A DECISION MODEL FOR THE TRADE-OFF BETWEEN THE BENEFITS OF ECONOMIC GROWTH AND ITS ENVIRONMENTAL COST

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In recent years there has been a growing awareness on the part of the public as well as the private sector of the limitations of our natural resources. It was made clear by those concerned that economic growth irreparably damages the environment. They call for an end or at least sharp curtailment of such growth. On the other hand, economists, in general, perceive growth as an essential requirement of our social welfare. The restoration and protection of the environment envisioned by ecologists require reduction in living standards which could seriously endanger the political well-being of the American society.

From all indications, the world, especially the western democracies and Japan, is destined and committed to a policy of economic growth. It then becomes necessary for policy-makers to devise positions and enforce policies where a trade-off between the benefits of growth and its environmental costs can be calculated in a quantifiable manner.

Such objective analysis could identify some projects as not being beneficial on environmental grounds though justifiable on economic grounds. It can also identify projects or programs that induce growth and simultaneously require minimal ecologic trade-off.

Among the most promising empirical models available at the present to evaluate the economic-ecologic trade-off is the "Materials Balance Approach" for the entire economy. The principle states that resources taken from the environment for use in production and services must be returned to the environment as waste residuals in equal mass. In describing this approach Allen Kneese [3] says:

> The inputs of the system are fuel, foods, and raw materials which are partly converted into final goods, and partly become residuals. Except for increases in inventory, final goods also ultimately enter the residuals stream. Thus, goods which are "consumed" really only render certain services. Their material substance remains in existance and must be either reused or discharged to the natural environment.

A comprehensive review of models in which the extension of input-output analysis includes environmental externalities as material flows into and out of the economic sector shows that there is basically a handful of comparable approaches. Among the most prominent are the Ayers-Kneese model [1], the Daly model [2], the Isard model [5], the Leontief model [7], the Victor model [15] and the Hite-Laurant model [4].

The approach followed in this study is in essence a modification of the Hite-Laurant model as was applied in their study of the Charleston metropolitan region [6]. It is practical and easy to operate and recognizes data problems. The model includes waste residuals from the economy to the environment. This allows the extension of the accounting framework of the input-output table to the environmental sector by specifying the outputs of a number of chemical and biological effluents to air and water and of solid wastes as exports of production by-products. It consists of three phases as follows:

(1) Development of an input-output accounting of the region. It is the flow of goods and services in dollars usually during a year period. The economic activities of the region are depicted in terms of sectors composed of industries. The elements of the transactions among these sectors are displayed in the "Transaction Matrix." These elements are inter-industry flow in the sense that goods are transferred from some sectors as output to be used by others as input. An exogenous sector defined as Final Demand which includes households, government, and exports absorbs the remainder of output. Output and employment multipliers can be calculated.

(2) Development of an inventory of water and air pollutants as well as solid wastes that were produced as consequences of economic activities of the diverse producing sectors including households. This is the residual stream of the material substances which are discharged to the natural environment.

(3) The economic-ecologic trade-off is then accomplished through the incorporation of the results obtained in (1) and (2) as follows:

Let:

E = A matrix of outflows of residuals to the environment.

$(I-A)^{-1}$ = The Leontief inverse. It is the inverse of the input-output model.

U = A matrix of the direct and indirect environmental impact of each economic sector.

Then:

$$E(I-A)^{-1} = U$$

The multiplication of these matrices provides the necessary linkage between the economy and the environment. The analysis is carried further by obtaining the environmental-output multipliers and environmental-income multipliers. These multipliers are obtained by dividing the output and employment multipliers calculated from the input-output matrix by the economic-ecologic matrix.

These multipliers in the form of matrices in a sense show the impacts of economic growth on the ecologic system. They can provide valuable information regarding the trade-off between the benefits of economic growth and its environmental costs.

Such information is potentially valuable in decision-making. It is an empirical assessment of benefit-cost between economic growth and environmental integrity.

