# ECONOMIC FLOWS AND ENVIRONMENTAL COEFFICIENTS

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A major goal of the environmental research undertaken at the University of Maryland has been to develop a comprehensive yet disaggregated systems approach to the economic analysis of environmental problems. An overall modelling system of this type could be conceptualized as follows: economic activity (production, distribution, and consumption) implies generation of residual materials. Some portion of these materials, which may be treated or left untreated, is discharged to the environment. The discharged material alters the ambient quality of the general environment, and this alteration implies various real costs to individuals and economic units within the system. By varying the material discharge, one may, generally at a cost, reduce its impact upon ambient quality and upon humans.

Our research effort has, to date, been oriented toward analyzing the link between production and the generation of gross residual, and the link between generated gross residual and discharges to the environment. Presently the model is being implemented primarily at the national level. However, since environmental management is essentially a spatial phenomenon, the research reported on here is regarded as an initial step towards regionalization of data and models.

## MODEL STRUCTURE

Because wide-scale concern over the impact of the economy on the environment is a relatively recent phenomenon, reliable data on pollutant generation are not readily available. Further, such data as do exist have not in general been collected on a systematic, uniform basis. Therefore the first objective has been to devise an accounting schema for residual materials.

This accounting schema, described elsewhere,[1] is defined so as to outline, with a limited number of aggregative data categories, all significant paths by which the residual materials can flow from the economic processes to the environment. These categories have structured the data search and have substantially determined the modelling format.

The single most basic data category identified in the accounting schema is termed "gross residual". Gross residual materials are most simply defined as those production (or activity) by-products which cannot be sold or which cannot be further processed under profitable procedures. In other words these are materials which the short-run profit maximizer would prefer to discharge to the environment.

In a sense gross residual represents the total potential loading of pollutants into the environment. Since the polluter generally does not bear the costs of his own residual emissions, he usually minimizes internal costs if he discharges these materials to the environmental media. The decision as to the initial disposition of this gross residual is the basic decision variable affecting residual emissions.

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The gross residual category also provides the basic departure point for our procedures. By definition, gross residual is an activity by-product, intimately related to the materials processed and to the activity technology. The functional link assumed to relate economic activity levels to generation of gross residual is similar to that of the input-output type interindustry model, namely that the quantity of gross residual is linearly determined by industry output. Of course as with any modelling procedure, this assumption represents as abstraction from reality. It retains certain information defined as essential while aggregating over and ignoring less essential information.

Several other basic assumptions, rules and priorities have shaped the accounting schema, data collection and model format. In particular: it was regarded as essential that conceptual structure of the model fully recognize the materials and energy balance concept; the classification system for residual materials was devised so as to follow, as substantially as possible, the chemical description of the materials; the data were collected by industry for national aggregates; and finally the industries were studied, in so far as was possible, in order of worst polluter first.

## MATERIAL AND ENERGY BALANCE

It is a well known physical law that the sum total of matter and energy does not change. For all practical purposes it may be assumed that the sum total of matter also does not change. The impact of this idea on the conceptualization of economic processes has been examined by Ayres, Kneese, and D'Arge.[2] This concept governed the development of the accounting schema mentioned previously. Equally important, this concept strongly implies that any emissions model must encompass discharges to all environmental media. Clearly, no treatment process can destroy matter. Thus the sum total of materials acted upon by any treatment process must equal the sum total of materials flowing out of the treatment process. Though some of this material flowing from the treatment processes may be recycled, much of it will be discharged to the environment. Presumably, but not necessarily, the treatment activity has rendered the material less harmless, but it would be unrealistic to assume it to be completely harmless.

Thus the materials balance concept leads to a more general specification of the residuals problem. It also provides for an analogue to the double entry accounting system. Once a material is entered into the system, it is known that the material must continue to exist within the system until it is emitted into the environment or recycled. One of the more immediate projects to be undertaken is to attempt to use this fact to "balance" data categories so that net emissions plus recycling is equal to gross residual. Finally, in order to take advantage of the materials balance concept, the quantity of the materials must be specified as to their weight.

