26	24													
27														
28														
29														

Fecal Coliform is not ranked because it is measured as a concentration rather than an aggregate.

TABLE 2 (Cont)

RANKING OF PHYSICAL QUANTITIES OF POLLUTION
CATEGORY BY SECTOR
Mississippi Coastal Region
1977

Rank	Lead	BOD	COD	Suspended Solids	Settleable Solids	Oil and Grease	Phenols	Organic Carbon	Nitrogen Oxide	Sulfer Oxides	Carbon Monoxide	Parti-culates	Alde-hydes	Hydro-carbons	Solid Waste
1	17	30	13	30	8	30	13	13	22	20	22	20	20	22	30
2		11		11		28	10		13	13	19	22	19	13	21
3		8		8		8	17		16	8	18	14	18	12	15
4		28		14		13			17	11	6	10	6	20	8
5		13		13		21			9	22	17	11	13	19	16
6		10		28		15			8	14	13	15	8	18	3
7		21		7		23			19	6	20	4	11	6	13
8		14,16		6		14			14	17	8	19	14	8	27
9		23		10		27			18	9	11	18	17	11	10
10		27		16		10			11	16	14	13	9	14	26
11		26		21		26			15	15	9	8	15	17	11
12		22		15		22			20	10	15	3	10	9	23
13		25		23		25			10	12	10	17		15	14
14		9		27		29						2		10	17
15		29		9		17						23			28
16		18		26		18						6			25
17		17		22		16						9			29
18		19		20		19									9
19		24		25		24									20
20		15		17		20									24
21		20		29											7
22				18											12
23				19											22
24				24											18
25															19
26															6
27															
28															
29															

TABLE 3

QUANTITIES OF POLLUTANTS PER $10,000 OUTPUT
MISSISSIPPI COASTAL REGION
1977

Sector	Waste Water (MGY)	Chlorine (Tons)	Nitrogen (Tons)	Sulfides (Tons)	Flouride (Tons)	Phosphate (Tons)	Heavy Metals (Tons)	Zinc (Tons)	Cadmium (Tons)	Iron (Tons)	Chromium (Tons)
1											
2											
3											
4	.410										
5											
6	.548										
7	.031										
8	.706	.001	.023								
9	.139	*	.001					*			*
10	.278		.012								
11	.648										
12	.008										
13	.507		.006	*	.010		.001		*	.002	*
14	1.291	*									
15	.105	*	.001			.001		*	*	*	*
16	4.928	*				*		*			*
17	.028	*	*					*		*	*
18	.006	*	*								
19	.003	*									
20	.003	*								*	
21	.092	*	.002								
22	.098	*	.002								
23	.009	*	*								
24	*	*	*	*							
25	.017	*	*								
26	.028	*	.001								
27	.037	*	.001								
28	.296	.001	.007								
29	.002	*	*								

* Less than .001

TABLE 3 (Cont)

QUANTITIES OF POLLUTANTS PER $10,000 OUTPUT
MISSISSIPPI COASTAL REGION
1977

Sector	Aluminum (Tons)	Copper (Tons)	Nickel (Tons)	Lead (Tons)	Fecal Coliform ** (#/ML)	BOD (Tons)	COD (Tons)	Suspended Solids (Tons)	Settleable (Tons)	Oil and Grease (Tons)
1										
2										
3										
4										
5										
6								.098		
7								.006		
8						.044		.076	.040	.020
9						.003		.009		
10						.037		.061		.007
11						.042		.124		
12										
13						.009	.026	.024		.005
14						.015		.252		.005
15	.001	*	*			*				.001
16						.001		.001		*
17			*	*		.001		.002		*
18						.001		.001		*
19						*		*		*
20		*				*		.001		*
21						.012		.012		.006
22						.012		.012		.006
23						.001		.001		.001
24						*		*		*
25						.002		.002		.001
26						.003		.003		.002
27						.005		.005		.002
28						.037		.037		.019
29						*		*		*

* Less than .001 Tons
** Not computed because fecal coliform is measured as a concentration rather than an aggregate.

TABLE 3 (Cont)

QUANTITIES OF POLLUTANTS PER $10,000 OUTPUT
MISSISSIPPI COASTAL REGION
1977

Sector	Phenols (Tons)	Organic Carbon (Tons)	Nitrogen Oxide (Tons)	Sulfur Oxide (Tons)	Carbon Monoxide (Tons)	Particulates (Tons)	Aldehydes (Tons)	Hydrocarbons (Tons)	Solid Waste (Tons)
1									
2						.030			
3						.170			55.900
4									
5									
6									
7									.009
8			.015	.076	.001	.008	.001	.001	3.988
9			.080	.061	.001	.006	.001	.001	.229
10	*		.008	.049	*	.601	*	*	3.064
11			.008	.049	*	.045	*	*	.237
12				*				.321	.273
13	*	.002	.139	.063	*	.003	*	.015	.675
14			.047	.081	.001	.435	.001	.001	.729
15			.006	.006	*	.022	*	*	3.087
16			.035	.002					.454
17	*		.062	.048	.004	.010	*	*	.359
18			.030		.046	.044	.007	.009	.026
19			.035		.054	.051	.008	.011	.013
20			.001	2.686	.001	.168	.005	.015	.020
21									17.866
22			2.138	.410	38.487	1.069		4.633	.079
23						.001			.079
24									.019
25									.254
26									.691
27									2.797
28									.079
29									.040

* Less than .001 Tons

TABLE 4

RANKING OF POLLUTANT QUANTITIES PER $10,000 OUTPUT
CATEGORY BY SECTOR
Mississippi Coastal Region
1977

Rank	Waste Water	Chlorine	Nitrogen	Sulfides	Flouride	Phosphate	Heavy Metals	Zinc	Cadmium	Iron	Chromium	Aluminum	Copper	Nickel
1	16	8	8	*	13	15	13	*	*	13	*	15	*	*
2	14	28	10											
3	8		28											
4	11		13											
5	6		21,22											
6	13		9,15,26,27											
7	4													
8	28													
9	10													
10	9													
11	15													
12	22													
13	21													
14	27													
15	7													
16	17,26													
17	25													
18	23													
19	12													
20	18													
21	19,20													
22	29													
23														
24														
25														
26														
27														
28														
29														

* All sectors less than .001 ton/$10,000.

TABLE 4 (Cont)

RANKING OF POLLUTANT QUANTITIES PER $10,000 OUTPUT
CATEGORY BY SECTOR
Mississippi Coastal Region
1977

Rank	Lead	Fecal** Coliform	BOD	COD	Suspended Solids	Settleable Solids	Oil and Grease	Phenols	Organic Carbon	Nitrogen Oxide	Sulfur Oxides	Carbon Monoxide	Parti-culates	Aldehydes	Hydro-carbons	Solid Waste
1	*		8	13	14	8	8	*	13	22	20	22	22	19	22	3
2			11		11		28			13	22	19	10	18	12	21
3			10		6		10			9	14	18	14	20	13,20	8
4			14		8		21,22			17	8	17	3	9,10,14	19	15
5			21,22		10		13,14			14	13	8,9,14,20	20		18	10
6			13		28		26,27			16,19	9		19		8,9,14	27
7			27		13		15,23,25			18	10,11		11			14
8			26		21,22					8	17		18			26
9			25		9					10,11	15		2			13
10			16,17,18,23		7					15	16		15			16
11					27					20			17			17
12					26								8			12
13					17,25								9			25
14					16,18,20,23								13			11
15													23			9
16																22,23,28
17																29
18																18
19																20
20																24
21																19
22																7
23																
24																
25																
26																
27																
28																
29																

* All sectors less than .001 ton/$10,000.
**Not ranked because fecal coliform is measured as a concentration rather than an aggregate.

TABLE 5

PERCENT OF TOTAL POLLUTANTS
ATTRIBUTABLE TO THE TOP FIVE SECTORS BY POLLUTANT CATEGORY
Mississippi Coastal Region
1977

Waste Water	
Transportation Equip.	88%
Chemicals & Petroleum	4%
Food Processing	2%
Paper & Allied	2%
Households	1%

Nitrogen	
Food Processing	36%
Chemicals & Petroleum	23%
Households	20%
Other Services	12%
Primary & Fabri. Metals	3%

Flouride	
Chemicals & Petroleum	100%

Heavy Metals	
Chemical & Petroleum	100%

Cadmium	
Primary & Fabri. Metals	72%
Chemicals & Petroleum	28%

Chromium	
Apparel & Finished	36%
Chemicals & Petroleum	34%
Primary & Fabri. Metals	23%
Transportation Equip.	6%
Miscellaneous Mfg.	1%

Chlorine	
Households	40%
Other Services	25%
Food Processing	19%
Transportation Equip.	7%
Primary & Fabricated Metals	3%

Sulfides	
Chemicals & Petroleum	100%

Phosphate	
Primary & Fabricated Metals	96%
Transportation Equip.	4%

Zinc	
Transportation Equip.	58%
Primary & Fabricated Metals	23%
Apparel & Finished	18%
Miscellaneous Mfg.	1%

Iron	
Chemicals & Petroleum	94%
Primary & Fabricated Metals	6%
Miscellaneous Mfg.	a
Communications & Pub. Util.	a

Aluminum	
Primary & Fabricated Metals	100%

TABLE 5 (Cont)

Copper

Primary and Fabri. Metals	100%

Lead

Miscellaneous Mfg.	100%

BOD

Households	26%
Paper & Allied	19%
Food Processing	19%
Other Services	17%
Chemicals & Petroleum	9%

Suspended Solids

Households	55%
Paper and Allied	14%
Food Processing	8%
Stone, Clay & Glass	6%
Chemicals & Petroleum	6%

Oil and Grease

Households	33%
Other Services	22%
Food Processing	22%
Chemicals & Petroleum	12%
Eating & Drinking Places	2%

Organic Carbon

Chemicals & Petroleum	100%

Sulfur Oxides

Communications & Pub. Util.	90%
Chemicals & Petroleum	4%
Food Processing	2%
Paper & Allied	1%
Service Stations[b]	a

Nickel

Primary & Fabri. Metals	100%

Fecal Coliform

(Not applicable to concentration)

COD

Chemicals & Petroleum	100%

Settleable Solids

Food Processing	100%

Phenols

Chemicals & Petroleum	66%
Lumber & Wood	34%
Miscellaneous Mfg.	a

Nitrogen Oxide

Service Stations[b]	56%
Chemicals & Petroleum	22%
Transportation Equip.	15%
Miscellaneous Mfg.	1%
Apparel & Finished	1%

Carbon Monoxide

Service Stations[b]	99%
Other Transportation	a
Water Transportation	a
Mining	a
Miscellaneous Mfg.	a

TABLE 5 (Cont)

Particulates	
Communications & Pub. Util.	35%
Service Stations[b]	16%
Stone, Clay, & Glass	15%
Lumber & Wood	10%
Paper & Allied	7%

Aldehydes	
Communications & Pub. Util.	45%
Other Transportation	18%
Water Transportation	13%
Mining	9%
Chemicals & Petroleum	5%

Hydrocarbons	
Service Station[b]	84%
Chemicals & Petroleum	7%
Printing & Publishing	4%
Communications & Pub. Util.	4%
Other Transportation	a

Solid Wastes	
Households	40%
Eating & Drinking Places	14%
Primary & Fabricated Metals	11%
Food Processing	10%
Transportation Equip.	7%

[a] Less than 1%

[b] Service Stations include private automobile emissions by Households (see Appendix B, Households).

V. EVALUATION OF THE MODEL

The purpose of this report is to determine the physical magnitudes of air, water and solid waste pollution generated through the economic activities of the coastal region of Mississippi. This is necessary, as mentioned earlier, for the subsequent stage where the linkage between the economic and environmental parts will be undertaken.

Water effluent information gathered in this report was based primarily upon actual data provided by the Mississippi Air and Water Pollution Control Commission obtained as part of their monitoring of producing establishments. However, other vehicles for collecting data had to be used such as secondary sources published by the Environmental Protection Agency or by incorporating findings of other similar studies. Some information was collected by phone or by personal contacts with engineers and experts in this field.

As is experienced by many regional researches, the problem of availability of necessary data in usable form was also encountered throughout this study. This fact is concisely expressed by Carter [7] who says, "The most common problem encountered in constructing regional economic models is the inadequacy of regional data." However, through painstaking efforts many results were obtained.

It is appropriate to mention that many estimates provided by this report were absent from most comparable regional studies. In this sense, the tables of environmental effluents in Section IV are more comprehensive and complete than many of similar make up.

Due to the shortcomings outlined above, the reader is cautioned to keep in mind the necessary qualifications when interpreting and applying the results of this report.

APPENDICES

APPENDIX A

APPENDIX A

Estimation of Sector Outputs
Mississippi Coastal Region
1977

Because environmental factors are stated in 1977 tons, control total output per sector must be updated to 1977 in order to derive the direct coefficients of the environmental matrix. This is accomplished by applying to 1972 output the estimated increase in employment from 1972 to 1977. Implicit in this procedure is, or course, the assumption that output per employee has not changed over the five year span.

Employment

Because of time lags in government publications, it was not possible to estimate all employment with a data base comparable to that used in the 1972 model. Thus, in order to utilize the most current data in keeping with the magnitudes established in the previous model, the 29 sectors were divided into the following categories: agriculture, manufacturing and non-manufacturing.

Total agriculture employment by category was unavailable as was the case for 1972 data. The rate of increase in the average annual number of agricultural workers based on place of residence from 1972 to 1977 was applied to the proportion of 1972 agricultural sector outputs. The resulting 1977 output estimates are published below in Table 1.