An actual application of this model was implemented for the Coastal Region of Mississippi. This region consists of three counties with a total population in excess of 270,000, and it is the fastest economically growing area in the State. An outline of this empirical study which is based on work reported in [9], [10], and [11] is presented.*

1. The Economic Model

The input-output model is arranged with 29 endogenous sectors. It is constructed by using regionalization techniques of the 83 sectors national input-output tables for 1971 [16]. The aggregation scheme for grouping common sectors is based on the Standard Industrial Classification (SIC) code developed by the Department of Commerce.

An essential component of the economic model is the Transaction Matrix given in Table 1. It illustrates the structure of the economy in an accounting format in the sense that sales by a sector to other sectors and the final demand (households, federal government, and exports) would equal the purchases of the particular sector from other sectors and value added (households as payment for labor, federal government as payment of taxes, and inputs). The horizontal rows are sales and the vertical columns are the purchases. Inputs comprise the residuals necessary to make sales (output) equal to purchases (input) and reflect purchases of labor, materials and input outside the study region. They also include items such as profit and depreciation.

Useful economic measures as consequences of input-output analysis are the output and income multipliers which are given in Table 2. Output multipliers measure the effects of changes in the final demand for output of each sector and the impulse it generates throughout the economy. Income multipliers express the total change in income due to change in sales of a particular sector to Final Demand.

When Households sector is included among the endogenous sectors, the multipliers are called Type II. Otherwise, they are called Type I. It can be shown that multipliers of Type II are larger than multipliers of Type I.

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*Due to their lengths, only parts of the tables are presented for illustration. For a more technical discussion and details, see [9], [10] and [11].

2. The Environmental Model

The environmental model consists of an inventory of water and air pollution as well as solid wastes. These are the physical magnitudes generated through the economic activities of the coastal region of Mississippi.

Water effluent information was based primarily upon actual data provided by the Mississippi Air and Water Pollution Control Commission [8] obtained as part of their monitoring of producing establishments. 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 contact with engineers and experts in this field.

Quantities of air pollutants were derived from national data 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-houshold 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 [13 and 14]. The non-household category includes sectors 1-29 and was estimated by adopting air pollution coefficients based on a pioneering study by Peter Victor [15].

Solid waste was estimated primarily from per-capita solid waste factors. The factors were obtained from the published detailed engineering study by Salvato [12].

The basic structure of the environmental matrix for the coastal region of Mississippi is illustrated in Table 3. It contains 29 rows representing the endogenous sectors, that is, the economic producing sectors of the region. Households, the last row, is the exogenous 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 emission, and solid waste from the area's economy into the environment. The coefficients in the table represent values estimated for the year 1977.

3. The Economic-Environmental Linkage

The economic model and the environmental model are then linked to show the interdependence between economic activities and waste generation. It will emphasize that changes in the economy will accompany changes in the environment. Estimates in the form of pollution produced per dollar of output, employment and income can be obtained. Furthermore, environmental-economic multipliers can be calculated for each combination of environmental category and economic sector.

Tables 4 and 5 are the results of the immediate application of the linkage. In each of these tables, the rows indicate the pollutants and the columns numbered 1 through 30 are the economic sectors of the region.

Table 4 shows the environmental effects resulting from the inter-industry sales and purchases. Every entry in this table represents the total exports of pollution to the environment. That is, a $1,000 increase in economic activity of a certain sector will cause increases in production in all other sectors due to the multiplier effect. Through their economic activities to meet the demands of that sector, they in turn will contribute to the pollution. For example, Sector 8, the Food Processing, when increasing its output by $1,000 will cause a total discharge to the environment of .108 (MGY) of waste water, .003 tons of nitrogen, .006 tons of BOD, .013 tons of suspended solids, .005 tons of settleable solids, .003 tons of oil and grease, .003 tons of nitrogen oxides, .03 tons of sulfur oxide, .02 tons of carbon monoxide, .006 tons of particulates, .002 tons of hydrocarbons, and .78 tons of solid waste.

It can be observed from Table 4 that though some of the sectors were not contributing to pollution directly through their production process, nevertheless, indirectly they cause other sectors to do so through their supporting activities. The construction industry, Sector 7, does not produce BOD directly, yet through the round of economic activities by the supporting industries .002 tons of BOD is produced for each $1,000 increase in construction.