## CLASSIFICATION OF MATERIALS

In addition to being specified as to quantity, it is obvious that the residual materials must be specified as to type. The effects of pollutants certainly vary substantially as to their physical, biological, and chemical properties. It is assumed that the precise chemical description of the pollutants, when combined with the designation of the physical characteristic of weight, provides a most useful description for analyzing the effects of the materials. The chemical designation is also superior in that a chemical classification system is inherently non-double counting.

At this time, the Maryland model is by no means complete. The major effort has been directed toward development of industry residual data. The basic industry categories used are those of the Office of Business Economics 363-order input-output model. At this level, residual data for approximately 50 industries have been obtained for 1967 (the base year for the study). These data are neither necessarily fully balanced, nor complete as to the residuals pertaining to all three environmental receptor media. Slightly in excess of seventy residual material types are presently arrayed in the model. The variegated nature of the data sources has necessitated compromises short of retaining materials balance and retaining the purely chemical materials classification. Some more limited projected data for 1970, 1975, and 1980 have also been collected and entered. The data have also been classified so as to fit the industry categories of the 185 sector Almon interindustry model.

## FINAL DEMAND DATA

Recently the model approach has been generalized to include consumption and other final use activity as well as production activity. This step is necessary to close the model. From a pure flow point of view, all materials which are operated upon and transformed by the production activities must eventually become embodied in a final product or become residual material. The question arises as to the disposition of materials received by final users. After the services provided by these materials have been extracted, they too must become gross residual.

To suggest a procedure for modelling this phenomena, it is assumed that the composition and quantity of residual materials resulting from the use of various products is related to the type of product and the quantity of the product. In particular, coefficients have been derived relating gross residual, by type, to the dollar levels of household and federal government purchases, by product categories. The product categories are those of the 90-order categories. The coefficients for the selected 90-order categories have been extrapolated to the OBE 363 level to make them consistent with the production activity data.

## POLICY ANALYSIS

The policy analysis permitted by the model structure in its present form is highly limited and is based upon linear operations. Policy variables can act on residual emission in that they could affect the level of gross residual discharged untreated. The impact of an emissions tax would be analyzed as follows: the cost data on present treatment practices would indicate on a cost per weight basis whether the present mix of treatment practices reduces emissions of the controlled pollutant at a cost lower than that imposed by the tax. Presumably, a pecuniary differential between the imposed tax and treatment cost would induce the various industries to direct presently untreated gross residual through treatment processes. The treatment process mix acting upon the incrementally treated gross residual would be assumed to be similar to existing industry practice.

The cost of treating this additional amount of gross residual could be estimated, and the tax imposed on the remaining emissions could also be computed. Such a computation is useful but has substantial weaknesses. The response to policy initiative is restricted to an on-off introduction of an existing mix of treatment practices. Obviously producers would in the real world tend to alter the treatment process mix according to the stringency of the various standards. Sufficiently stringent regulations cause previously unused treatment processes to be adopted.

## MODEL EXTENSION

The major internal weakness of the Maryland environmental model as indicated is the inflexible response of treatment activity. Policy initiatives can alter only the proportion of gross residual undergoing treatment. In the coming year, an effort will be made to extend the model by the addition of pure treatment activities to an input-output model. This effort will require the intensive study of the treatment processes, both presently available and prospective, for the control of the environmental release of a selected set of major pollutants. This study may yield detailed information as to treatment process costs and a materials balance accounting of treatment residuals, per unit of gross residual treated. The treatment cost data should be expressed in terms of purchases from industries supplying the inputs to the treatment processes.

If such an attempt to enter treatment sectors in an interindustry model is successful, the calculation of complete direct and indirect interindustry effects of changes in treatment activity level could be possible. More important, the mix of treatment processes employed by any one industry would be highly flexible with regard to selected residual materials.