TABLE 1

ESTIMATED CHANGE IN AGRICULTURAL OUTPUT
Mississippi Coastal Region
1972-1977

Sector	1972 Output [a]	Estimated 1977 Output [b]
Fisheries	11,900,000	12,240,000
Forestry	7,900,000	8,126,000
Livestock	4,160,000	4,279,000
Crops	1,582,000	1,627,000
Agriculture, forestry, fisheries, services	1,667,000	1,715,000
Total Output	27,209,000	27,987,000

[a] [38]
[b] [27]

Manufacturing employment is taken directly from the 1978 Mississippi Manufacturers Directory which is the same source used previously to estimate 1972 employment [29]. The researchers feel that it is important to maintain the same data base for the ten manufacturing sectors because of their relatively significant air and water pollution loadings on the environment. The results are published in Table 2.

Non-manufacturing employment was derived in the previous report from several sources to utilize the most accurate estimate consistent with specific sectoral compositions [38]. These data sources, however, were unavailable for year 1977 at the time of the research. An indirect estimation procedure was used by which the estimated change in total non-manufacturing employment is allocated among the sectors according to their relative proportion of 1972 non-manufacturing employment. Again, the assumption of homogeneous regional structure is made.

To derive the estimated change in non-manufacturing employment, simply find the difference between the change in total non-agricultural employment (manufacturing and non-manufacturing) and the change in

TABLE 2

CHANGE IN MANUFACTURING EMPLOYMENT
Mississippi Coastal Region
1972-1977

Sector	1972 [a] Employment	1977 [b] Employment	Absolute Change
Food Processing	2,015	2,153	138
Apparel & Finished Prod.	734	1,745	1,011
Lumber & Wood	556	398	(158)
Paper & Allied Products	1,650	1,326	(324)
Painting & Publishing	334	433	99
Chemicals, Petroleum, & Refining	1,682	2,023	341
Stone, Clay, Glass	528	762	234
Primary & Fabricated Metals	1,328	3,351	2,023
Transportation Equipment	18,299	23,033	4,734
Miscellaneous Manufacturing	1,017	1,090	73
Total Employment	28,143	36,314	8,171

[a] [38]
[b] [29]

manufacturing employment. The Employment Security Commission gave the following average annual non-agricultural employment based on place of work. It is noted that employment based on place of work varied only one percent from employment based on place of residence.

TABLE 3

NON-AGRICULTURAL EMPLOYMENT
Mississippi Coastal Region
1977

County	1972	1977
Hancock	4,260	5,450
Harrison	40,490	46,450
Jackson	38,230	51,470
Total	82,980	103,370

Source: [27]

Employment in 1972 of 82,980, however, differs from the total of 80,897 actually used as a basis for the Mississippi coastal model in the previous report. Also, the change in manufacturing employment is not compiled from a directly comparable source and currently published data are continually revised. Thus, to keep the data consistent with magnitudes used in the model of the previous report, the current data were modified according to the following ratio:

$$\text{Total Non-Agricultural Employment} = \frac{NAP_{72} \times NAB_{77}}{NAB_{72}}$$

where:

NAP_{72} = Total 1972 Non-Agricultural Employment, Previous Report,
NAB_{77} = Total 1977 Non-Agricultural Employment, Benchmarks,
NAB_{72} = Total 1972 Non-Agricultural Employment, Benchmarks.

Substituting the appropriate values yields an adjusted non-agricultural employment of 100,775 in 1977. Using this as a controlling total, the change in both total non-agricultural and manufacturing employment is computed below. The difference between the change in non-agricultural and manufacturing equals the estimated total change in non-manufacturing.

Change in Non-Agricultural	
100,775	1977
- 80,897	1972
19,878	

Change in Manufacturing	
36,314	1977
- 28,143	1972
8,171	

Estimated Change in Non-Manufacturing
19,878
- 8,171
11,701

The estimated change in non-manufacturing employment is allocated among the 14 non-manufacturing sectors as shown in Table 4. The estimated five year change in per sector employment shown in Column (3) is based on each sector's respective 1972 proportion of total non-manufacturing employment Column (2). Final results are shown in Column (4).

TABLE 4

ESTIMATED SECTORAL NON-MANUFACTURING EMPLOYMENT
Mississippi Coastal Region
1977

Sector	(1) 1972 Employment	(2) Proportion of Total Non-Mfg. Employment	(3) Estimated Change in Employment 1972-1977 (2) x (1977 non-Mfg.)	(4) Estimated 1977 Employment (1) + (3)
Mining	180	.003412	40	220
Construction	5,296	.100391	1,175	6,471
Water transportation	955	.018103	212	1,167
Other transportation and warehousing	564	.010691	125	689
Communication and public utilities	2,457	.046575	545	3,002
Eating and drinking places	3,851	.072999	855	4,706
Service stations	979	.018558	217	1,196
Wholesale/retail trade	11,603	.219945	2,575	14,178
Finance, insurance, and real estate	3,101	.058782	688	3,789
Hotels, motels, and lodging	2,524	.047845	560	3,084
Medical services	1,779	.033723	395	2,174
Educational services	539	.010217	120	659
Other services	10,159	.024098	2,389	13,156
State and local government	8,159	.154661	1,811	9,907
TOTAL	52,754	1.000000	11,707	64,461

Output

Output per sector for the year 1977 is estimated in Table 5 by multiplying 1972 output per employee by 1977 estimated employment. Agricultural output for sectors 1-5, which is based on agricultural workers and previous output, is taken directly from Table 1. The Paper and Allied sector experienced a 20 percent decrease in employment as noted in the table. However, the regional R & D office indicated that the implementation of labor-saving equipment has changed the production function of the Paper and Allied sector such that the capital-labor ratio and the total output have increased. Since actual data were unavailable, 1977 output for the Paper and Allied sector is estimated by applying the average percentage change in output by all other regional manufacturing sectors. Other sectors exhibiting an employment drop are considered to have experienced a concomitant output decrease.

TABLE 5

ESTIMATED SECTOR OUTPUT
Mississippi Coastal Region
1977

Sector	Output Per Employee (1972)[a]	Estimated Employment 1977	Estimated Output (Thousands) 1977
Fisheries	NA	NA	12,240c
Forestry	NA	NA	8,126c
Livestock products	NA	NA	4,279c
Crops and agricultural	NA	NA	1,627c
Ag, forestry, fisheries services	NA	NA	1,715c
Mining	52,544.44	220c	11,560
Construction	37,651.06	6,471c	243,640
Food processing	49,547.40	2,153b	106,676
Apparel and finished prod.	13,508.17	1,745b	23,572
Lumber and wood	28,120.50	398b	11,192
Paper and allied	49,113.93	1,326b	111,832d
Printing and publishing	17,973.05	433b	7,782
Chemicals, petroleum, and related	125,581.45	2,023b	254,051
Stone, clay, and glass	32,939.39	762b	25,100
Primary and fabricated metals	41,629.52	3,351b	139,501
Transportation equipment	28,614.73	23,033b	659,083
Miscellaneous mfg.	28,143.56	1,090b	30,676
Water transportation	26,251.31	1,167c	30,635
Other transportation and warehousing	53,244.68	689c	36,686
Communication and public utilities	49,599.77	3,002c	148,899
Eating and drinking places	6,881.07	4,706c	32,382
Service station	8,725.23	1,196c	10,435
Wholesale/retail trade	17,578.64	14,178c	249,230
Finance, insurance, and real estate	35,763.30	3,789c	135,507
Hotels, motels, and lodging	11,516.24	3,084c	35,516
Medical services	20,044.97	2,174c	43,578
Educational services	70,530.61	659c	46,480
Other services	8,683.85	13,156c	114,245
State and local government	17,332.64	9,970c	172,806

[a] [38]
[b] [29]
[c] [27], [38]
[d] Percentage change in output by all other manufacturing sectors multiplied by Paper and Allied output of 1972. See Text.

APPENDIX B

APPENDIX B

Estimation of Physical Pollutant Quantities Per Sector

This appendix summarizes the estimating techniques used to derive pollutant quantities in physical units for each economic sector listed in Table I of Section IV. Many detailed calculations are enumerated and documented according to methodologies presented in Section III. Rather than repeat equations and actual technical data, reference is made frequently to the section from which equations and data were taken. Tables in Appendix B are not numbered because they refer only to specific sectoral computations.

Sectors are discussed in SIC categorical order as in the input-output model. Pollutant categories for each sector are treated in the following order: (1) water effluents, (2) air emissions, and (3) solid waste. All pollutants are ultimately converted to tons per year except waste water and fecal coliform. Waste water is expressed in million gallons per year (MGY) and fecal coliform in number per milliliter (#/ML).

SECTOR 1

FISHERIES

The absence of pollutant entries in the Fisheries sector reflects the severe lack of data encountered at the national as well as state and county levels. Some waste water, oil and grease, and solid waste are involved with Fisheries activities but are small and somewhat isolated from the eco-system of urban centers [25].

SECTOR 2

FORESTRY

Air

Technical data suggested the presence of particulates for the Forestry sector[25]. The South Carolina coefficient for combined Agriculture, Forestry, and Fisheries sectors was adapted to the Forestry sector of the Mississippi coastal region by the methodology of Section III-B as shown below.

Particulates

.023	Pounds per dollar [16]
x .290	Forestry proportion category output (Appendix A)
.00667	Adjusted pounds per dollar
x $ 8126000	Forestry output Mississippi (Appendix A)
27.133	Tons Mississippi coastal region

SECTOR 3

LIVESTOCK AND LIVESTOCK PRODUCTS

Water

Water effluent data for the Livestock sector were not practically available. Even though water useage is probably significant, a large proportion of total water is consumed rather than disposed as waste water.

Air

Livestock production is an agricultural category which emits particulates into the air. The procedure of Section III-B yielded .327 tons of particulates per year. Engineering data indicated this figure to be too low and recommended an allocation of the remaining tonnage between agricultural particulates available for the Livestock and Crops sectors of .25 and .75, respectively [25]. Thus, 25 percent of non-Forestry emissions were allocated to the Livestock sector as shown below. Total particulates were computed by applying the South Carolina coefficient to total output in all corresponding Mississippi agricultural sectors.

	321.851	Total Agricultural particulate tonnage [16]
-	27.133	Forestry particulates (See Sector 2)
=	294.718	Livestock and Crops particulates
x	.250	Livestock proportion [25]
=	73.680	Total tons Livestock

Solid

Solid waste consists of dried animal manures and is derived below. The number of animals was multiplied by unit wet manure tonnage. The average dry percentage content of manure was then applied to give total tons of dry manure.

Livestock Dry Solid Waste
Mississippi Coastal Region
1977

Animal	Number of Animals[a]	Annual Wet Waste per Animal (Tons)[b]	Total Annual Wet Waste	Dry Weight Factor[c]	Total Animal Dry Waste Tons
Beef Cattle	10015	10.900	109164	.15	16374.6
Dairy Cattle	1649	14.600	24075	.12	2889.0
Chickens (fryer)	603	.0064	4	.30	1.2
Hens (layers)	88491	.0670	5929	.30	1778.7
Horses	518	12.0000	6216	.15	932.4
Hogs, pigs, sheep	2250	3.2000	7200	.27	1944.0
Total	103626	40.7734	152588	-	23919.9

a [48]
b [42]
c [13].

SECTOR 4

CROPS AND OTHER AGRICULTURE

Water

Although the Crops sector is known to generate some quantities of water effluents such as sediment runoff and pesticides, quantifiable data were unavailable. Irrigation water was treated as waste water flow because it was deposited in the environment carrying effluent loadings. Irrigation water in acre feet was converted to million gallons per year as shown in the table below. Data for year 1974 were the latest available.

Irrigation Water Crops and Other Agriculture
Mississippi Coastal Region
1977

County	Irrigation Water[a] (acre feet year)	Irrigation Water[b] (MGY)
Hancock	538	175.308
Harrison	1	.326
Jackson	-	-
Total	539	175.634

[a] [48]

[b] $\text{acre foot} = 1 \text{ acre ft} \times \frac{43560 \text{ ft}^2}{\text{acre}} \times \frac{1728 \text{ in}^3}{\text{ft}^3} \times \frac{1 \text{ gal}}{231 \text{ in}^3} = 325851.4286$ gallons

Air

Air pollution data for Crops are sketchy, but engineering sources indicated that crop production in the coastal region generates about 75 percent of non-Forestry particulates (see Livestock) [25]. Total tonnage of Crops particulates is derived below using unpublished MAWPCC data.

321.851	Total Agricultural particulate tonnage [16]
- 27.133	Forestry particulates (See Sector 2)
= 294.718	Livestock and Crops particulates
x .750	Crops proportion [25]
= 221.037	Total particulate tonnage Crops

SECTOR 5

AGRICULTURAL, FORESTRY, AND FISHERIES SERVICES

The lack of data for all categories of pollution explains the zero entries in Agricultural, Forestry, and Fisheries Services. Although minimal sewage and vehicle emissions may be present, it was discovered that quantities in the Mississippi coastal region would be so insignificant that omission of probable categories was justifiable [25].

SECTOR 6

MINING

Water

Water effluents for the Mining sector were estimated with the methodology of Section III-A. One regional computer printout was processed for waste water and suspended solids using Equation 4 as shown below.

Waste Water[a]

Sample	Sample Emp	MGY[b]	MGY/Emp	Weight
Region	5	14.4	2.880	1.0
Non-Region	-	-	-	-

[a] [23]
[b] Million gallons per year

$$\bar{X} = 2.880 \text{ MGY/emp}$$
$$N = 220$$
$$X = N\bar{X} = 633.6 \text{ MGY}$$

Suspended Solids

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	5	5150.1	1030.02	1.0
Non-Region	-	-	-	-

[23]

$$\bar{X} = 1030.02 \text{ Lbs/emp}$$
$$N = 220$$
$$\bar{X} = N\bar{X} = 113.302 \text{ Tons/year}$$

Air

The Non-Metallic Mining Sector of the South Carolina study corresponded exactly to the Mining sector of the Mississippi model. Thus, the South Carolina air coefficients were used without adjustment and converted to tons as discussed in Section III-B.

Solid

Solid waste tonnage was estimated using the methodology of Section III-C. The average daily industrial solid waste factor was applied to sector employment and converted to an annual basis.