The trade-off between income and the environment is given in the matrix illustrated in Table 5. The entries represent the physical quantities of pollutants generated through $1,000 increase in income of the various sectors. Looking at this from another view point, the limitations in environmental pollution by the quantities listed for each sector will necessarily cause a $1,000 decrease in income.

The values computed in Tables 4 and 5 are obtained by allowing the Households sector to be included among the producing sectors. Therefore, these tables give the direct, indirect, and induced effects of the economic-environmental interdependencies.

A Practical Example

The model discussed can be used in a variety of useful ways depending on the nature of inquiry as regards to the interplay between the economy and the environment. As an example, environmental requirements due to attracting new industries will be discussed.

The attraction of a new industry to a region would have a multiple effect over the other producing sectors. First, through the economic interrelationships, all sectors in the region will expand their outputs to meet the new demands.

Assume that a comparison of economic-ecologic trade-off is desired between a new Food Processing industry and a new Chemcial-Petroleum industry. Further assume that the anticipated potential for both industries is of a magnitude of a million dollars per year. Anticipated sales of all the economic sectors can be calculated using the information from Table 1. These estimated values are given in Table 6.

In order to obtain estimates of pollution factors that will be caused by all sectors, Columns 8 and 13 of Table 4 can be used as the basis of calculation. The resulting detailed environmental pollutions to be contributed by each sector in the region are portrayed in Tables 7 and 8 for the Food Processing and the Chemical-Petroleum. Hence, information provided can be used for the purpose of deciding on the merits of each plan regarding the benefits of economic growth and its environmental cost.

Information currently available does not permit measuring the impact of the pollutants on the environment in dollar values. Some wastes (by products) have a positive economic effect; and some, negative. In other words discards from some sectors may enhance economic output of other sectors while other residuals may reduce productivity of other industries. For example, BOD discharges from the household and other sectors may harm the environment and thus reduce output of the fishery sector. Research to facilitate measuring such effects is needed.

TABLE 1

TRANSACTIONS MATRIX - MISSISSIPPI COASTAL REGION, 1972
(Thousands of Dollars)

	Input (Purchases) \ Output (Sales)	Fisheries	. . .	Construction	Food Processing	. . .	Chemical/Petro/ Other	. . .
		1	. . .	7	8	. . .	13	. . .
1	Fisheries	150.	. . .	0.	7235.	. . .	0.	. . .
2	Forestry	0.	. . .	0.	0.	. . .	881.	. . .
3	Livestock Products	0.	. . .	0.	2235.	. . .	0.	. . .
4	Crops & Agricultural	0.	. . .	0.	1135.	. . .	23.	. . .
5	Ag Forestry, Fish Svc	219.	. . .	352.	0.	. . .	0.	. . .
6	Mining	0.	. . .	1245.	0.	. . .	301.	. . .
7	Construction	0.	. . .	48.	461.	. . .	3056.	. . .
8	Food Processing	0.	. . .	0.	8335.	. . .	172.	. . .
9	Apparel & Finished	0.	. . .	0.	0.	. . .	0.	. . .
10	Lumber & Wood	0.	. . .	5008.	29.	. . .	156.	. . .
11	Paper & Allied	0.	. . .	111.	483.	. . .	894.	. . .
12	Printing/Publishing	0.	. . .	41.	163.	. . .	34.	. . .
13	Chemical/Petro/Other	11.	. . .	111.	73.	. . .	1528.	. . .
14	Stone, Clay & Glass	1.	. . .	4296.	512.	. . .	447.	. . .
15	Primary/Fab Metals	54.	. . .	3858.	172.	. . .	151.	. . .
16	Transportation Equip	3024.	. . .	2.	2.	. . .	0.	. . .
17	Miscellaneous Mfg	36.	. . .	917.	140.	. . .	586.	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
29	State/Local Gov't	3.	. . .	139.	175.	. . .	500.	. . .
	ENDOGENOUS TOTALS	4167.	. . .	34670.	30400.	. . .	39702.	. . .
30	Households	2795.	. . .	51352.	26854.	. . .	56807.	. . .
31	Federal Gov't	336.	. . .	4017.	2176.	. . .	7170.	. . .
32	Imports	4602.	. . .	29361.	40408.	. . .	107549.	. . .
	TOTAL PURCHASES	11900.	. . .	119400.	99838.	. . .	221228.	. . .