## EMPIRICAL FINDINGS

For presentation purposes, the residual data have been aggregated from 70 residual categories basically chemical in nature to five basically physical in nature. These are airborne residual, waterborne residual materials, BOD, solid waste, and pesticides. Industry detail has been preserved, and data for both the OBE 363 order activities and Almon 185 order activities are presented in the accompanying tables.

Table I

This table indicates the data base available for generated gross residual on an industry basis. The industries listed generated the displayed quantities of gross residual per unit of output. The dimensions are in thousands of tons per millions of dollars. The industry level of aggregation is that of the 363-order OBE activities. It should be noted that the pollutant category "BOD" is unique in that it represents not weight of materials, but rather weight of potential oxygen demand. For this reason, it is listed separately from the aggregated water pollutants.

Table II

Of the gross residual generated per unit of output, as displayed in Table I, the "Gross Residual Discharged Untreated" indicated in Table II, is that amount of gross residual discharged to the environment with no intervening treatment processes. The level of industry aggregation remains similar to Table I.

Table III

Some of the generated gross residual receives treatment. The material is altered by the treatment process whereupon much of it is emitted to the environment. Table III indicates, per unit of output, the amount of this material for each industry. Again the industry level of aggregation is that of the 363-order OBE activities.

Table IV *

Table IV is derived from Table I. The coefficients displayed in Table I are multiplied by a production figure for each industry yielding a total gross residual figure for each pollutant category and each industry. The data are expressed in thousands of tons.

Table V*

Table V is derived from Table II. The coefficients displayed in Table I are multiplied by a production figure for each industry yielding a total of gross residual discharged to the environment untreated for each pollutant category of each industry. The data are expressed in thousands of tons.

Table VI*

Table VI is derived from Table III. The coefficients displayed in Table I are multiplied by a production figure for each industry yielding a total of treatment residuals discharged to the environment for each pollutant category and each industry. The data are expressed in thousands of tons.

Table VII*

In order for any activity to deliver one dollar of output to final demand, direct production from the industry in question plus indirect production from numerous other activities in the model is required. Table VII indicates the quantity of gross residual, per unit of delivery to final demand, resulting from the production, direct plus indirect, necessary to deliver one million dollars of product to final demand by each activity. The activities are those of the 185-order Almon input-output model. (A key to these industries is included.) The quantities are expressed in terms of thousands of tons per million of dollars. The gross residual generation taken into consideration is only that for those industries shown in Table I.

Table VIII*

Table VIII is similar to Table VII. The quantities represented are those of gross residual discharged untreated rather than gross residual.

Table IX*

Table IX is similar to Table VII. The quantities displayed are weight of direct plus indirect treatment residuals discharged to the environment per million dollars of delivery to final demand.

## CONCLUSIONS

These tables represent a major portion of the data base which has been developed. Much analysis of these data remains to be done. However, we believe that this base is an appropriate one with which to begin a complete analysis of residual emissions resulting from economic activity.

*(Note: Tables I-III only are included. Tables IV-IX are derived from I-III, and are available from the authors on request.)