220	Mining employment (Appendix A)
x .65	Solid waste lbs/emp [42]
=.0715	Tons solid waste/day
x 300	Days/industrial year
=21.45	Tons solid waste/year

SECTOR 7

CONSTRUCTION

Water

Water effluents and waste water flow for the Construction sector were estimated from a printout which covered the construction phase of a chemical plant in the region [23]. No employment data for the construction were available, and specific construction companies were not monitored. Because the types of effluents listed on the printout were not typical of all construction activity, the single printout was processed as discussed in Section III-A and entered as a proxy for sector loadings without adjusting for sector employment. In this way, zero entries common to many studies were avoided while hedging against an excessive sector allocation.

Air

The absence of air pollution data reflects the lack of data in studies from which coefficients were adapted. In addition many obstacles were encountered in using construction equipment and EPA factors because most construction vehicles were not registered with the state highway department.

Solid

Solid waste was estimated by applying a demolition-construction waste factor to sector employment. This procedure is described below.

	6471	Construction employment (Appendix A)
x	.23	Solid waste lbs/emp [42]
=	.7742	Tons solid waste/day
x	300	Days/industrial year
=	223.5	Tons solid waste/year

SECTOR 8

FOOD PROCESSING

Water

Regional water effluent samples for Food Processing covered about 57 and 62 percent of regional establishments and employees, respectively (Table 1, Section III-A). Product supplementation was needed because only seafood processors were included in the regional sample. A study of the remaining 15 firms revealed the following categories with respect to water effluent loadings: dairies, packing houses, and beverages. A review of effluent printouts for other regions of the state resulted in the selection of three firms to the non-regional sample. They covered the following SIC product classifications corresponding to uncovered product categories: 2011, 2086, and 2026.

Many data problems were encountered in the regional sample, e.g., missing data and unreported effluent values. Missing water flow rates were estimated with average flow per employee of known firms. Equation 2 of Section III-A was used to estimate missing effluent values, and consulting engineers provided data on firms which utilized municipal facilities rather than their own monitored plants [8]. Regional and non-regional firms were processed and effluents estimated using Equation 4 of Section III-A as summarized by the following computations.

Waste Water[a]

Sample	Sample Emp	MGY[b]	MGY/Emp	Weight
Region	1591	5919.870	3.720849	.76
Non-Region	512	97.635	.190693	.24

[a] [23]
[b] Million gallons per year

$\bar{X}$ = (.76) (3.720849) + (.24) (.190693)
$\bar{X}$ = 2.873611 MGY/emp
N = 562
X = 519.870 + N$\bar{X}$ ≈ 7534.839 Tons

BOD

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	718	427246	594.9109	.58
Non-Region	512	11546	22.5508	.42

[23]

$\bar{X}$ = (.58) (594.9109) + (.42) (22.5508)
X = 354.5196 Lbs/emp
N = 1435
X = 427146 + N$\bar{X}$ ≈ 467.941 Tons

Chlorine

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	525	3.085	5.8762	.57
Non-Region	400	117	.2925	.43

[23]

$\bar{X}$ = (.57) (5.8762) + (.43) (.2925)
$\bar{X}$ = 3.4752 Lbs./emp
N = 1628
X = 3085 + N$\bar{X}$ ≈ 4.372 Tons

Fecal Coliform (#/ML)

Sample	Sample Emp	Lbs	Lbs/emp	Weight
Region	283	253218.00	89476.325	1.0
Non-Region	-	-	-	-

[23]

$\bar{X}$ = 89476.325/ML/emp
N = 2153
$X = N\bar{X} \simeq 1926425.279$/ML

Suspended Solids

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	708	431216	609.0621	.58
Non-Region	512	26499	51.7559	.42

[23]

$\bar{X} = (.58)(609.0621) + (.42)(51.7559)$
$\bar{X}$ = 825.777 lbs/emp
N = 1445
$X = 431216 + N\bar{X} \simeq 96321.264$ Tons

Settleable Solids

Sample	Sample Emp	Lbs	Lbs/Emps	Weight
Region	813	319602	393.1144	1.0
Non-Region	-	-	-	-

[23]

$\bar{X}$ = 393.1144 lbs/emp
N = 2153
$X = N\bar{X} \simeq 423.188$ Tons

Nitrogen

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	283	84675	299.2049	.72
Non-Region	112	769	6.8661	.28

[23]

$\bar{X}$ = 194.5027 lbs/emp
N = 2153
$X = N\bar{X} \simeq 209.382$ Tons

Oil and Grease

	Sample Emp	Lbs	Lbs/Emp	Weight
Sample Region	185	35,983	194.5027	1.0
Non-Region	-	-	-	-

[23]

$\bar{X}$ = 194.5027 Lbs/emp
N = 2153
$X = N\bar{X}$ = 209.382 tons

Air

Air pollution coefficients were taken directly from the South Carolina Food and Kindred Products sector which corresponded to the Food Processing sector of the Mississippi model. Multiplying the appropriate output yielded the following tonnages of air pollution.

Nitrogen oxides	160.014 tons	Particulates	80.007 tons
Sulfur oxides	810.204 tons	Aldehydes	6.934 tons
Carbon Monoxide	6.934 tons	Hydrocarbons	6.934 tons

Solid

Solid wastes were estimated by averaging all subcategories of food processors listed in the engineering study and multiplying by sector employment. All categories were included in Mississippi coastal production.

Food Processing Solid Waste Factors

SIC	Industry	Solid waste/emp/year/(tons)
201	Meat processing	6.2
2033	Cannery	55.6
2037	Frozen foods	18.3
Other 203	Preserved foods	12.9
Other 20	Food processing	5.8
20	Average sector	19.76

Source: [42]

2153 Food Processing employment (Appendix A)
x 19.76 Tons/emp/year [42]
≈ 42543.28 Tons/year

SECTOR 9

APPAREL AND OTHER FINISHED PRODUCTS

Water

The Apparel sector required total supplementation for water effluents because of the absence of monitoring printouts. Two Mississippi firms producing SIC products 2327 and 2254 were selected as a proxy for coastal firms in the non-regional samples. Both categories were significant to coastal production. One non-regional firm had to be processed using Equation 2 of Section III-A. Final tonnages are summarized in the following computations using Equations 3 and 4 of Section III-A.

Waste Water[a]

Sample	Sample Emp	MGY[b]	MGY/Emp	Weight
Region	-	-	-	-
Non-Region	820	154.43	.188329	1.0

[a] [23]
[b] Million gallons per year

$\bar{X}$ = .188329 MGY/emp
N = 1745
$X = N\bar{X} \simeq 328.634$

BOD

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	270	2042	7.748	1.0

[23]

$\bar{X}$ = 7.748 Lbs/emp
N = 1745
$X = N\bar{X} \simeq 6.76$ Tons

Chlorine

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	550	85	.1545	1.0

[23]

$\bar{X}$ = .1545 Lbs/emp
N = 1745
$X = N\bar{X} \simeq .135$ Tons

Suspended Solids

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	270	6467	23.9519	1.0

[23]

$\bar{X}$ = 23.9519 Lbs/emp
N = 1745
$X = N\bar{X} \simeq 20.885$ Tons

Nitrogen

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	270	695	2.57411	1.0

[23]

$\bar{X}$ = 2.57411 Lbs/emp
N = 1745
$X = N\bar{X} \simeq 2.246$ Tons

Zinc

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region				
Non-Region	550	423	.7691	1.0

[23]

$\bar{X}$ = .7691 Lbs/emp
N = 1745
$X = N\bar{X} \simeq .671$ Tons

Chromium

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	550	423	.7691	1.0

[23]

$\bar{X}$ = .7691 Lbs/emp
N = 1745
X = N$\bar{X}$ = .671 Tons

Air

Air pollution tonnages for the Apparel sector were estimated with the procedure of Section III-B for sectors which correspond exactly to Mississippi Coastal sectors [16]. Coefficients were multiplied by Apparel output of the Mississippi coastal region.

Solid

The solid waste factor for the Apparel category of the engineering study was applied to Apparel employment to estimate solid wastes.

1745 = Apparel Employment (Appendix A)
x .31 = Tons solid waste/emp/year [42]
= 540.95 = Tons/year

SECTOR 10

LUMBER AND WOOD

Water

Water effluent quantities for Lumber and Wood were derived with regional and non-regional MAWPCC samples by Equations 3 and 4 of Section III-A. The regional sample of 2 firms covered only 32 percent of sector employment (Table 1, Section III-A) and both firms were engaged in creosoting operations. Product supplementation was undertaken to cover effluents discharged by firms producing such lumber products as kiln-dried southern pine, trim veneer, and finished lumber.

Waste Water[a]

Sample	Sample Emp	MGY[b]	MGY/Emp	Weight
Region	43	.24	.005580	.16
Non-Region	233	242.775	1.041953	.84

[a] [23]
[b] Million gallons per year

$$\bar{X} = (.16)\ (.005580) + (.84)\ (1.041953)$$
$$\bar{X} = .876134 \text{ MGY/emp}$$
$$N = 355$$
$$X = .24 + N\bar{X}$$
$$X = 311.268 \text{ MGY}$$

BOD

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	129	7248	56	.36
Non-Region	233	94377	405	.64

[23]

$\bar{X} = (.36)\ (56) + (.64)\ (405)$
$\bar{X} = 280$ Lbs/emp
$N = 269$
$X = 7248 + N\bar{X} \simeq 41.284$ Tons

Suspended Solids

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	233	79742	342.24	1.0

[23]

$\bar{X} = 342.24$ Lbs/emp
$N = 398$
$X = N\bar{X} \simeq 68.11$ Tons

Nitrogen

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	83	5414	65.22	1.0

[23]

$\bar{X} = 65.22$ Lbs/emp
$N = 398$
$X = N\bar{X} \simeq 12.979$ Tons

Oil and Grease

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	129	177	1.37	.46
Non-Region	150	15600	104.00	.54

[23]

$\bar{X} = (.46)\ (1.37) + (.54)\ (104)$
$\bar{X} = 56.79$ Lbs/emp
$N = 269$
$X = 177 + N\bar{X} \simeq 7.727$ Tons

Phenols

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	129	111	.86	.46
Non-Region	150	105	.70	.54

[23]

$$\bar{X} = (.46)(.86) + (.54)(.7)$$
$$\bar{X} = .7736 \text{ Lbs/emp}$$
$$N = 269$$
$$X = 111 + N\bar{X} \approx .160 \text{ Tons}$$

Air

Air pollution quantities were estimated from Lumber and Wood air coefficients of the South Carolina study [16]. Multiplying the coefficients by Mississippi Lumber and Wood output yielded the tonnages listed in **Table 1**, Section IV.

Solid

Solid waste factors for the SIC categories of Lumber and Wood were averaged and applied to sector employment as shown below.

Lumber and Wood Solid Waste Factor

SIC	Industry	Tons/Employed/Year
2421	Sawmills and planing mills	162.0
Other 24	Wood products	10.3
Total 24	Average sector	86.15

[42]

398	= Lumber and Wood employment (Appendix A)
x 86.75	= Tons solid waste/emp/year [42]
3428.70	= Tons/year

SECTOR 11

PAPER AND ALLIED

Water

The regional sample of the Paper and Allied sector provided complete sector coverage as shown in Table 1, Section III-A. Thus, the processed sector worksheets covered 100 percent of sector employment so that allocation and supplementation were not necessary. The regional printouts generated the following Paper and Allied water effluent loadings. Although paper production would appear to entail other significant loadings, printouts of similar firms in other areas of Mississippi listed similar effluent categories.

Paper and Allied Water Effluents

Effluent	Tons/year[a]
Waste Water	7245[b]
BOD	473
Suspended Solids	1383

[a] [23]
[b] MGY

Air

Air pollution coefficients for the Pulp and Paper sector of the South Carolina study correspond to the Paper and Allied sector of the Mississippi study. Sector output for Mississippi Paper and Allied was multiplied by the appropriate air pollution coefficients to yield air pollution in Table 1, Section IV.

Solid

The solid waste factor for Paper and Allied was applied to sector employment to yield total solid waste, as shown below.

```
  1326 = Paper and Allied employment (Appendix A)
x    2 = Tons solid waste/emp/year [42]
  2652 = Tons/year
```

SECTOR 12

PRINTING AND PUBLISHING

Water

Neither regional nor non-regional MAWPCC printouts were available for Printing and Publishing. Other studies gave zero values to effluent categories of Printing and Publishing [16], [17], [52]. Waste water flow, primarily consisting of sewage, was estimated however by multiplying average per-capita waste water discharge by sector employment (See Households, Appendix C for per-capita waste water).

	433	= Printing and Publishing employment (Appendix A)
x	50	= Gallons/emp/day (Appendix B, Households)
	21,650	= Gallons/day
x	300	= Industrial year
	6.495	= Million gallons/year (MGY)

Air

Sulfur oxide emissions were estimated with air coefficients of the South Carolina Printing and Publishing sector by the methodology of Section III-B. Computations are given below. Unpublished engineering data provided the basis for estimating hydrocarbons, given the three county area and total employment [25].

Sulfur Oxides

	$ 7,782,000	= Printing and Publishing Output (Appendix A)
x	.00007	= Pounds/dollar, South Carolina [16]
	544.74	= Pounds/year, Mississippi
÷	2000	= Pounds/ton
	.273	= Ton/year

Solid

Printing and Publishing solid waste engineering factors were applied to sector output to derive solid waste tonnage, as shown below.

	433	= Printing-Publishing employment (Appendix A)
x	.49	= Tons solid waste/emp/year [42]
	212.17	= Tons/year

SECTOR 13

CHEMICALS, PETROLEUM, REFINING, AND RELATED PRODUCTS

Water

Water effluent tonnages for the Chemicals, Petroleum Refining, and Related sector were estimated with Equations 3 and 4 of Section III-A. Table 1 of Section III-A indicates that 50 percent and 91 percent of total firms and employment, respectively, were covered by the regional sample. Although this would appear to be quite adequate, five SIC product categories were not covered. A non-regional sample was constructed with four firms covering SIC 2821 and SIC 2852. These two categories involved production processes similar to the uncovered sector. The results are given below.

