The Cost of Clean Water

U.S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration

VOLUME III

INDUSTRIAL WASTE PROFILE NO. 8
MEAT PRODUCTS

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DEPARTMENT OF THE INTERIOR
Control Admin.

THE COST OF CLEAN WATER

Volume III

Industrial Waste Profiles
No. 8 - Meat Products

U. S. Department of the Interior
Federal Water Pollution Control Administration

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PREFACE

The Industrial Waste Profiles are part of the National Requirements and Cost Estimate Study required by the Federal Water Pollution Control Act as amended. The Act requires a comprehensive analysis of the requirement and costs of treating municipal and industrial wastes and other effluents to attain prescribed water quality standards.

The Industrial Waste Profiles were established to describe the source and quantity of pollutants produced by each of the ten industries studied. The profiles were designed to provide industry and government with information on the costs and alternatives involved in dealing effectively with the industrial water pollution problem. They include descriptions of the costs and effectiveness of alternative methods of reducing liquid wastes by changing processing methods, by intensifying use of various treatment methods, and by increasing utilization of wastes in by-products or water reuse in processing. They also describe past and projected changes in processing and treatment methods.

The information provided by the profiles cannot possibly reflect the cost or wasteload situation for a given plant. However, it is hoped that the profiles, by providing a generalized framework for analyzing individual plant situations, will stimulate industry's efforts to find more efficient ways to reduce wastes than are generally practiced today.

James M. Quigley

Commissioner
Federal Water Pollution Control Administration

INDUSTRIAL WASTE PROFILE: MEAT PRODUCTS

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FOREWORD

The Meat Products Industry (SIC 201) includes Meat Packing Plants (SIC 2011), Sausage and other Prepared Meat Products (SIC 2013), and Poultry and Small Game Dressing and Packing (SIC 2015). For purposes of this report the Meat Products Industry will be divided into two Parts:

I. "Meat Packing" (SIC 2011 and 2013)

II. "Poultry Packing" (SIC 2015)

Each of these Parts will be analyzed separately.

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Meat Packing Profile	Part I, page 1
Poultry Processing Summary	Part II, page S-1
Poultry Processing Profile	Part II, page 1

INDUSTRIAL WASTE PROFILE

MEAT PRODUCTS

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PART I

MEAT PACKING PROFILE

MEAT PACKING SUMMARY

Measure of Plant and Industry Size

Since animal slaughter is the most important factor determining wastewater volumes and pollution loads of the meat packing industry, pounds of liveweight slaughter will be used as the measure of plant and industry size. Both value-added and sales have been rejected as measures of plant and industry size upon which to base pollution estimates since neither will necessarily reflect the pollution load of the industry.

Slaughter Data Available

Total Commercial Slaughter is the best available measure of industry size. This statistic includes all U.S. slaughter except that which takes place on individual farms, which would not present a significant pollution problem. Much more detailed information is available about meat packing plants which are federally inspected. The use of the federally inspected sector to represent the entire total commercial slaughter industry in many instances is reasonable since eighty-five per cent of total U.S. slaughter occurs in federally inspected meat packing plants. The fact that this percentage is growing over time might mean that this sector of the industry will become more and more representative of the entire industry. Liveweight, rather than numbers of animals, is the measure of plant and industry size because this unit makes possible the meaningful addition of unlike species.

Definition of Small, Medium, and Large Meat Packing Plants

For purposes of this report, plant size will be defined in terms of annual liveweight slaughter. It should be mentioned that "national packers" (Armour, Swift, Hormel, etc.) may not agree with the definitions given in this report. "National packers" might disagree especially with the definition of a small plant. "National packers" also define plant size differently, depending upon the type of animal killed. A medium-sized cattle plant will be twice as large as a medium sized hog plant in terms of liveweight killed. This report, however, assumes that plant size is a function of annual liveweight kill, regardless of the type of animal killed.

A small plant is one whose annual liveweight kill is less than twenty five million pounds. Any plant killing less than one hundred cattle per day or less than four hundred hogs per day would be small.

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In 1966, approximately thirty-eight per cent of federally inspected plants would be classified as small. This thirty-eight per cent, however, killed only five per cent of the liveweight.

For projection purposes the typical small plant will be one whose annual liveweight kill is twenty million pounds.