TABLE 2

TYPE I AND TYPE II MULTIPLIERS

	Sector	Type I Output	Type I Income	Type II Output	Type II Income
1	Fisheries	1.40	1.49	2.22	1.99
2	Forestry	1.14	1.19	1.79	1.58
3	Livestock Products	1.72	1.88	2.75	2.50
4	Crops & Agricultural	1.42	1.56	2.27	2.07
5	Ag Forestry, Fish Svc	1.09	1.12	1.70	1.48
6	Mining	1.30	1.79	1.78	2.38
7	Construction	1.38	1.28	2.66	1.70
8	Food Processing	1.42	1.45	2.33	1.92
9	Apparel & Finished	1.27	1.31	2.09	1.74
10	Lumber & Wood	1.50	1.51	2.45	2.00
11	Paper & Allied	1.30	1.36	2.15	1.80
12	Printing/Publishing	1.32	1.38	2.18	1.83
13	Chemical/Petro/Other	1.24	1.29	2.05	1.72
14	Stone, Clay & Glass	1.37	1.45	2.28	1.93
15	Primary/Fab Metals	1.35	1.45	2.26	1.93
16	Transportation Equip	1.08	1.09	1.76	1.44
17	Miscellaneous Mfg	1.27	1.33	2.10	1.76
18	Water Transportation	1.52	1.46	3.00	1.93
19	Other Transp/Whse	1.41	1.35	2.79	1.80
20	Communication/Pu Utl	1.10	1.38	1.35	1.84
21	Eating & Drinking	1.35	1.29	2.50	1.72
22	Service Stations	1.31	1.27	2.44	1.69
23	Wholesale/Retail	1.20	1.15	2.23	1.53
24	Finance/Ins/Real Est	1.28	1.42	1.97	1.88
25	Hotel, Motel, Lodging	1.30	1.21	2.53	1.61
26	Medical Services	1.25	1.16	2.44	1.55
27	Educational Services	1.26	1.17	2.45	1.55
28	Other Services	1.24	1.16	2.42	1.54
29	State/Local Gov't	1.62	1.59	3.04	2.12
	TOTAL	38.41	39.54	66.00	52.53
	AVERAGE	1.32	1.36	2.28	1.81

TABLE 3

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

Sector Number	Sector Name	Waste Water (MGY) 1	Chlorine (Tons/yr) 2	Nitrogen (Tons/yr) 3	Sulfides (Tons/yr) 4	Flouride (Tons/yr) 5	. . .
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					. . .
8	Food Processing	7,534.839	4.372	245.560			. . .
9	Apparel & Finish	328.634	.135	2.246			. . .
10	Lumber & Wood	311.268		12.949			. . .
11	Paper & Allied	7,245.000					. . .
12	Printing & Publishing	6.495					. . .
13	Chemical/Petro/Other	12,874.239		153.936	1.811	256.363	. . .
14	Stone, Clay & Glass	3,240.408	.010				. . .
15	Primary/Fab Metals	1,458.868	.777	17.983			. . .
16	Transportation Equip	324,804.460	1.586				. . .
17	Miscellaneous Mfg	86.848	.028	.919			. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .
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	. . .

MGY = Million gallons per year.

TABLE 4

TYPE II ENVIRONMENTAL-OUTPUT INTERDEPENDENCE MATRIX (TONS)
(ENVIRONMENTAL CHANGE PER $1,000 CHANGE IN FINAL DEMAND)
MISSISSIPPI COASTAL REGION, 1977