Waste Water[a]

Sample	Sample Emp	MGY[b]	MGY/Emp	Weight
Region	1834	11838.56	6.455049	.81
Non-Region	431	569.8066	1.322057	.19

[a] [23]
[b] Million gallons per year

$$\bar{X} = .81(6.455049) + .19(1.322057)$$
$$\bar{X} = 5.479781 \text{ MGY/emp}$$
$$N = 189$$
$$X = 11838.56 + N\bar{X} \simeq 12874.239 \text{ MGY}$$

BOD

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	1688	374790	222.032	.72
Non-Region	666	227442	341.505	.28

[23]

$\bar{X} = .72(222.032) + .28(341.505)$
$\bar{X} = 255.484$ lbs/emp
$N = 335$
$X = 374790 + N\bar{X} \approx 230.19$ Tons

COD

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	340	95286	280.25294	.35
Non-Region	640	626355	978.67969	.65

[23]

$\bar{X} = (.35)(280.25294) + (.65)(978.67969)$
$\bar{X} = 734.23$
$N = 1683$
$X = 95286 + N\bar{X} \approx 665.498$ Tons

Fecal Coliform (#/ML)

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	186	650.01	3.4947	1.0
Non-Region	-	-	-	-

[23]

$\bar{X} = 3.4947$/ML/emp
$N = 2023$
$X = N\bar{X} \approx 7069.778$/ML

Suspended Solids

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	1834	1123500	612.5954	.73
Non-Region	666	78317	117.5931	.27

[23]

$\bar{X} = .13(612.595) + .27(117.593)$
$\bar{X} = 478.945$ Lbs/emp
$N = 189$
$X = 1123500 + N\bar{X} \approx 607.011$ Tons

Nitrogen

Sample	Sample Emp	Lbs.	Lbs/Emp	Weight
Region	1456	238726	163.9602	.74
Non-Region	511	4674	9.1468	.26

[23]

$\bar{X} = .74(163.9602) + .26(9.1468)$
$\bar{X} = 121.9488$ Lbs/emp
$N = 567$
$X = 238726 + N\bar{X} \approx 153.936$ Tons

Oil and Grease

	Sample Emp	Lbs	Lbs/Emp	Weight
Sample Region	1509	173991	115.302	1.0
Non-Region	-	-	-	-

[23]

$\bar{X} = 115.302$ Lbs/emp
$N = 2023$
$X = N\bar{X} \approx 116.626$ Tons

Phenols

	Sample Emp	Lbs	Lbs/Emp	Weight
Sample Region	697	216	.3099	1.0
Non-Region	-	-	-	-

[23]

$\bar{X} = .3099$ Lbs/emp
$N = 2023$
$X = N\bar{X} \approx .314$ Tons

Sulfides

	Sample Emp	Lbs	Lbs/Emp	Weight
Sample Region	883	1581	1.7905	1.0
Non-Region	-	-	-	-

[23]

$\bar{X} = 1.7905$ Lbs/emp
$N = 2023$
$X = N\bar{X} \approx 1.811$ Tons

Flouride

	Sample Emp	Lbs	Lbs/Emp	Weight
Sample Region	580	147000	253.4483	1.0
Non-Region	-	-	-	-

[23]

$\bar{X} = 253.4483$ Lbs/emp
$N = 2023$
$X = N\bar{X} \approx 256.363$ Tons

Heavy Metals

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	580	7500	12.931	1.0
Non-Region	-	-	-	-

[23]

$\bar{X}$ = 12.031 Lbs/emp
N = 2023
X = N$\bar{X}$ ≃ 13.080 Tons

Cadmium

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	580	330	.569	1.0
Non-Region	-	-	-	-

[23]

$\bar{X}$ = .569 Lbs/emp
N = 2023
X = N$\bar{X}$ ≃ .576 Tons

Iron

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	580	27030	45.9694	1.0
Non-Region	-	-	-	-

[23]

$\bar{X}$ = 45.9694 Lbs/emp
N = 2023
X = N$\bar{X}$ ≃ 46.498

Chromium

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	805	498	.6186	1.0
Non-Region	-	-	-	-

[23]

$\bar{X}$ = .6186 Lbs/emp
N = 2023
X = N$\bar{X}$ ≃ .626 Tons

Air

Air pollution coefficients of the South Carolina study for Chemicals and Allied Products were adapted to the corresponding Mississippi coastal sector using the non-household methodology of Section III-B. The results thus obtained for sulfur oxides, hydrocarbons, and aldehydes were adjusted substantially based upon unpublished regional data [25]. Final results are summarized below in tons per year.

Nitrogen oxide	3526.913	Particulates	82.567
Sulfur oxides	1600.000	Aldehydes	7.623
Carbon Monoxide	7.622	Hydrocarbons	381.077

Solid

Solid waste factors for three categories of SIC 28 listed in the engineering study were averaged as shown below to coincide with the Mississippi coastal category. The averaged per-employee waste factor was then applied to sector employment to give total solid waste tonnage.

Chemical-Petroleum-Related Solid Waste Factor

SIC	Industry	Solid Waste/Emp/Year(tons)
281	Basic Chemicals	10.000
28-other	Chemical and Allied	.630
29	Petroleum	14.800
28-29	Average sector	8.477

[42]

2023	= Chemical-Petroleum employment (Appendix A)
x 8.477	= Solid waste tons/emp [42]
17148.971	= Tons/year

SECTOR 14

STONE, CLAY AND GLASS

Water

Water effluents were estimated with Equations 3 and 4 of Section III-A. Product supplementation was necessary even though 60 percent of sector employment was covered (Table 1, Section III-A) because regional sample firms included only glass manufacturing. A non-regional sample was constructed with three firms covering ready-mixed concrete (SIC 3273), glazed ceramic tile (SIC 3253), and sand and gravel processing (SIC 3295). Computations of effluent tonnages are presented below.

Waste Water[a]

Sample	Sample Emp	MGY[b]	MGY/Emp	Weight
Regional	460	3116.49	6.774978	.59
Non-Regional	325	84.03	.258554	.41

[a] [23]
[b] Million gallons per year

$$\bar{X} = (.59)\,(6.774978) + (.41)\,(.258554)$$
$$\bar{X} = 4.103244 \text{ MGY/emp}$$
$$N = 302$$
$$X = 3116.49 + N\bar{X}$$
$$X \simeq 3240.408 \text{ MGY}$$

Chlorine

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	300	7.4	.0247	1.0
Non-Region	-	-	-	-

[23]

$\bar{X}$ = .0247 Lbs/emp
N = 762
X = N$\bar{X}$ ≈ .010 Tons/year

Suspended Solids

Sample	Sample Emp.	Lbs.	Lbs/Emp	Weight
Region	460	901962	1960.7870	.59
Non-Region	325	33770	103.9077	.41

[23]

$\bar{X}$ = (.59) (1960.787) + (.41) (103.9077)
$\bar{X}$ = 1199.4665 Lbs/emp
N = 302
X = 901962 + N$\bar{X}$
X ≈ 632.101 Tons/year

Oil and Grease

Sample	Sample Emp.	Lbs	Lbs/Emp	Weight
Region	160	5418	33.8625	1.0
Non-Region	-	-	-	-

[23]

$\bar{X}$ = 33.8625 Lbs/emp
N = 762
X = N$\bar{X}$ ≈ 12.902 Tons/year

Air

South Carolina coefficients for Stone, Clay and Glass corresponded to the Mississippi coastal sector and were multiplied by Mississippi sector output to yield annual tonnages. Results are given below in tons.

Nitrogen Oxides	117.970	Particulates	1091.850
Sulfur Oxides	203.310	Aldehydes	1.632
Carbon Monoxide	1.632	Hydrocarbons	1.632

Solid

The engineering solid waste factor for Stone, Clay, and Glass was applied to sector employment to estimate solid waste tonnages. Calculations are listed below.

762 = Stone, Clay and Glass employment (Appendix A)
x 2.4 = Tons/emp/year [42]
= 1828.8 = Tons/year

SECTOR 15

PRIMARY AND FABRICATED METALS

Water

Water effluent tonnages were derived with Equations 3 and 4 of Section III-A using regional and non-regional samples. The fabricated metal industry in particular is a very large and diverse sector on the Mississippi Gulf Coast, producing many SIC product categories. The regional sample covered only 9 and 13 percent of total firms and employment, respectively, as shown in Table 4 of Section III-A. Furthermore, all but a fraction of regional sample employment was aluminum fabrication not typical of overall coastal activity. A non-regional sample of 8 firms was drawn representing all uncovered SIC product categories. Emphasis was given SIC 3440 through SIC 3470. It is noted that some firms in the non-regional sample made products not exactly the same as those of coastal industries, but which entailed essentially the same production processes and waste residuals. Final sector estimates from regional and non-regional sector worksheets are given below.

Waste Water[a]

Sample	Sample Emp	MGY[b]	MGY/Emp	Weight
Region	267	128.07	.479663	.09
Non-Region	2670	1136.978	.425834	.91

[a] [23]
[b] Million gallons per year

$\bar{X}$ = .09(.479663) + .91(.425834)
$\bar{X}$ = .430679 Lbs/emp
N = 3090
X = 128.07 + N$\bar{X}$
X = 1458.868 MGY

BOD

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	1280	39	.0305	1.0

[23]

$\bar{X}$ = .0305 Lbs/emp
N = 3351
X = N$\bar{X}$ = .051 Tons

Chlorine

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	95	40	.4211	.48
Non-Region	1310	662	.5053	.52

[23]

$\bar{X}$ = .48(.4211) + .52(.5053)
$\bar{X}$ = .4649 Lbs/emp
N = 3256
X = 40 + N$\bar{X}$
X = .777 Tons

Suspended Solids

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	172	1172	6.814	.11
Non-Region	1339	31.110	23.234	.89

[23]

$\bar{X}$ = .11(6.814) + .89(23.234)
X = 21.43 Lbs/emp
N = 3179
X = 1172 + N$\bar{X}$ ≃ 34.469 Tons

Nitrogen

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	15	161	10.733	1.0
Non-Region	-	-	-	-

[23]

$\bar{X}$ = 10.733 Lbs/emp
N = 3351
X = N$\bar{X}$ ≈ 17.983 Tons

Oil and Grease

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	445	4502	10.117	1.00

[23]

$\bar{X}$ = 10.117 Lbs/emp
N = 3351
X = N$\bar{X}$ ≈ 16.951 Tons

Phosphates

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	300	1254	4.18	1.0

[23]

$\bar{X}$ = 4.18 Lbs/emp
N = 3351
X = N$\bar{X}$ ≈ 7.004 Tons

Zinc

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	95	33	.3474	.05
Non-Region	1710	911	.5328	.95

[23]

$\bar{X}$ = .05(.3474) + .95(.5328)
$\bar{X}$ = .5235 Lbs/emp
N = 3256
X = 33 + N$\bar{X}$
X ≈ .869 Tons

Cadmium

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	10	9	.9	1.0

[23]

$\bar{X}$ = .9 Lbs/emp
N = 3351
$\bar{X}$ = N$\bar{X}$ ≈ 1.508 Tons

Iron

Sample	Sample/Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	785	1362	1.735	1.0

[23]

$\bar{X}$ = 1.735 Lbs/emp
N = 3351
X = N$\bar{X}$ ≃ 2.907 Tons

Chromium

Sample	Sample/Emp	Lbs	Lbs/Emp	Weight
Region	95	38	.4	.04
Non-Region	2395	591	.2468	.96

[23]

$\bar{X}$ = .04(.4) + .96(.2468)
X = .2529 Lbs/emp
N = 3256
X = 38 + N$\bar{X}$
X ≃ .431 Tons

Aluminum

Sample	Sample/Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	785	3481	4.434	1.0

[23]

$\bar{X}$ = 4.434 Lbs/emp
N = 3351
X = N$\bar{X}$ ≃ 7.429

Copper

Sample	Sample/Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	795	369	.4642	1.0

[23]

$\bar{X}$ = .4642 Lbs/emp
N = 3351
X = N$\bar{X}$ ≃ .778 Tons

Nickel

Sample	Sample Emp	Lbs	Lbs/Emp	Weight
Region	-	-	-	-
Non-Region	1085	1124	1.0359	1.0

[23]

$$\bar{X} = 1.0359 \text{ Lbs/emp}$$
$$N = 3351$$
$$X = N\bar{X} \approx 1.736 \text{ Tons}$$

Air

The South Carolina study contained separate Primary Metals and Fabricated Metals sectors, necessitating the use of Equation 6 in Section III-B. However, there were no emissions listed under the primary category so that the remaining fabricated sector corresponded exactly to the Mississippi sector. Coefficients of the South Carolina Fabricated Metals sector were multiplied by Mississippi coastal output and converted to tons. Data for nitrogen oxide and particulates were adjusted based upon unpublished data [25]. Results in tons per year are listed below.

Nitrogen oxide	77.500	Particulates	300.000
Sulfur oxides	77.702	Aldehydes	.698
Carbon Monoxide	.698	Hydrocarbons	.698

Solid

The solid waste engineering factors for Primary Metals and Fabricated Metals were averaged and applied to Mississippi coastal Primary and Fabricated Metals employment. The procedure is given below.

Primary-Fabricated Solid Waste Factor

SIC	Industry	Solid Waste/Emp/Year(Tons)
34	Primary Metals	24.0
35	Fabricated Metals	1.7
34 & 35	Average Sector	12.85

Source: [42]

$$\begin{array}{rl} 3351 & = \text{Primary-Metal employment (Appendix A)} \\ \underline{\times\ \ 12.85} & = \text{Tons/emp/year [42]} \\ 43060.35 & = \text{Tons/year} \end{array}$$

SECTOR 16

TRANSPORTATION EQUIPMENT

Water

Water effluent tonnages for Transportation Equipment were estimated with Equation 4 of Section III-A. No supplementation was needed because 96 percent of Sector employment was covered in the regional sample as shown in Table 1, Section III-A. Other small firms were engaged in similar production processes. Final results of the sector estimation are summarized below. Here, N equals total sector employment.