A large plant is one whose annual liveweight kill is greater than two hundred million pounds. In 1966 over ten per cent of federally inspected plants would be so classified. These large plants killed approximately forty-two per cent of the liveweight.

Probably this group should be subdivided into the "large" (two to four hundred million pounds per year) and "very large" (above four hundred million per year). Approximately eight per cent of federally inspected plants in 1966 were "large," and their annual kill was twenty-four per cent of all liveweight. Between two and three per cent of federally inspected plants were "very large." The "very large" plants killed about eighteen per cent of all liveweight slaughtered. The "very large" plant would probably correspond to what a "national packer" would define as large.

For projection purposes, the large plant is assumed to kill three hundred pounds annually. The typical large plant, in other words, would kill eleven hundred cattle per day or four thousand hogs per day.

Medium plants would include all those plants killing between twenty-five and two hundred million pounds annually. For projection purposes, the typical medium plant is defined as one killing one hundred million pounds per year. On a daily basis the typical medium plant is one which kills approximately four hundred cattle or twelve hundred hogs.

Source of Data

Much of the data upon which this report is based was collected by the author under a grant from the National Science Foundation. These data were the basis of her doctoral dissertation at the University of Missouri. The plants presented in this data source are referred to in the report as "questionnaire data" and these plants represent about fifty-four per cent of all federally inspected slaughter and forty-six per cent of total commercial slaughter (on a liveweight basis).

When conclusions are based upon "questionnaire data" the implicit assumption is that the "questionnaire" sample is representative of both federally inspected slaughter plants and total commercial slaughter plants.

Processes and Pollutants

Five processes were singled out for analysis because of their potential impact upon the wasteload of the meat packing industry. In some cases it could be argued that what has been classified as a process or subprocess might more appropriately be classified as by-product recovery. In an industry well known for "utilizing all parts but the 'squeal,'" by-product recovery has essentially become part of the process mix. It was decided to classify all such alternatives as processes and subprocesses rather than as by-products.

The five processes relevant to the "red" meat sector are:

1. Blood recovery
2. Paunch handling
3. Edible rendering
4. Inedible rendering
5. Cleanup

1. Blood recovery is an "all or nothing" situation with respect to the subprocess mix. Either it is recovered, or it escapes to the sewer. Recovery means a forty-two per cent reduction in the gross wasteload of a meat packing plant. In 1966 over ninety-five per cent of the industry, on a liveweight basis, were recovering blood.

Blood is a rich source of protein and, hence, for all but the very small plant it is economically rational to recover this blood. The very small plant, which does not render (inedible products), which does not produce tankage, and which is not located in an area where it can sell raw blood to others, would probably dump blood in the sewer.

2. The handling of paunch material becomes a source of pollution problems if this material is dumped into the sewer, as the total solids concentration becomes so large that it interferes with the efficient workings of traditional waste treatment methods.

3. Edible rendering can be a very polluting process, depending upon the method of rendering. The most polluting alternative is wet rendering without evaporating tank water. This subprocess is the oldest type, and it is not being adopted by new plants. If users of the wet rendering process will evaporate tank water, wasteloads are cut in half. The newer methods of rendering cut wasteloads by sixty per cent. These newer methods include dry rendering and low temperature rendering.

4. Inedible rendering is basically of two types---dry or wet. Wet rendering must be followed by evaporation of tank water in order to cut wasteloads in half. Both forms of dry rendering, batch and continuous, will produce wasteloads sixty per cent less than those from a wet rendering system without evaporations of tank water. The continuous dry rendering is the latest in terms of technology.

5. Cleanup by water from high pressure hoses has been and continues to be the general practice in the meat packing industry. Pollution loads could be substantially reduced by the use of dry cleanup prior to the wet cleanup. Dry cleanup could also mean greater recovery of scraps for utilization in inedible rendering. Thus, rather than hosing scraps into the sewer, one would collect them for use in the inedible rendering department.

Another direct effect of dry cleanup is the reduction of wastewater volume. Analysis of the "questionnaire data" indicated a high, direct correlation between wastewater use per thousand pounds liveweight killed and wasteload per thousand pounds liveweight. Decrease in wastewater volumes seems to be accompanied by utilization of dry cleanup and, hence, lower wasteload per unit of product as well as lower wastewater volumes per unit of product.