		Fisheries	. . .	Construction	Food Processing	. . .	Chemical/Petro/ Other	. . .
		1	. . .	7	8	. . .	13	. . .
1	Waste Water*	.169131	. . .	.030262	.107967	. . .	.070990	. . .
2	Chlorine	.000009	. . .	.000018	.000059	. . .	.000010	. . .
3	Nitrogen	.000152	. . .	.000339	.002879	. . .	.000902	. . .
4	Sulfides	.000000	. . .	.000000	.000000	. . .	.000009	. . .
5	Fluoride	.000002	. . .	.000002	.000002	. . .	.001223	. . .
6	Phosphate	.000001	. . .	.000005	.000001	. . .	.000000	. . .
7	Heavy Metals	.000000	. . .	.000000	.000000	. . .	.000062	. . .
8	Zinc	.000001	. . .	.000001	.000000	. . .	.000000	. . .
9	Cadmium	.000000	. . .	.000001	.000000	. . .	.000003	. . .
10	Iron	.000001	. . .	.000002	.000001	. . .	.000222	. . .
11	Chromium	.000000	. . .	.000000	.000000	. . .	.000003	. . .
12	Aluminum	.000000	. . .	.000005	.000001	. . .	.000000	. . .
13	Copper	.000000	. . .	.000001	.000000	. . .	.000000	. . .
14	Nickel	.000000	. . .	.000001	.000000	. . .	.000000	. . .
15	Lead	.000000	. . .	.000000	.000000	. . .	.000000	. . .
16	Fecal Colifm	.000000	. . .	.000000	.000000	. . .	.000000	. . .
17	BOD	.000675	. . .	.001519	.005995	. . .	.001868	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
29	Hydrocarbons	.002165	. . .	.004571	.002291	. . .	.004235	. . .
30	Solid Waste	.149270	. . .	.258157	.778712	. . .	.213749	. . .

*Million gallons per year (MGY).

TABLE 5

TYPE II ENVIRONMENTAL-INCOME INTERDEPENDENCE MATRIX (TONS)
(ENVIRONMENTAL CHANGE PER $1,000 CHANGE IN INCOME)
MISSISSIPPI COASTAL REGION, 1977

		Fisheries	. . .	Construction	Food Processing	. . .	Chemical/Petro/ Other	. . .
		1	. . .	7	8	. . .	13	. . .
1	Waste Water *	.362757	. . .	.041293	.208602	. . .	.153765	. . .
2	Chlorine	.000020	. . .	.000024	.000114	. . .	.000021	. . .
3	Nitrogen	.000326	. . .	.000463	.005563	. . .	.001953	. . .
4	Sulfides	.000000	. . .	.000000	.000000	. . .	.000019	. . .
5	Fluoride	.000004	. . .	.000003	.000003	. . .	.002649	. . .
6	Phosphate	.000003	. . .	.000006	.000001	. . .	.000001	. . .
7	Heavy Metals	.000000	. . .	.000000	.000000	. . .	.000135	. . .
8	Zinc	.000003	. . .	.000001	.000000	. . .	.000000	. . .
9	Cadmium	.000001	. . .	.000001	.000000	. . .	.000006	. . .
10	Iron	.000002	. . .	.000003	.000001	. . .	.000481	. . .
11	Chromium	.000001	. . .	.000001	.000000	. . .	.000007	. . .
12	Aluminum	.000003	. . .	.000007	.000001	. . .	.000001	. . .
13	Copper	.000000	. . .	.000001	.000000	. . .	.000000	. . .
14	Nickel	.000001	. . .	.000002	.000000	. . .	.000000	. . .
15	Lead	.000000	. . .	.000000	.000000	. . .	.000000	. . .
16	Fecal Colifm	.000000	. . .	.000000	.000000	. . .	.000000	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
29	Hydrocarbons	.004644	. . .	.006237	.004427	. . .	.009173	. . .
30	Solid Waste	.320158	. . .	.352262	1.504537	. . .	.462984	. . .

*Million gallons per year (MGY)

TABLE 6

INPUTS REQUIRED FOR A MILLION DOLLAR NEW INDUSTRY
IN THE FOOD PROCESSING AND CHEMICAL-PETROLEUM SECTORS
MISSISSIPPI COASTAL REGION (THOUSANDS OF 1972 DOLLARS)