Waste Water

$\bar{X}$ = 14.1017 MGY/emp
N = 23033
X = N$\bar{X}$ ≈ 324804.46 MGY

[23]

BOD

$\bar{X}$ = 3.1828 Lbs/emp
N = 23033
X = N$\bar{X}$ ≈ 36.655 Tons

[23]

Chlorine

$\bar{X}$ = .1377 Lbs/emp
N = 23033
X = N$\bar{X}$ ≈ 1.586 Tons

[23]

Fecal Coliform (#/ML)

$\bar{X}$ = 1.0438/ML/emp
N = 23033
X = N$\bar{X}$ ≈ 24041.845/ML

[23]

Suspended Solids

$\bar{X}$ = 4.1132 Lbs/emp
N = 23033
X = N$\bar{X}$ ≈ 47.37 Tons

[23]

Oil and Grease

$\bar{X}$ = .0610 Lbs/emp
N = 23033
X = N$\bar{X}$ ≈ .703 Tons
[23]

Phosphates

$\bar{X}$ = .0235 Lbs/emp
N = 23033
X = N$\bar{X}$ ≈ .271 Tons

[23]

Zinc

$\bar{X}$ = .1882 Lbs/emp
N = 23033
X = N$\bar{X}$ ≈ 2.168 Tons

[23]

Chromium

$\bar{X}$ = .0094 Lbs/emp
N = 23033
X = N$\bar{X}$ ≈ .109 Tons

[23]

Air

Using the methodology of Section III-B, air coefficients of the South Carolina Transportation Equipment sector were applied directly to Mississippi output to derive total emissions tonnages. The results yielded large quantities of nitrogen oxide and sulfur oxides as shown below.

Nitrogen Oxide

	\$659083000	= Transp. Equip output Mississippi (Appendix A)
x	.007	= Lbs/dollar [16]
=	4613581	= Lbs Mississippi
÷	2000	= Lbs/Ton
≃	2306.791	= Tons

Sulfur Oxides

	\$659083000	= Transp. Equip. output Mississippi (Appendix A)
x	.000354	= Lbs/dollar [16]
	233315.38	= Lbs Mississippi
÷	2000	= Lbs/Ton
≃	116.658	= Tons

Solid

The solid waste factor for Transportation Equipment was applied to sector output to derive solid waste tonnage. Computations are presented below.

	23033	= Transportation Equipment employment (Appendix A)
x	1.3	= Tons Solid waste/emp/year [42]
	29942.9	= Tons/year

SECTOR 17

MISCELLANEOUS MANUFACTURING

Water

As shown in Table 1 of Section III-A, intensive supplementation for the Miscellaneous Manufacturing sector was necessary since no data were available for regional firms. One regional printout was published but contained no actual data values.

A non-regional sample of nine miscellaneous manufacturing firms in other regions of the state was drawn. Every effort was made to include only firms which produced the same products as firms in the coastal area. While this objective was met for the most part, some substitution of products with similar production processes was necessary because of the heterogeneous nature of the products manufactured by this diverse sector. The final sample reflected a representative profile of the SIC structure for the industry in the region. Final sector effluent estimation is summarized in the following table using the symbols of Equation 4, Section III-A.

Water Effluents
Miscellaneous Manufacturing

Effluent	Sample Emp[a]	Lbs Pollutant[a]	X	N	X[c]
Waste Water	3243	258.3917[b]	.079677	1090	86.848[b]
BOD	1693	6577	3.8848	1090	2.117
Chlorine	1550	79.1	.0510	1090	.028
Fecal Coliform	300	1583.27	5.2776	1090	5752.584
Susp Solids	1993	20527	10.2995	1090	5.613
Nitrogen	693	1168	1.6854	1090	.919
Oil & Grease	1607	3424	2.1307	1090	1.161
Phenols	600	2	.0033	1090	.002

Zinc	1850	30	.0162	1090	.009
Iron	1450	16	.0110	1090	.006
Chromium	900	20.5	.0228	1090	.013
Lead	100	14	.14	1090	.077

[a] [23]
[b] Million gallons per year (MGY)
[c] Tons per year
[d] #/ML

Air

The South Carolina study contained more sectors in the given miscellaneous manufacturing category than the corresponding regional sector. The non-household methodology of Section III-B incorporating Equation 6 was used to estimate air emissions. The sector estimation is detailed in the following calculations. Total tonnage is equal to X.

Nitrogen Oxide

SIC	Lbs/Dollar	Dollar Output	Ts (Tons)
22	.016	275,998,859	2,207.99
25	.0022	43,236,115	47.56
35	.016	8,025,953	64.21
36	.0014	50,930,519	35.65
Total	-	378,191,446	2,355.41

Source: [16]

$$X = \frac{(2355.41)(\$30676000)}{\$378191446} \simeq 191.053 \text{ Tons}$$

Sulfur Oxides

SIC	Lbs/Dollar	Dollar Output	Ts (Tons)
22	.012150	275,998,859	1,676.693
25	.006580	43,236,115	142.247
35	.000710	8,025,953	2.849
36	.000121	50,930,519	3.081
Total	-	378,191,446	1,824.87

Source: [23]

$$X = \frac{(1824.87)(\$30676000)}{\$378191446} \simeq 148.027 \text{ Tons}$$

Carbon Monoxide

SIC	Lbs/Dollar	Dollars Output	Ts (Tons)
22	.0001	275,998,859	138.00
25	.00006	43,236,115	1.30
35	.00001	8,025,953	.04
36	.000001	50,930,519	.03
39	.000003	2,013,396	.01
Total	-	380,204,842	139.38

Source: [16]

$$X = \frac{(139.38)(\$30676000)}{\$380204842} \approx 11.246 \text{ Tons}$$

Particulates

SIC	Lbs/Dollar	Dollars Output	Ts (Tons)
22	.0012	275,998,859	165.60
25	.00064	43,236,115	13.84
35	.051	8,025,953	204.66
36	.00001	50,930,519	.25
39	.00004	2,013,396	.04
Total	-	380,204,842	384.39

Source: [16]

$$X = \frac{(384.39)(\$30676000)}{\$380204842} \approx 31.014 \text{ Tons}$$

Aldehydes

SIC	Lbs/Dollar	Dollars Output	Ts (Tons)
22	.0001	275,998.859	13.80
25	.00006	43,236,115	1.30
35	.00001	8,025,953	.04
36	.000001	50,930,519	.03
39	.000003	2,013,396	.01
Total	-	380,204,842	15.18

Source: [16]

$$X = \frac{(15.18)(\$30676000)}{\$380204842} \approx 1.225 \text{ Tons}$$

Hydrocarbons

SIC	Lbs/Dollars	Dollar Output	Ts (Tons)
22	.0001	275,998,859	13.80
25	.00006	43,236,115	1.3
35	.00001	8,025,953	.04
36	.000001	50,930,519	.03
39	.000003	2,013,396	.01
Total	-	380,204,842	15.18

Source: [16]

$$X = \frac{(15.18)(\$30676000)}{\$380204842} = 1.225 \text{ Tons}$$

Solid

Solid waste engineering factors per employee for SIC categories corresponding to the Mississippi Miscellaneous Manufacturing sector were averaged and multiplied by sector employment. Solid waste estimation is summarized below.

Miscellaneous Mfg. Solid Waste Factor

SIC	Industry	Solid Waste/Emp/Year(Tons)
22	Textiles	.26
25	Furniture	.52
30	Rubber-plastic	2.60
31	Leather	.17
35	Nonelectrical mach.	2.60
36	Electrical mach.	1.70
38	Instruments	.12
39	Misc. mfg.	.14
Total	Average sector	1.01

[42]

	1090	= Miscellaneous Mfg. employment (Appendix A)
x	1.01	= Tons/emp/year [42]
=	1100.9	= Tons/year

SECTOR 18

WATER TRANSPORTATION

Water

The commercial methodology of Section III-A was used to estimate Water Transportation effluent loadings. Waste water flow factors as shown in Table 2 of Section III-A were not available for the Water Transportation sector, necessitating the substitution of average per-capita water use (see Appendix B, Households). Waste water flow is given below.

	1167	= Water Transportation employment (Appendix A)
x	50	= Gallons per-capita waste water/day (Appendix B)
	58350	= Gallons/day
x	300	= Days/year
=	17.5	= Million gallons/year (MGY)

Waste water flow of 17.5 MGY was applied to net medium effluent concentrations as illustrated in Table 3 of Section III-A to allocate water effluent tonnages contained in waste water flow. Calculations are summarized below.

Water Transportation Effluents

Effluent	Waste Water (MGY)	Concentration (MG/L)[a]	Effluent/ MGY (lbs)[b]	Conversion (lbs/gal)[c]	Annual Tonnage
BOD	17.5	30	-	8.34	2.190
Chlorine	17.5	-	3.478	-	.031
Fec. Coliform	17.5	-	2.80	-	49.000[d]
Sus. Solids	17.5	30	-	8.34	2.190
Nitrogen	17.5	6	-	8.34	.438
Oil & Grease	17.5	15	-	8.34	1.095

[a] [20]
[b] [23]
[c] Weight of 1 gallon water
[d] #/ML

Air

The South Carolina study aggregated all transportation into one Transport and Storage sector. The non-household methodology of Section III-B was used in the following computations to allocate total air emissions to Water Transportation. Total tonnage was found by multiplying the adjusted coefficient (pounds per dollar) by Mississippi Water Transportation output.

Mississippi	Output	Percent
Water Transportation	$30,635,000	46
Other Transp. & Warehousing	36,686,000	54

Water Transportation Air Emissions

Air Pollutant	Lbs/Dollar	Adj. Miss. Coefficient	Tonnage
Nitrogen Oxide	.013	.00598	91.599
Sulfur Oxide	-	-	-
Carbon Monoxide	.020	.00920	140.921
Particulates	.019	.00874	133.874
Aldehydes	.003	.00138	21.138
Hydrocarbons	.004	.00184	28.184

Sources: [16]

Solid

The commercial average per-capita solid waste factor for urban areas was applied to sector employment to give tonnage of solid waste. Total pounds were converted to tons as shown below.

	1167	= Water transportation employment (Appendix A)
x	.46	= Pounds/day/employee [42]
	536.82	= Pounds/day
x	300	= Days/year
=	80.523	= Tons/year

SECTOR 19

OTHER TRANSPORTATION AND WAREHOUSING

Water

The commercial methodology of Section III-A was used to derive Other Transportation effluent loadings. Average per-capita water use (Appendix B, Household) was used to estimate waste water flow rate because engineering factors were not available.

	689	= Other Transp. and Whse. employment (Appendix A)
x	50	= Gallons per capita waste water/day (Appendix B)
	34450	= Gallons/day
x	300	= Days/year
=	10.335	= Million gallons/year (MGY)

Waste water of 10.335 MGY was multiplied by net medium effluent concentration shown in Table 3 of Section III-A to allocate effluent tonnage. Calculations are presented below.

Other Transportation Water Effluents

Effluent	Waste Water (MGY)	Concentration (MG/L)[a]	Effluent/ Gal (lbs)[b]	Conversion (Lbs/gal)[c]	Annual Tonnage
BOD	10.335	30	-	8.34	1.293
Chlorine	10.335	-	3.478	-	.018
Fecal Coliform	10.335	-	2.800	-	28.938[d]
Sus. Solids	10.335	30	-	8.34	1.293
Nitrogen	10.335	6	-	8.34	.295
Oil & Grease	10.335	15	-	8.34	.647

[a] [20]
[b] [23]
[c] Conversion factor
[d] #/ML

Air

The South Carolina study aggregated all transportation into Transport and Storage. The non-household methodology of Section III-B was used in the following to allocate total emissions to Other Transportation. Total tonnage was found by multiplying the adjusted coefficient (pounds per dollar) by sector output. Some of the tonnage value may seem too low, but any transportation carried out in another sector was counted in the same. Only firms involved with transportation as a business were included in Other Transportation.

Mississippi	Output	Percent
Water Transportation	$30,635,000	46
Other Transportation & Warehousing	36,686,000	54

Other Transportation Air Emissions

Air Pollutant	Lbs/Dollar	Adj. Miss. Coefficient	Tonnage
Nitrogen Oxide	.013	.00702	128.768
Sulfur Oxides	-	-	-
Carbon Monoxide	.020	.01080	198.104
Particulates	.019	.01026	188.199
Aldehydes	.033	.00162	29.716
Hydrocarbons	.004	.00216	39.621

Source: [16]

Solid

The average commercial per-capita solid waste factor for urban areas was applied to sector employment to give solid waste tonnage. Total pounds were converted to tons as shown below.

	689	= Other Transportation employment (Appendix A)
x	.46	= Pounds/day/employee [42]
	316.94	= Pounds/day
x	300	= Days/year
=	47.541	= Tons/year

SECTOR 20

COMMUNICATIONS AND PUBLIC UTILITIES

Water

The major source of effluent loadings in the Communications and Public Utilities sector is power generating activity, to which there were two large power generating facilities located in the Mississippi coastal region. As shown below, plant 1 in 1977 generated 67 percent of electricity in the region, receiving about 75 percent of its power from coal. The other 25 percent was via fuel oil and natural gas. Plant 2 supplied 33 percent of total generation using fuel oil exclusively, but has recently converted to coal.

	Kilowatt Hours	Percent Generation
Plant 1	1,000,000	67
Plant 2	500,000	33

Source: Mississippi Power Company

Effluent printouts were available only for plant 1. Plant 2 effluents were estimated by allocating its respective share of total generation as summarized below.