TABLE I
DIRECTLY GENERATED GROSS RESIDUAL, BY INDUSTRY FOR 1967, THOUSAND TONS/MILS $

| OBE No. | Name | Air Pollutants | Waterborne Waste | BOD | Solid Waste | Pesticides |
|---|---|---|---|---|---|---|
| 1.01 | Dairy Farm Prod. | .00000 | 15,66643 | .90921 | .00000 | .00000 |
| 1.02 | Poultry & Eggs | .00000 | 5,05505 | .64799 | .00000 | .00000 |
| 1.03 | Meat Animals & Livestock | .00000 | 17,92921 | 1.34274 | .00000 | .00000 |
| 2.01 | Cotton | .00000 | .45253 | .00000 | .00000 | .08772 |
| 2.02 | Food Feed Grains & Seeds | .00000 | .37849 | .00000 | .00000 | .00873 |
| 2.03 | Tobacco | .00000 | .12105 | .00000 | .00000 | .01386 |
| 2.04 | Fruit & Tree Nuts | .00000 | .12049 | .00000 | .00000 | .06545 |
| 2.05 | Veg., Sugar & Misc. Crops | .00000 | .36587 | .00000 | .00000 | .01103 |
| 2.06 | Oil Bearing Crops | .00000 | .12272 | .00000 | .00000 | .00364 |
| 2.07 | Forest & Greenhouse Prod. | .00000 | .00815 | .00000 | .00000 | .00000 |
| 4.00 | Forestry & Fishery Prod. | .04110 | .00000 | .00000 | .00000 | .00000 |
| 5.00 | Iron & Ferroalloy Ores Min. | .00000 | .00000 | .00000 | 381.00000 | .00000 |
| 6.01 | Copper Ore Mining | .00000 | .00000 | .00000 | 772.00000 | .00000 |
| 6.02 | Nonfer Metal Ores Mining | .00000 | .00000 | .00000 | 136.00000 | .00000 |
| 7.00 | Coal Mining | .32400 | .24000 | .00000 | 1048.00000 | .00000 |
| 9.00 | Stone & Clay Min. & Quarr | .00000 | .00000 | .00000 | 40.00000 | .00000 |
| 10.00 | Chem. & Fert. Mineral Min. | .00000 | .00000 | .00000 | 622.00000 | .00000 |
| 14.01 | Meat Products | .00000 | .06524 | .02785 | .00000 | .00000 |
| 14.02 | Creamery Butter | .00000 | .00000 | .19352 | .00000 | .00000 |
| 14.03 | Cheese, Natural & Process | .00000 | .52699 | .23458 | .00000 | .00000 |

TABLE I
DIRECTLY GENERATED GROSS RESIDUAL, BY INDUSTRY FOR 1967, THOUSAND TONS/MILS $
Continued

| OBE No. | Name | Air Pollutants | Waterborne Waste | BOD | Solid Waste | Pesticides |
|---|---|---|---|---|---|---|
| 14.04 | Condensed & Evap. Milk | .00000 | .00523 | .00996 | .00000 | .00000 |
| 14.05 | Ice Cream & Frozen Des | .00000 | .00000 | .00831 | .00000 | .00000 |
| 14.06 | Fluid Milk | .00000 | .00767 | .01143 | .00000 | .00000 |
| 14.09 | Canned Fruits & Veg. | .00000 | 4.68502 | .15961 | .00000 | .00000 |
| 14.11 | Pickles, Sauces & Dress. | .00000 | .01710 | .00000 | .00000 | .00000 |
| 14.13 | Frozen Fruits & Veg. | .00000 | 2.64220 | .00000 | .00000 | .00000 |
| 14.14 | Flour & Cereal Prep. | .98913 | .00000 | .00000 | .00000 | .00000 |
| 14.17 | Wet Corn Milling | .00000 | .08119 | .00000 | .00000 | .00000 |
| 14.19 | Sugar | .00000 | .01446 | .00000 | .00000 | .00000 |
| 14.21 | Alcoholic Beverages | .00000 | .35195 | .02819 | .00000 | .00000 |
| 14.22 | Bot. & Canned Soft Drinks | .00000 | .00261 | .00760 | .00000 | .00000 |
| 14.25 | Soybean Oil Mills | .00000 | .01396 | .00000 | .00000 | .00000 |
| 16.01 | Broad Fab Mill & Fab Fin | .00000 | .09258 | .05793 | .00000 | .00000 |
| 24.01 | Pulp Mills | 1.01824 | .00000 | .00000 | .00000 | .00000 |
| 24.02 | Paper Mills, Except Bldg. | .00000 | 1.35705 | .26215 | .00000 | .00000 |
| 26.01 | Newspapers | .00000 | .00000 | .00000 | .11163 | .00000 |
| 26.02 | Periodicals | .00000 | .00000 | .00000 | .09854 | .00000 |
| 26.03 | Book Printing & Pub. | .00000 | .00000 | .00000 | .06251 | .00000 |
| 26.05 | Commerical Printing | .00000 | .00000 | .00000 | .14581 | .00000 |
| 26.08 | Misc. Printing Services | .00000 | .00000 | .00000 | .05036 | .00000 |