		Sales To Food Processing	Sales To Chemicals-Petroleum
1	Fisheries	72470	
2	Forestry		4170
3	Livestock	22390	
4	Crops	11370	110
5	Ag, Forestry, Fish Svc		
6	Mining		1430
7	Construction	4620	14470
8	Food Processing	83490	810
9	Apparel & Finished		
10	Lumber & Wood	290	740
11	Paper and Allied	4840	4230
12	Printing & Publishing	1630	160
13	Chemicals & Petroleum	730	7230
14	Stone, Clay & Glass	5130	2120
15	Primary & Fab Metals	1720	710
16	Transportation Equip	20	
17	Miscellaneous Mfg	1400	2770
18	Water Transportation	8830	16920
19	Other Trans/Warehousing	6460	32750
20	Communication/Pu Util	13700	29030
21	Eating/Drinking Places	4110	2410
22	Service Stations		780
23	Wholesale & Retail Trade	31610	18530
24	Finance, Insur., Real Estate	9980	27110
25	Hotels, Motels & Lodging	1290	1180
26	Medical Services	90	150
27	Educational Services	100	170
28	Other Services	16480	1760
29	State & Local Gov't	1750	2370
30	Households	268980	268940

TABLE 7

INDUCED ENVIRONMENTAL IMPACT ATTRIBUTABLE TO A MILLION DOLLAR EXPANSION
IN THE FOOD PROCESSING INDUSTRY
MISSISSIPPI COASTAL REGION
(TONS PER YEAR)

	Environmental Factors	Fisheries	. . .	Construction	Food Processing	. . .	Chemical/Petro/ Other	. . .
		1	. . .	7	8	. . .	13	. . .
1	Waste Water*	7824.151	. . .	498.794	9013.914	. . .	78.814	. . .
2	Chlorine	4.276	. . .	.273	4.926	. . .	.043	. . .
3	Nitrogen	208.641	. . .	13.301	240.368	. . .	2.102	. . .
4	Sulfides		. . .			. . .		. . .
5	Fluorides		. . .			. . .		. . .
6	Phosphate		. . .			. . .		. . .
7	Heavy Metals		. . .			. . .		. . .
8	Zinc		. . .			. . .		. . .
9	Cadmium		. . .			. . .		. . .
10	Iron	.072	. . .	.005	.083	. . .	.001	. . .
11	Chromium		. . .			. . .		. . .
12	Aluminum	.072	. . .	.005	.083	. . .	.001	. . .
13	Copper		. . .			. . .		. . .
14	Nickel		. . .			. . .		. . .
15	Lead		. . .			. . .		. . .
16	Fecal Coliform		. . .			. . .		. . .
17	BOD	434.458	. . .	27.697	500.523	. . .	4.376	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
29	Hydrocarbons	166.029	. . .	10.584	191.276	. . .	1.672	. . .
30	Solid Waste	56433.259	. . .	3597.649	65014.665	. . .	568.460	. . .

*Million gallons per year (MGY)

TABLE 8

INDUCED ENVIRONMENTAL IMPACT ATTRIBUTABLE TO A MILLION DOLLAR EXPANSION
IN THE CHEMICALS-PETROLEUM INDUSTRY
INDUSTRY SECTORS

Environmental Factors*		Fisheries	. . .	Construction	Food Processing	. . .	Chemical/Petro/ Other	. . .
		1	. . .	7	8	. . .	13	. . .
1	Waste Water		. . .	1027.110	57.495	. . .	513.200	. . .
2	Chlorine		. . .	.145	.008	. . .	.072	. . .
3	Nitrogen		. . .	13.052	.731	. . .	6.521	. . .
4	Sulfides		. . .			. . .		. . .
5	Fluoride		. . .			. . .		. . .
6	Phosphate		. . .			. . .		. . .
7	Heavy Metals		. . .	.897	.050	. . .	.448	. . .
8	Zinc		. . .			. . .		. . .
9	Cadmium		. . .	.043	.002	. . .	.022	. . .
10	Iron		. . .	3.212	.180	. . .	1.605	. . .
11	Chromium		. . .	.043	.002	. . .	.022	. . .
12	Aluminum		. . .			. . .		. . .
13	Copper		. . .			. . .		. . .
14	Nickel		. . .			. . .		. . .
15	Lead		. . .			. . .		. . .
16	Fecal Coliform		. . .			. . .		. . .
17	BOD		. . .	27.030	1.513	. . .	13.506	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
..	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
29	Hydrocarbons		. . .	61.280	3.430	. . .	30.619	. . .
30	Solid Waste		. . .	3092.948	173.137	. . .	1545.405	. . .

*Environmental factors are represented in tons per year, except for Waste Water which is represented in million gallons per year.

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