Communications-Public Utilities Effluents

Effluent	Plant 1 (Tons)[a]	Plant 2 Allocation	Total Tonnage
Waste Water[b]	33.708	1.33	44.832
BOD	.014	1.33	.019
Chlorine	.001	1.33	.002
Fecal Coliform[c]	3338.650	1.33	4440.405
Sus. Solids	5.989	1.33	7.965
Oil and Grease	.128	1.33	.170
Iron	.002	1.33	.003

Copper	.0006	1.33	.001

[a] [23]
[b] MGY
[c] #/ML

Air

The South Carolina study had more sectors in the Communications and Public Utilities category than the corresponding Mississippi sector. However, the only South Carolina sector with air pollution coefficients was the Electric Utilities sector which corresponded exactly to the Mississippi sector. Thus, power generating coefficients were multiplied by Mississippi sector output and converted to tons. Technical data indicated that emissions were too low for sulfur oxides and particulates and revised accordingly [25]. Final results are shown below in tons per year.

Nitrogen Oxide	9.083	Particulates	2500.000
Sulfur Oxides	40000.000	Aldehydes	74.450
Carbon Monoxide	7.445	Hydrocarbons	223.349

Solid

The industrial average solid waste factor for urban areas was used to derive solid waste loadings. The engineering factor was multiplied by sector output as shown below.

3002	=	Comm. Public Utilities employment (Appendix A)
x .65	=	Pounds/day/employee [42]
1951.3	=	Pounds/day
x 300	=	Days/year
= 292.695	=	Tons/year

SECTOR 21

EATING AND DRINKING PLACES

Water

To estimate waste water flow Eating and Drinking Places were divided into full service and fast food categories to utilize available data sources. Restaurant waste water factors were applied to number of seats in estimating full service restaurant waste water. Average gallons per fast food worker was applied to sector employment for fast food waste flow. Full service and fast food waste water flow were summed to yield total sector waste water. The procedure is detailed below, assuming a 360 day year. It is noted that bars and taverns are frequently licensed within eating establishments. Mississippi Tax Commission data suggested an extremely small percentage of separate drinking places; thus, the accuracy of the estimation is not impaired [33].

	4706	= Eating Drinking employment (Appendix A)
x	.29	= Fast food proportion [35], [30]
=	1365	= Fast food employment

	761	= Eating Drinking establishments [33]
x	.29	= Fast food proportion [35], [30]
=	221	= Fast food establishments
=	540	= Full service establishments

Fast Food

	1365	= Employment
x	133	= Gallons/emp/day [37]
	181545	= Gallons/day
x	360	= Days/year
-	63.356	= Million gallons/year

Full Service

	540	= Establishments
x	150	= Seats/establishment [36],[30]
	81000	= Full service seats
x	8	= Gallons/seat/day [20]
	648000	= Gallons/day
x	360	= Days
=	233.280	= Million gallons/year

```
    65.356 = MGY Fast food
 + 233.280 = MGY Full Service
   298.636 = MGY Eating and Drinking
```

Total waste water flow of 298.636 MGY was applied to net concentration factors listed in Table 3 Section III-A to allocate effluent tonnages. The procedure is summarized below.

Eating and Drinking Places Effluents

Effluent	Waste Water (MGY)	Concentration (MG/L)[a]	Effluent/ Gal (lbs)[b]	Conversion (lbs/gal)[c]	Annual Tonnage
BOD	298.636	30	-	8.34	37.359
Chlorine	298.636	-	3.478	-	.519
Fec. Coliform	298.636	-	2.800	-	836.181[d]
Sus. Solids	298.636	30	-	8.34	37.359
Nitrogen	298.636	6	-	8.34	7.472
Oil & Grease	298.636	15	-	8.34	18.680

[a] [20]
[b] [23]
[c] Weight of 1 gallon water
[d] #/ML

Air

There were no listed air pollution coefficients for Eating and Drinking places in other studies. Emissions were assumed to be zero.

Solid

Solid waste factors for fast food and full service categories were multiplied by average number of meals and converted to an annual basis. Sector estimation is summarized below, assuming a 360 day year.

Fast Food

```
      221 = Establishments
 x    692 = Meals/day [35]
   152932 = Meals/day
 x    360 = Days/year
= 27527.76 = Tons/year
```

Full Service

```
    81000 = Seats (See waste water)
 x   1.04 = Turnover/seat [36]*
    84240 = Meals/day
 x      2 = Pounds/meal [42]
   168480 = Pounds/day
      360 = Days/year
= 30326.4 = Tons/year
```

*Low side estimate of range

Total Eating and Drinking

Fast Food	27527.760	= Tons/year
Full Service	30326.400	= Tons/year
	57854.160	= Tons/year

SECTOR 22

SERVICE STATIONS

Water

Waste water flow for the Service Station sector was estimated with the waste water engineering factor of Table 2, Section III-A. The procedure is given below.

	285	= Service station establishments [33]
x	3	= Pumps/station [19]*
	855	= Total pumps
x	400	= Gallons/pump/day [20]
	342000	= Gallons/day
x	300	= Days/year
=	102.600	= Million gallons/year

*Pump is defined as underground tank servicing gasoline dispensers.

Waste water flow of 102.6 MGY was multiplied by effluent concentrations shown in Table 3, Section III-A to allocate water effluent tonnages. The procedure is summarized below.

Service Station Effluents

Effluent	Waste Water (MGY)	Concentration (MG/L)[a]	Effluent/ Gal (lbs)[b]	Conversion (lbs/gal)[c]	Annual Tonnage
BOD	102.6	30	-	8.34	12.836
Chlorine	102.6	-	3.478	-	.179
Fec. Coliform	102.6	-	2.800	-	287.280[d]
Sus. Solids	102.6	30	-	8.34	12.836
Nitrogen	102.6	6	-	8.34	2.568
Oil and Grease	102.6	15	-	8.34	6.418

[a] [20]
[b] [23]
[c] Weight of 1 gallon water
[d] #/ML

Air

Private household motor vehicle emissions were entered in the Service Station sector to minimize distortion of linear assumptions between auto emissions and household income [17]. Input-output methodology assumes a proportionate relationship between resource useage and dollar output regardless of output level. However, as household income increases, automobile travel and, consequently, emissions will increase disproportionately. Thus, household pollution was charged to Service Stations because emissions are more linearly related to gasoline sales than to household income. Household emissions are estimated in Appendix B, Households.

Solid

The average commercial solid waste factor was used to estimate Service Station solid wastes. The procedure is summarized below.

	1196	= Service Station employment (Appendix A)
x	.46	= Pounds/day/employee [42]
	550.16	= Pounds/day
x	300	= Days/year
=	82.524	= Tons/year

SECTOR 23

WHOLESALE AND RETAIL TRADE

Water

Waste water sewage engineering factors for trade establishments could not be used because store frontage feet were practically unavailable for an area as large as the coastal region. Waste water sewage flow was estimated using average per-capita water use as shown below. Although there are problems with this methodology, no other data were available.

	14178	= Wholesale and Retail employment (Appendix A)
x	50	= Gallon per-capita water/day (Appendix B)
	708900	= Gallons/day
x	300	= Days/year
	212.67	= Millions gallons/year (MGY)

Waste water flow of 212.67 MGY was applied to net waste water factors of Table 3, Section III-A to allocate effluent tonnages. This procedure is summarized below.

Wholesale-Retail Trade Effluents

Effluent	Waste Water (MGY)	Concentration (MG/L)[a]	Effluent/ Gal (lbs)[b]	Conversion (lbs/gal)[c]	Annual Tonnage
BOD	212.67	30	-	8.34	26.606
Chlorine	212.67	-	3.478	-	.370
Fec. Colif.	212.67	-	2.800	-	595.476[d]
Sus. Solids	212.67	30	-	8.34	26.606
Nitrogen	212.67	6	-	8.34	5.321
Oil & Grease	212.67	15	-	8.34	13.303

a [20]
b [23]
c Conversion factor
d #/ML

Air

The South Carolina study did not list air pollution coefficients for Wholesale and Retail Trade. Unpublished engineering data did allow an estimation of incinerator particulates for the Mississippi coastal region totalling 20 tons [25].

Solid

Solid wastes were estimated using engineering factors based upon units of 1000 square feet of interior store space. Total square footage was estimated by dividing gross sales (including cost of goods sold) by average retail/wholesale sales per square foot for typical types of stores. Calculations are summarized below.

Gross Sales

$203,965,000	Wholesale/retail sales adjusted for cost of goods sold, (Appendix A)
x 4.2553	Cost of goods sold multiple [38]
$867,932,260	Gross sales unadjusted for cost of goods sold (4.2553 = 1/.235, where.235 equals margin)

Square Feet

$79 Sales per square foot, average of stores under $1 million and over $1 million [43]

$$\frac{\$867{,}932{,}260 \text{ sales}}{\$79 \text{ sales/ft}^2} = 10{,}986{,}484 \text{ square feet}$$

$$\frac{10{,}986{,}484 \text{ ft}^2}{1000} = 10986.5(1000 \text{ ft}^2)$$

Waste Factor

10,986.5	= 1000 ft^2
x 1.2	= Pounds/1000 ft^2/day [42]
13,183.8	= Pounds/day
X 300	= Days/year
= 1,977.57	= Tons/year

SECTOR 24

FINANCE, INSURANCE, AND REAL ESTATE

Water

Waste water sewage flow for the Finance, Insurance, and Real Estate sector is based upon the number of offices as shown in Table 2, Section III-A. For purposes of estimation it was assumed that on the average there were two employees per office unit.

	3789	= FIRE employment (Appendix A)
÷	2	= Employees/office
=	1895	= Offices
x	10	= Average waste water/day/office [20]
	18950	= Waste water/day
x	300	= Day/year
=	5.685	= Million gallons/year (MGY)

Waste water sewage flow of 5.685 MGY was multiplied by net concentrations per effluent to estimate tonnages of water effluents. Estimations are summarized below.

FIRE Effluents

Effluent	Waste Water (MGY)	Concentration (MG/L)[a]	Effluent/ Gal (lbs)[b]	Conversion (lbs/gal)[c]	Annual Tonnage
BOD	5.685	30	-	8.34	.711
Chlorine	5.685	-	3.478	-	.010
Fec. Colif.	5.685	-	2.800	-	15.918[d]
Sus. Solids	5.685	30	-	8.34	.711
Nitrogen	5.685	6	-	8.34	.142
Oil & Grease	5.685	15	-	8.34	.356

a [20]
b [23]
c Conversion factor
d #/ML

Solid

Solid waste consisted mainly of paper waste and was estimated using the average commercial solid waste factor. The procedure is given below.

	3789	= FIRE employment (Appendix A)
x	.46	= Pounds/day/employee [42]
	1742.94	= Pounds/day
x	300	= Days/year
=	261.441	= Tons/year

SECTOR 25

HOTELS, MOTELS, AND LODGING

Water

Waste water flow for Hotels, Motels, and Lodging was estimated using the waste water factor of Table 2, Section III-A. The procedure is given below.

	4600	= Total rooms, Miss. gulf coast [5]
x	.59	= Average yearly occupancy [28]
=	2739	= Rooms occupied
x	75	= Gallons/day/room [20]
	205425	= Gallons/day
x	300	= Days/year
=	61.628	= Million gallons/year (MGY)

Waste flow of 61.628 MGY was multiplied by effluent concentrations shown in Table 3 of Section III-A to allocate effluent tonnage.

Hotels, Motels, and Lodging Effluents

Effluent	Waste Water (MGY)	Concentration (MG/L)[a]	Effluent/ Gal (lbs)[b]	Conversion (lbs/gal)[c]	Annual Tonnage
BOD	61.628	30	-	8.34	7.710
Chlorine	61.628	-	3.478	-	.107
Fec. Coliform	61.628	-	2.800	-	172.559[d]
Sus. Solids	61.628	30	-	8.34	7.710
Nitrogen	61.628	6	-	8.34	1.542
Oil & Grease	61.628	15	-	8.34	3.855

[a] [20]
[b] [23]
[c] Conversion factor
[d] #/ML

Solid

Solid wastes were derived using the appropriate engineering factor for hotels and motels as shown in Table 4, Section III-C. All classes of lodging places including the medium class were averaged to give 2.2 pounds per room daily.

	2739	=	Rooms [5], [28]
x	2.2	=	Pounds/day/room [42]
=	903.87	=	Tons/year

SECTOR 26

MEDICAL SERVICES

Water

Waste water flow for Medical Services was estimated using the average waste water factor of Table 2, Section III-A. The number of beds was based upon a telephone survey of 9 major medical facilities. Using a reported annual occupancy rate of 92 percent, there were approximately 2,062 beds in use on an annual basis. A 365 day year was assumed in the calculations below.

	2062	= Hospital beds (telephone survey)
x	160	= Average gallons/bed/day [20]
	329920	= Gallons/day
x	365	= Days/year
≃	120.421	= Million gallons/year (MGY)

Waste water flow of 120.421 MGY was applied to appropriate effluent concentration factors to allocate effluent tonnages, as shown below.

Medical Services Effluents

Effluent	Waste Water (MGY)	Concentration (MG/L)[a]	Effluent/ Gal (lbs)[b]	Conversion (lbs/gal)[c]	Annual Tonnage
BOD	120.421	30	-	8.34	15.065
Chlorine	120.421	-	3.478	-	.210
Fec. Coliform	120.421	-	2.800	-	337.179[d]
Sus. Solids	120.421	30	-	8.34	15.065
Nitrogen	120.421	6	-	8.34	3.013
Oil & Grease	120.421	15	-	8.34	7.533

[a] [20]
[b] [23]
[c] Conversion factor
[d] #/ML

Solid

Solid wastes were estimated using the per-bed engineering factor of Table 4, Section III-C, as shown below.

$$
\begin{array}{rrl}
 & 2062 & = \text{Beds (telephone survey)} \\
\times & 8 & = \text{Pounds/bed/day [42]} \\
\hline
 & 16496 & = \text{Pounds/day} \\
\times & 365 & = \text{Day/year} \\
\hline
\simeq & 3010.520 & = \text{Tons/year}
\end{array}
$$

SECTOR 27

EDUCATIONAL SERVICES

Water

Waste water flow was estimated with a per-pupil factor as shown in Table 2 of Section III-A. Estimated number of students in the coastal region based upon average daily attendance is given in the table below.