TABLE I

DIRECTLY GENERATED GROSS RESIDUAL, BY INDUSTRY FOR 1967, THOUSAND TONS/MILS $

Continued

| OBE No. | Name | Air Pollutants | Waterborne Waste | BOD | Solid Waste | Pesticides |
|---|---|---|---|---|---|---|
| 27.01 | Ind. Inorg. & Org. Chem. | 3.53200 | .00000 | .00000 | .00000 | .00000 |
| 27.02 | Fertilizers | .70366 | .00000 | .00000 | .00000 | .00000 |
| 28.01 | Plast Mat. & Resins | .00000 | .00000 | .01614 | .00000 | .00000 |
| 31.01 | Pet Ref. & Related Prod. | .96304 | .00001 | .00005 | .00000 | .00000 |
| 31.02 | Paving Mixt. & Blocks | 1.74000 | .00000 | .00000 | .00000 | .00000 |
| 32.01 | Tires & Inner Tubes | ..00000 | .00000 | .00000 | .04821 | .00000 |
| 32.02 | Rubber Footwear | .00000 | .00000 | .00000 | .11655 | .00000 |
| 32.03 | Recl. Rubber & Misc. Prod. | .00000 | .00000 | .00000 | .08468 | .00000 |
| 33.00 | Leather Tan & Ind. Leather | .00000 | .63830 | .09201 | .00000 | .00000 |
| 36.01 | Cement, Hydraulic | 6.39167 | .00000 | .00000 | .00000 | .00000 |
| 36.13 | Lime | 3.58333 | .00000 | .00000 | .00000 | .00000 |
| 37.01 | Blast Furn. & Basic Steel | .47263 | .01268 | .00000 | .00000 | .00000 |
| 37.02 | Iron & Steel Foundries | 1.73704 | .00000 | .00000 | .00000 | .00000 |
| 38.01 | Primary Copper | 1.56250 | .00000 | .00000 | .00000 | .00000 |
| 38.02 | Primary Lead | 8.60769 | .00000 | .00000 | .00000 | .00000 |
| 38.04 | Primary Aluminum | .14103 | .00000 | .00000 | .00000 | .00000 |
| 59.01 | Truck & Bus Bodies | .00000 | .00000 | .00000 | .00000 | .00000 |
| 59.03 | Motor Vehicles & Parts | .00000 | .00169 | .00039 | .00000 | .00000 |
| 65.05 | Air Transport | .08803 | .00000 | .00000 | .00000 | .00000 |
| 68.01 | Electric Utilities | 2.41279 | .00000 | .00000 | .00000 | .00000 |