Number of Students

School or District	Average Daily Attendance
Hancock	1751
Bay St. Louis	1811
Harrison Co.	9230
Biloxi	6981
Gulfport	6774
Long Beach	3307
Pass Christian	1375
Jackson Co.	6276
Moss Point	6482
Ocean Springs	4009
Pascagoula	8291
County Total	56287

Source: [45]

Average daily attendance of 56,287 was multiplied by the average engineering factor, assuming a 220 day year. That is, the academic year was assumed to be a nine month session plus two months of summer school (20 days per month). The inclusion of all students in the summer term helped to account for some college and junior college attendance not covered in the table.

	56287	= Average daily attendance [45]
x	14	= Gallons/pupil/day [20]
	788018	= Gallons/day
x	220	= Days/year
	173.364	= Million gallons/year (MGY)

Waste water flow of 173.364 MGY was then applied to the effluent concentration listed in Table 3, Section III-A.

Educational Services Effluents

Effluent	Waste Water (MGY)	Concentration (MG/L)[a]	Effluent/ Gal (lbs)[b]	Conversion (lbs/gal)[c]	Annual Tonnage
BOD	173.364	30	-	8.34	21.689
Chlorine	173.364	-	3.478	-	.302
Fec. Coliform	173.364	-	2.800	-	485.419[d]
Sus. Solids	173.364	30	-	8.34	21.689
Nitrogen	173.364	6	-	8.34	4.317
Oil & Grease	173.364	15	-	8.34	10.844

[a] [20]
[b] [23]
[c] Conversion factor
[d] #/ML

Solid

The per-pupil solid waste factor of Table 4, Section III-C was applied to number of students to estimate solid waste tonnage.

	56287	= Average daily attendance [45]
x	2.1	= Pounds/pupil/day [42]
	118202.7	= Pounds/day
x	220	= Days/year
=	13002.297	= Tons/year

SECTOR 28

OTHER SERVICES

Water

Waste water flow for Other Services required residual allocation because the heterogeneity of services and the data required thereof caused the use of waste water engineering factors to be impractical. The approach taken was to subtract water flows of all other commercial sectors from the total commercial water magnitude discussed in Section III-A. This procedure is given below.

Commercial Sector Waste Water Except Other Services

Number	Sector	Waste Water (MGY)
18	Water transportation	17.500
19	Other transportation	10.335
21	Eating-drinking	298.636
22	Service station	102.600
23	Wholesale-retail	212.670
24	FIRE	5.685
25	Hotels-motels	61.628
26	Medical services	120.421
27	Educational services	173.364
29	State-local gov't	29.910
	Total Water Flow	1032.760

Source: [20],[23]

4417.895	Commercial flow, sectors 18-19, 20-29 (Section III-A)
- 1032.760	Non-Other Svc. flow, sectors 18-19, 20-27,29
= 3385.135	Other Services flow, sector 28 (MGY)

Waste water flow of 3385.135 MGY was multiplied by appropriate concentration factors to allocate effluent tonnages as shown in the following. Although total waste water loadings by the Other Services sector may appear high, this sector includes many diverse, water-consuming businesses such as laundromats and swimming pools.

Other Services Effluents

Effluent	Waste Water (MGY)	Concentration (MG/L)[a]	Effluent/ Gal (lbs)[b]	Conversion (lbs/gal)[c]	Annual Tonnage
BOD	3385.135	30	-	8.34	423.480
Chlorine	3385.135	-	3.478	-	5.887
Fec. Coliform	3385.135	-	2.800	-	9478.378[d]
Sus. Solids	3385.135	30	-	8.34	423.480
Nitrogen	3385.135	6	-	8.34	84.696
Oil and Grease	3385.135	15	-	8.34	211.740

a [20]
b [23]
c Conversion factor
d #/ML

Solid

The commercial average solid waste engineering factor for urban areas shown in Table 5 of Section III-C was used to estimate sectoral solid waste tonnage, as shown below.

	13156	= Other Services employment (Appendix A)
x	.46	= Pounds/emp/day [42]
	6051.76	= Pounds/day
x	300	= Days/year
=	907.764	= Tons/year

SECTOR 29

STATE AND LOCAL GOVERNMENT

Water

Waste water flow was estimated using the average office factor shown in Table 2 of Section III-A. For government, one person per office was assumed.

	9970	= State-Local Gov't employment (Appendix A)
x	10	= Average gallons/emp/day [20]
	99700	= Gallons/day
x	300	= Days/year
=	29.91	= Million gallons/year (MGY)

Waste water flow of 29.91 MGY was multiplied by the appropriate effluent concentration factors shown in Table 3 of Section III-A to allocate effluent tonnages.

State-Local Government Effluents

Effluent	Waste Water (MGY)	Concentration (MG/L)[a]	Effluent/ Gal (lbs)[b]	Conversion (lbs/gal)[c]	Annual Tonnage
BOD	29.91	30	-	8.34	3.742
Chlorine	29.91	-	3.478	-	.053
Fec. Coliform	29.91	-	2.800	-	83.748[d]
Sus. Solids	29.91	30	-	8.34	3.742
Nitrogen	29.91	6	-	8.34	.749
Oil and Grease	29.91	15	-	8.34	1.841

[a] [20]
[b] [23]
[c] Conversion factor
[d] #/ML

Solid

The commercial average solid waste factor for urban areas was applied to sector employment to yield total solid waste, as shown below.

	9970	=	State-Local Gov't employment (Appendix A)
x	.46	=	Pounds/emp/day [42]
	4586.2	=	Pounds/day
x	300	=	Days/year
=	687.93	=	Tons/year

SECTOR 30

HOUSEHOLDS

Water

Household waste water flow of 5205.740 MGY was estimated by applying 1977 population to average per-capita waste water loadings. The following procedure gives an approximation of average residential waste water, assuming that 20 percent of total use is consumed or recycled [25]. Per-capita waste water use is based upon the average of these separate studies.

Mississippi Coastal Region Population

County	1975 Population[a]	1980 Population[b]
Hancock	18,100	21,442
Harrison	146,800	148,247
Jackson	105,800	137,376
Total	270,700	307,065

[a] [49]
[b] [26]

Estimated 1977 Population

	36365	= Population change, 1975-1980
÷	5	= Years
=	7273	= Change/year
x	2	= Years
=	14546	= Change, 2 years
+	270700	= Population, 1975
=	285246	= Estimated population, 1977

Average Per-Capita Waste Water Use

Study	Total Use Gallons/Day
Bailey Study, [1]	255
Reid Study, [40]	246
Geological Survey [11]	260
Average family (4 per family)	254
Average per-capita	64

64 = Gallons/person/day [1], [11], [40]
x .8 = Waste water proportion [25]
≃ 50 = Gallons/person/day/waste water
x 285246 = Population Mississippi coastal region [49], [26]
14262300 = Gallons/day/waste water
x 365 = Days/year
≃5205.740 = Million gallons/year (MGY)

As discussed in Section III-A, we now have waste water flow for households and need to estimate effluent tonnages. The sum of commercial effluent allocations was subtracted from its combined commercial and household loadings. Total commercial and household effluent tonmages were found by adding printout and non-printout treatment facility effluent loadings. This procedure is summarized below.

Household Effluent Tonnages

Effluent	MAWPCC Facility Total (Tons/year)[a]	Allocated Commercial (Tons/yr)[a]	Household Effluent (Tons/yr)
BOD	1226.839	561.919	664.920
Chlorine	16.755	7.812	8.943
Fec. Coliform	26787.084	12370.076	14417.008[b]
Sus. Solids	5929.190	561.919	5367.271
Nitrogen	248.748	112.365	136.383
Oil and Grease	601.958	280.997	320.961

[a] [23], [20]
[b] #/ML

Air

Using the methodology of Section III-B the correction factors for air emissions in Equation 2 were derived to regionalize the mean emission factors in order to estimate private vehicle pollution in tons. The fraction of annual travel by vehicle model year is given below.

Fraction of Vehicle Travel by Model Year, M_{in}
(1977 Annual Data)

(1) Year	(2) No. Vehicles[a]	(3) Percent of Total[b]	(4) Average Annual Miles Driven[c]	(5) (3) x (4)	(6) Min
1977	7,176,880	.072	15,900	1,145	.104
1976	9,557,278	.096	15,000	1,440	.131
1975	7,477,202	.075	14,000	1,050	.095
1974	9,594,193	.096	13,100	1,258	.114
1973	10,854,200	.109	12,200	1,330	.121
1972	9,562,731	.096	11,300	1,085	.098
1971	7,865,782	.079	10,300	814	.074
1970	7,449,104	.075	9,400	705	.064
Pre-1970	30,366,224	.304	7,240[d]	2,201	.199
Total	99,903,594	1.002	-	11,028	1.000

[a] [41]
[b] Total does not sum to 1.0 because of rounding
[c] [45]
[d] Average of last 5 years of Strate data

Speed correction factors (Vips) were computed with information from the following table taken from EPA projected emissions inventory [51]. Computations were divided among pre-1970, 1970, and post-1970. Pre-1970 is composed of the simple average of 1957-1967, 1968, and 1969. Average speed

COEFFICIENTS FOR SPEED CORRECTION FACTORS FOR LIGHT-DUTY VEHICLES

Location	Model year	$V_{ips} = e^{(A + BS + CS^2)}$ Hydrocarbons A	Hydrocarbons B	Hydrocarbons C	Carbon monoxide A	Carbon monoxide B	Carbon monoxide C	$V_{ips} = A + BS$ Nitrogen oxides A	Nitrogen oxides B
Low altitude (Excluding 1966 1967 Calif.)	1957 1967	0.953	-6.00×10^{-2}	5.81×10^{-4}	0.967	-6.07×10^{-2}	5.78×10^{-4}	0.808	0.980×10^{-2}
California	1966 1967	0.957	-5.98×10^{-2}	5.63×10^{-4}	0.981	-6.22×10^{-2}	6.19×10^{-4}	0.844	0.798×10^{-2}
Low altitude	1968	1.070	-6.63×10^{-2}	5.98×10^{-4}	1.047	-6.52×10^{-2}	6.01×10^{-4}	0.888	0.569×10^{-2}
	1969	1.005	-6.27×10^{-2}	5.80×10^{-4}	1.259	-7.72×10^{-2}	6.60×10^{-4}	0.915	0.432×10^{-2}
	1970	0.901	-5.70×10^{-2}	5.59×10^{-4}	1.267	-7.72×10^{-2}	6.40×10^{-4}	0.843	0.798×10^{-2}
	Post-1970	0.943	-5.92×10^{-2}	5.67×10^{-4}	1.241	-7.52×10^{-2}	6.09×10^{-4}	0.843	0.804×10^{-2}
High altitude	1957 1967	0.883	-5.58×10^{-2}	5.52×10^{-4}	0.721	-4.57×10^{-2}	4.56×10^{-4}	0.602	2.077×10^{-2}
	1968	0.722	-4.63×10^{-2}	4.80×10^{-4}	0.662	-4.23×10^{-2}	4.33×10^{-4}	0.642	1.835×10^{-2}
	1969	0.706	-4.55×10^{-2}	4.84×10^{-4}	0.628	-4.04×10^{-2}	4.26×10^{-4}	0.726	1.403×10^{-2}
	1970	0.840	-5.33×10^{-2}	5.33×10^{-4}	0.835	-5.24×10^{-2}	4.98×10^{-4}	0.614	1.978×10^{-2}
	Post-1970	0.787	-4.99×10^{-2}	4.99×10^{-4}	0.894	5.54×10^{-2}	4.99×10^{-4}	0.697	1.553×10^{-2}

(S) is assumed to approximate the national average of 45 miles per hour and includes both highway and city travel. The Mississippi coastal region falls into the category of low altitude, non-California.

(1) Hydrocarbons: $V_{ips} = e^{(A + BS + CS^2)}$

where:

S = average speed
A, B, and C from table

Pre-1970

$$A = \begin{array}{r} .953 \\ 1.070 \\ \underline{1.005} \\ 1.009 \end{array} \qquad B = \begin{array}{r} -6.00 \times 10^{-2} \\ -6.63 \times 10^{-2} \\ \underline{-6.27 \times 10^{-2}} \\ -6.3 \times 10^{-2} \end{array} \qquad C = \begin{array}{r} 5.81 \times 10^{-4} \\ 5.98 \times 10^{-4} \\ \underline{5.80 \times 10^{-4}} \\ 5.86 \times 10^{-4} \end{array}$$

$$V_{ips} = e^{[1.009 + (-.063)(45) + .000586(45)^2]}$$

$$V_{ips} = .53$$

1970

$$V_{ips} = e^{[.901 + (-.057)(45) + .000559(45)^2]}$$

$$V_{ips} = .59$$

Post-1970

$$V_{ips} = e^{[.943 + (-.0592)(45) + .000567(45)^2]}$$

$$V_{ips} = .56$$

(2) Carbon Monoxide: $V_{ips} = e^{(A + BS + CS^2)}$

where:

S = Average speed
A,B, and C from table

Pre-1970

$$A = \begin{array}{r} .967 \\ 1.047 \\ \underline{1.259} \\ 1.091 \end{array} \qquad B = \begin{array}{r} -6.07 \times 10^{-2} \\ -6.52 \times 10^{-2} \\ \underline{-7.72 \times 10^{-2}} \\ 6.77 \times 10^{-2} \end{array} \qquad C = \begin{array}{r} 5.87 \times 10^{-4} \\ 6.01 \times 10^{-4} \\ \underline{6.60 \times 10^{-4}} \\ 6.13 \times 10^{-4} \end{array}$$

$$V_{ips} = e^{[1.091 + (-.0677)(45) + .000613(45)^2]}$$

$$V_{ips} = .49$$

<u>1970</u>

$$V_{ips} = e^{[1.267 + (-.0772)(45) + .000640(45)^2]}$$

$$V_{ips} = .40$$

<u>Post-1970</u>

$$V_{ips} = e^{[1.241 + (-.0752)(45) + .000609(45)^2]}$$

$$V_{ips} = .40$$

(3) Nitrogen Oxides: $V_{ips} = A + BS$

where:

S = Average speed
A and B from table

<u>Pre-1970</u>

$$A = \begin{array}{r} .808 \\ .888 \\ \underline{.915} \\ .870 \end{array} \qquad B = \begin{array}{r} .980 \times 10^{-2} \\ .569 \times 10^{-2} \\ \underline{.432 \times 10^{-2}} \\ .660 \times 10^{-2} \end{array}$$

$$V_{ips} = .87 + (.0066)(45)$$

$$V_{ips} = 1.167$$

<u>1970</u>

$$V_{ips} = .843 + (.00798)(45)$$

$$V_{ips} = 1.202$$

<u>Post-1970</u>

$$V_{ips} = .843 + (.00804)(45)$$

$$V_{ips} = 1.205$$

Temperature correction factors (Z_{ipt}) are presented in tne following table where t equals ambient coastal temperature. The final columns will be used later to determine the hot/cold operation factor (R_{iptw}). The average ambient temperature for the Mississippi coastal region for 1977 was 67° Farenheit [34]. This temperature falls within the EPA temperature band (20°-80°) governing the temperature correction factors listed in the table. Computations were based upon two basic engine types: catalytic and non-catalytic. For purposes of estimation it was assumed that catalytic convertors were common to vehicles only after 1975 [50]. Non-catalyst factors were applied to pre-1975 model years.

Light-Duty Vehicle Temperature Correction Factors
And Hot/Cold Vehicle Operation Correction Factors
For FTP Emission Factors

Pollutant and Controls	Temperature Correction factor(Z_{ipt})	Hot/Cold Vehicle Operation correction factors	
		g(t)	f(t)
Carbon Monoxide			
Non-Catalyst	-0.0127t + 1.95	-	0.0045t + 0.02
Catalyst	-0.0743t + 6.58	0.035t - 5.24	0.036t - 4.14
Hydrocarbons			
Non-Catalyst	-0.0113t + 1.81	-	0.0079t + 0.03
Catalyst	-0.0304t + 3.25	0.0018t + 0.0095	0.0050t - 0.0409
Nitrogen Oxides			
Non-Catalyst	-0.0046t + 1.36	-	-0.0068t + 1.64
Catalyst	-0.0060t + 1.52	-0.0010t + 0.858	0.0010t + 0.835

Source: [51]

(1) Carbon Monoxide:

Catalyst $Z_{ipt} = -.0743(67) + 6.58$

$Z_{ipt} = 1.689$

Non-Catalyst $Z_{ipt} = -.0127(67) + 1.95$

$Z_{ipt} = 1.0991$

(2) Hydrocarbons:

<u>Catalyst</u> $Z_{ipt} = -.0304(67) + 3.25$

$Z_{ipt} = 1.2132$

<u>Non-Catalyst</u> $Z_{ipt} = -.0113(67) + 1.81$

$Z_{ipt} = 1.0529$

(3) Nitrogen Oxides:

<u>Catalyst</u> $Z_{ipt} = -.0060(67) + 1.52$

$Z_{ipt} = 1.118$

<u>Non-Catalyst</u> $Z_{ipt} = -.0046(67) + 1.36$

$Z_{ipt} = 1.0518$

The hot/cold vehicle operation correction factor (R_{iptw}) adjusts vehicle emissions during three phases of typical engine use: (1) a cold transient phase (start-up after long engine-off period), (2) a hot transient phase (start-up after short engine-off period), and (3) a stabilized phase (warmed-up operation)[50]. The following two formulas specify emission corrections based upon the assumption of national averages that 20, 27, and 53 percent of all vehicles operate in cold, hot transient, and stabilized phases, respectively, for automobiles with catalytic converters after 1975. For non-catalytic pre-1975 vehicles the hot-transient phase is combined with stabilized phase to yield 20 percent cold operation and 80 percent hot operation. The formulas for both categories are given below. The terms f(t) and g(t) were derived from Columns (2) and (3) of the previous table of temperature correction factors.

<u>Pre-1975, Non-Catalyst Vehicles</u>

$$R_{iptw} = \frac{w + (100-w)\ f(t)}{20 + 80\ f(t)}$$

where:

w = Percentage of cold operation
f(t) = Computed from previous table

Post-1975, Catalytic Vehicles

$$R_{iptw} = \frac{w + f(t) + (100-w-x)\ g(t)}{20 + 27\ f(t) + 53\ g(t)}$$

where:

x = Percentage of hot start-up

g(t) = Computed from previous table

The above functions are based upon national average conditions as specified earlier. If the study area is exactly the same, the correction factor reduces to one and has no effect upon air emissions. This, of course, would be a naive assumption. An EPA study shows that the higher the proportion of urban population, the more likely are vehicles to increase cold operation during afternoon rush when work-to-home trips are at a peak and vehicles have been standing idle for 8 hours [50]. Using this principle, cold operation for the Mississippi coastal region was adjusted by multiplying the national average cold operation factor times the ratio of regional to national urban population proportion, as shown below.

$$\frac{\text{Regional Urban Proportion}}{\text{National Urban Proportion}} \times \text{National Cold Operation}$$

Catalyst (Post-1975)

$$\frac{.77}{.735} \times .47 = .49$$

where: .47 = .27 + .20

Source: [47]

Non-Catalyst (Pre-1975)

1.048 x .20 = .21

The adjusted hot/cold proportions for catalytic and non-catalytic vehicles are given below.

Catalytic Adjusted

Cold (w)	21%
Hot Start-up (x)	28%
Hot Stabilized	51%

Non-Catalytic Adjusted

Cold (w)	21%
Hot	79%

Using the adjusted hot/cold proportions in the correction factor formulas (R_{iptw}), the hot/cold temperature correction factors for air emissions were computed as shown below.

(1) Carbon Monoxide:

Pre-1975

$$R_{iptw} = \frac{20 + (100-21)(.3215)}{20 + 80(.3215)} = .995$$

Post-1975

$$R_{iptw} = \frac{21 + 28(.3215) + (100-21-28)(-2.895)}{20 + 27(.3215) + 53(-2.895)}$$

$$R_{iptw} = .94$$

(2) Hydrocarbons:

Pre-1975

$$R_{iptw} = \frac{20 + (100-21)(.5593)}{20 + 80(.5593)} = .99$$

Post-1975

$$R_{iptw} = \frac{21 + 28(.5593) + (100-21-28)(.1301)}{20 + 27(.5593) + 53(.1301)}$$

$$R_{iptw} = 1.03$$

(3) Nitrogen Oxides:

Pre-1975

$$R_{iptw} = \frac{21 + (100-21)(1.1844)}{20 + 80(1.1844)} = .99$$

Post-1975

$$R_{iptw} = \frac{21 + 28(1.1844) + (100-21-28)(.791)}{20 + 27(1.1844) + 53(.791)}$$

$$R_{iptw} = 1.01$$

At this point we have derived the following correction factors of Equation 5, Section III-B: M, V, Z, and R. The uncorrected mean emissions factor in grams per mile (C_{ipn}) for each pollutant is given in the table below.

Carbon Monoxide, Hydrocarbon, and Nitrogen Oxides
Exhaust Emission Factors For Light-Duty, Gasoline-Powered Vehicles
Excluding California-For Calendar Year 1977
(Based on 1975 Federal Test Procedure)

Location and model year	Carbon Monoxide		Hydrocarbons		Nitrogen oxides	
	g/mi	g/km	g/mi	g/km	g/mi	g/km
Low Altitude						
Pre-1968	98.0	60.9	9.2	5.7	3.34	2.07
1968	79.6	49.4	9.2	5.7	4.32	2.68
1969	77.4	48.1	7.3	4.5	5.08	3.15
1970	66.0	41.0	7.3	4.5	4.35	2.70
1971	63.5	39.4	5.9	3.7	4.30	2.67
1972	47.0	29.2	4.7	2.9	4.55	2.83
1973	45.0	27.9	4.4	2.7	3.9	2.4
1974	43.0	26.7	4.1	2.5	3.7	2.3
1975	10.8	6.7	1.4	0.9	3.3	2.0
1976	9.9	6.1	1.2	0.7	3.2	2.0
1977	9.0	5.6	1.0	0.6	2.0	1.2

Source: [51]

The mean emissions factors (C) were multiplied by appropriate correction factors thus derived in order to regionalize the estimation of air emissions tonnages. The sum of the composite emissions factors ($E_{nstw}(x)$) in coastal regions for all years yields total emissions in grams per mile. The procedure is applied to carbon monoxide, hydrocarbons, and nitrogen oxides in the next three tables. Emissions of particulates and sulfur oxides do not require correction and are computed in the final table.

Carbon Monoxide

Model Year	C_{in}	M_{in}	V_{is}	Z_{it}	$R_{itw(x)}$	$E_{nstw(x)}$
1977	9.0	.104	.4	1.69	.94	.60
1976	9.9	.131	.4	1.69	.94	.82
1975	10.8	.095	.4	1.69	.94	.65
1974	43.0	.114	.4	1.10	.995	2.15
1973	45.0	.121	.4	1.10	.995	2.38
1972	47.0	.098	.4	1.10	.995	2.02
1971	63.5	.074	.4	1.10	.995	2.06
1970	66.0	.064	.4	1.10	.995	1.85
Pre-1970	85.0	.199	.4	1.10	.995	9.07
Composite Emissions: Grams Per Mile						21.60

Source: [51]

Hydrocarbons

Model Year	C_{in}	M_{in}	V_{is}	Z_{it}	$R_{itw(x)}$	$E_{nstw(x)}$
1977	1.0	.104	.56	1.21	1.03	.07
1976	1.2	.131	.56	1.21	1.03	.11
1975	1.4	.095	.56	1.21	1.03	.09
1974	4.1	.114	.56	1.05	.99	.27
1973	4.4	.121	.56	1.05	.99	.31
1972	4.7	.098	.56	1.05	.99	.27
1971	5.9	.074	.56	1.05	.99	.25
1970	7.3	.064	.59	1.05	.79	.29
Pre-1970	8.6	.199	.53	1.05	.99	.94
Composite Emissions: Grams Per Mile						2.60

Source: [51]

Nitrogen Oxides

Model Year	C_{in}	M_{in}	V_{is}	Z_{it}	$R_{itw(x)}$	$E_{nstw(x)}$
1977	2.0	.104	1.205	1.12	1.01	.28
1976	3.2	.131	1.205	1.12	1.01	.57
1975	3.3	.095	1.205	1.12	1.01	.43
1974	3.7	.114	1.205	1.05	.99	.53
1973	3.9	.121	1.205	1.05	.99	.59
1972	4.55	.098	1.205	1.05	.99	.56
1971	4.3	.074	1.205	1.05	.99	.40
1970	4.35	.064	1.202	1.05	.99	.35
Pre-1970	4.25	.199	1.167	1.05	.99	1.03
Composite Emissions: Grams Per Mile						4.74

Source: [51]

Total miles traveled in 1977 by privately-owned passenger vehicles are given below. Total miles traveled were then multiplied by composite emissions factors (E) in grams per mile to yield total grams of air emissions. This procedure is summarized in the final table. Total grams were converted to tons to complete the estimation of household air emissions. Particulates and sulfur oxides did not require regional correction and were estimated directly from their composite emission factors. As explained earlier, household air pollution was entered in the Service Station sector because of the more linear relationship between gasoline sales and automobile usage.

Total Miles Traveled Registered Private Vehicles
Mississippi Coastal Region 1977

Model Year	Proportion of Total Annual Travel[a]	Total Passenger Vehicles, MS Coastal Region 1977[b]	Avg. Annual mi. Traveled/ veh/model yr[c]	Miles Traveled 1977
1977	.104	14,859	15,900	236,258,100
1976	.131	18,715	15,000	280,725,000
1975	.095	13,573	14,000	190,022,000
1974	.114	16,288	13,100	213,372,800
1973	.121	17,288	12,000	207,456,000
1972	.098	14,002	11,300	158,222,600
1971	.074	10,573	10,300	108,901,900
1970	.064	9,144	9,400	85,953,600
Pre-1970	.199	28,432	7,240	205,847,680
Total	1.000	142,874	-	1,686,759,680

[a] [41], [45]
[b] [32], [31]
[c] [46], [51]

Household Sector Air Pollution
Mississippi Coastal Region, 1977

Air Pollutant	Composite Emissions Grams/Mile[a]	Total Miles	Total Grams	Total Tonnage[b]
Carbon Monoxide	21.60	1,686,759,680	36,434,009,088	40,160.945
Hydrocarbons	2.60	"	4,385,575,168	4,834.188
Nitrogen Oxides	4.74	"	7,995,240,883	8,813.096
Particulates[c]	.60	"	1,012,055,808	1,115.582
Sulfur Oxides[c]	.23	"	387,954,726	427.640

[a] [51], See previous discussion
[b] 1 Ton ≈ 907,200 grams
[c] No regional correction required

<u>Solid</u>

The solid waste factor for urban areas with a population density of 10-200 persons per square mile was applied to estimated 1977 Mississippi coastal population to give solid waste tonnage. The upper limit of the range for the waste factor was used since population density approached 200 per square mile [34]. A 365 day year is assumed.

	285246	= Population (See Households, Water)
x	3.1	= Pounds/day/person [42]
=	884262.6	= Pounds/day
x	365	= Days/year
=	161377.920	= Tons/year

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