TABLE II

DIRECTLY GENERATED GROSS RESIDUAL DISCHARGED UNTREATED, BY INDUSTRY, FOR 1967, THOUSAND TONS/MIL $



| OBE No. | Name | Air Pollutants | Waterborne Waste | BOD | Solid Waste | Pesticides |
|---|---|---|---|---|---|---|
| 4.00 | Forestry & Fishery Prod. | .01233 | .00000 | .00000 | .00000 | .00000 |
| 5.00 | Iron & Ferroalloy Ores Min. | .00000 | .00000 | .00000 | 230.00000 | .00000 |
| 6.01 | Copper Ore Mining | .00000 | .00000 | .00000 | 575.00000 | .00000 |
| 6.02 | Nonfer Metal Ores Mining | .00000 | .00000 | .00000 | 66.00000 | .00000 |
| 7.00 | Coal Mining | .05933 | .24000 | .00000 | 31.00000 | .00000 |
| 9.00 | Stone & Clay Min. & Quarr | .00000 | .00000 | .00000 | 37.00000 | .00000 |
| 10.00 | Chem. & Fert. Mineral Min. | .00000 | .00000 | .00000 | 434.00000 | .00000 |
| 14.01 | Meat Products | .00000 | .00000 | .00248 | .00000 | .00000 |
| 14.02 | Creamery Butter | .00000 | .00000 | .11226 | .00000 | .00000 |
| 14.03 | Cheese, Natural & Processed | .00000 | .00000 | .02998 | .00000 | .00000 |
| 14.04 | Condensed & Evap. Milk | .00000 | .00000 | .00577 | .00000 | .00000 |
| 14.05 | Ice Cream & Frozen Des. | .00000 | .00000 | .00133 | .00000 | .00000 |
| 14.06 | Fluid Milk | .00000 | .00000 | .00192 | .00000 | .00000 |
| 14.14 | Flour & Cerel Prep. | .49457 | .00000 | .00000 | .00000 | .00000 |
| 14.21 | Alcoholic Beverages | .00000 | .00003 | .00017 | .00483 | .00000 |
| 16.01 | Broad Fab Mill & Fab Fin. | .00000 | .02933 | .02040 | .00000 | .00000 |
| 24.01 | Pulp Mills | .98529 | .00000 | .00000 | .00000 | .00000 |
| 24.02 | Paper Mills, Except Bldg. | .00000 | .36640 | .07078 | .00000 | .00000 |
| 27.01 | Ind. Inorg. & Org. Chem. | 3.04400 | .00000 | .00000 | .00000 | .00000 |
| 27.02 | Fertilizers | .06829 | .00000 | .00000 | .00000 | .00000 |

TABLE II

DIRECTLY GENERATED GROSS RESIDUAL DISCHARGED UNTREATED, BY INDUSTRY, FOR 1967, THOUSAND TONS/MIL $

Continued

| OBE No. | Name | Air Pollutants | Waterborne Waste | BOD | Solid Waste | Pesticides |
|---|---|---|---|---|---|---|
| 28.01 | Plast Mat & Resins | .00000 | .00000 | .00471 | .00000 | .00000 |
| 31.01 | Pet Ref. & Related Prod. | .49956 | .00000 | .00000 | .00000 | .00000 |
| 33.00 | Leather Tan & Ind. Leather | .00000 | .03191 | .00460 | .00000 | .00000 |
| 36.01 | Cement, Hydraulic | .31667 | .00000 | .00000 | .00000 | .00000 |
| 36.13 | Lime | .71667 | .00000 | .00000 | .00000 | .00000 |
| 37.01 | Blast Furn. & Basic Steel | .28977 | .00655 | .00000 | .00000 | .00000 |
| 37.02 | Iron & Steel Foundries | 1.35704 | .00000 | .00000 | .00000 | .00000 |
| 38.01 | Primary Copper | 1.10500 | .00000 | .00000 | .00000 | .00000 |
| 38.02 | Primary Lead | 4.47692 | .00000 | .00000 | .00000 | .00000 |
| 59.03 | Motor Vehicles & Parts | .00000 | .00025 | .00006 | .00000 | .00000 |
| 65.05 | Air Transport | .08803 | .00000 | .00000 | .00000 | .00000 |
| 68.01 | Electric Utilities | 1.27117 | .00000 | .00000 | .00000 | .00000 |

TABLE III

TREATMENT PROCESS RESIDUAL DISCHARGED TO THE ENVIRONMENT, BY INDUSTRY, FOR 1967, THOUSAND TONS/MIL $



| OBE No. | Name | Air Pollutants | Waterborne Waste | BOD | Solid Waste | Pesticides |
|---|---|---|---|---|---|---|
| 4.00 | Forestry & Fishery Prod. | .00822 | .00000 | .00000 | .00000 | .00000 |
| 7.00 | Coal Mining | .05293 | .00000 | .00000 | .21173 | .00000 |
| 14.01 | Meat Products | .00000 | .00000 | .00226 | .00000 | .00000 |
| 14.02 | Creamery Butter | .00000 | .00000 | .00229 | .00000 | .00000 |
| 14.03 | Cheese, Natural & Processed | .00000 | .00000 | .00061 | .00000 | .00000 |
| 14.04 | Condensed Y Evap. Milk | .00000 | .00000 | .00011 | .00000 | .00000 |
| 14.05 | Ice Cream & Frozen Des. | .00000 | .00000 | .00001 | .00000 | .00000 |
| 14.06 | Fluid Milk | .00000 | .00000 | .00002 | .00000 | .00000 |
| 14.09 | Canned Fruits & Veg. | .00000 | .06541 | .02180 | .00000 | .00000 |
| 14.14 | Flour & Cereal Prep. | .14717 | .00000 | .00000 | .00000 | .00000 |
| 14.21 | Alcoholic Beverages | .00000 | .00000 | .00001 | .00204 | .00000 |
| 16.01 | Broad Fab Mill & Fab. Fin. | .00000 | .01107 | .00524 | .00000 | .00000 |
| 24.01 | Pulp Mills | .00618 | .00000 | .00000 | .01265 | .00000 |
| 24.02 | Paper Mills, Except Bldg. | .00000 | .23290 | .10220 | .00000 | .00000 |
| 27.01 | Ind. Inorg. & Org. Chem. | .24400 | .00000 | .00000 | .00000 | .00000 |
| 27.02 | Fertilizers | .06732 | .00000 | .00000 | .52439 | .00000 |
| 28.01 | Plast Mat. & Resins | .00000 | .00000 | .00180 | .00000 | .00000 |
| 31.01 | Pet Ref. & Related Prod. | .01515 | .00000 | .00000 | .00000 | .00000 |
| 31.02 | Paving Mixt. & Blocks | .34800 | .00000 | .00000 | .00000 | .00000 |
| 33.00 | Leather Tan & Ind. Leather | .00000 | .01439 | .00570 | .00000 | .00000 |

TABLE III

TREATMENT PROCESS RESIDUAL DISCHARGED TO THE ENVIRONMENT, BY INDUSTRY, FOR 1967, THOUSAND TONS/MIL $

Continued

| OBE No. | Name | Air Pollutants | Waterborne Waste | BOD | Solid Waste | Pesticides |
|---|---|---|---|---|---|---|
| 36.01 | Cement, Hydraulic | .40000 | .00000 | .00000 | 2.33333 | .00000 |
| 36.13 | Lime | 1.43333 | 1.06667 | .00000 | .00000 | .00000 |
| 37.01 | Blast Furn. & Basic Steel | .01519 | .00268 | .00000 | .16767 | .00000 |
| 37.02 | Iron & Steel Foundries | .03852 | .00000 | .00000 | .00000 | .00000 |
| 38.01 | Primary Copper | 1.10925 | .00000 | .00000 | .08300 | .00000 |
| 38.02 | Primary Lead | .16615 | .00000 | .00000 | .00000 | .00000 |
| 38.04 | Primary Aluminum | .01914 | .03380 | .00000 | .08846 | .00000 |
| 59.03 | Motor Vehicles & Parts | .00000 | .00006 | .00001 | .00000 | .00000 |
| 68.01 | Electric Utilities | .15982 | .00000 | .00000 | .98176 | .00000 |

## FOOTNOTES

[1]John H. Cumberland, Charles S. Gibson, Jr., Robert J. Korbach, Paul Gerhardt, James R. Hibbs, and Bruce N. Stram, 'EQUIPS-MABET Model Description' and Worksheet Instructions, September 23, 1970 (mimeographed)

[2]Allen V. Kneese, Robert U. Ayres, and Ralph C. D'Arge, Economics and the Environment: A Materials Balance Approach; Resources For the Future, Inc. 1970.