Effect of Technology on Wasteloads

Technology has been defined in terms of the subprocess mix. The three levels of technology: "Old", "Typical", and "Advanced" are defined as follows:

"Old Technology" (10 per cent of all plants in 1966)

1. Recovery of all blood
2. Washing of all paunch material down the sewer
3. Edible rendering--wet with no evaporation of tank water
4. Inedible rendering--wet with no evaporation of tank water
5. Wet cleanup

"Typical Technology" (80 per cent of all plants in 1966)

1. Recovery of all blood
2. Wet dumping of paunch material followed by hauling away of the gross paunch material
3. Edible rendering--dry rendering or wet rendering with evaporation of tank water
4. Inedible rendering--dry rendering
5. Wet cleanup

"Advanced Technology" (10 per cent of all plants in 1966)

1. Recovery of all blood
2. Dry dumping of the paunch material followed by the hauling of the gross material away from the plant premises
3. Edible rendering--low temperature
4. Inedible rendering--continuous
5. Dry cleanup followed by wet cleanup

There are definite differences in wastewater volume and wasteload per unit of product depending upon the type of technology. In general the more advanced the technology, the smaller the wastewater and wasteload per unit of product.

WASTELOAD AND WASTEWATER PER THOUSAND POUNDS LIVEWEIGHT KILLED BY TYPE OF TECHNOLOGY, 1966

Type of Technology	Wasteload lbs. BOD/1000 lbs. LWK	Wastewater gals/1000 lbs LWK
"Old Technology"	26.9	2112
"Typical Technology"	19.2	1294
"Advanced Technology"	15.1	1116

*Technology is defined by subprocess mix as indicated above. The BOD values are pre-catch basin values.

Recirculation of Process Water

Process water is not recirculated in the Meat Packing Industry.

Waste Reduction by Subprocess Change

Although subprocess change can be an effective means of wasteload reduction, it is often economically unfeasible. There appears to be agreement within the industry, for example, that often the change from a wet rendering system to a low temperature (edible) or continuous (inedible) system could not be justified from an economic point of view. One reason is the continually declining demand for lard and edible animal fats. In short, subprocess change does not seem feasible for rendering process except for the case of that plant which wet renders and dumps unevaporated tank water into the sewer. At relatively little cost, a fifty per cent reduction of wasteload can be achieved by installing evaporators and selling the "evaporated stick" to a renderer for use in the manufacture of animal feed.

Blood recovery is practiced by all but the very small plants. The expense of collecting and hauling to an off site disposal will be relatively little in return for a forty-two per cent reduction in wasteload.

If any subprocess changes are to be encouraged, the following would appear to be logical choices:

1. Evaporation of tank water and disposal of the evaporated stick
2. Collection of all blood
3. Screening of all paunch material and disposal of the gross material elsewhere than the sewer.

Notice that all subprocesses requiring change are those associated with the "old technology" and/or very small plants.

Because these "old technology" plants are in the minority today (10 per cent) and are disappearing, the regulation of subprocesses as part of the effort to reduce the gross pollution loads seems to be of little significance.

Waste Reduction by Use of Waste Treatment Facilities

The most common form of waste treatment facility in the meat packing industry is the "catch basin" (a sedimentation tank with grease skimming). "Catch basins" could reduce wasteloads by approximately twenty-five per cent if they are properly designed. Most packing plants installed "catch basins" to aid in by-product recovery. The grease recovered meant dollars earned in terms of rendering products. The detention time of wastewater in the "catch basin" based upon the economics of grease recovered was approximately twenty minutes. The detention time for optimal pollution reduction

is at least double. Many existing "catch basins", then, are under-designed from the point of view of pollution control.

Approximately eighty-five per cent of all plants today have some form of waste treatment facility. In 1966, the existing waste treatment facilities were responsible for reducing gross wasteloads by one-third. To achieve this reduction the industry required a thirty-five million dollar investment in waste treatment equipment and spent $3.5 million in 1966 for operation and maintenance of the waste treatment facilities.

Pollution Reduction by Municipal Treatment

Approximately seventy per cent of meat packing wastewater was treated by Municipal Treatment Facilities. As wastewater passed through municipal facilities, fifty-six per cent of the wasteload (BOD) was removed. The industry paid approximately $6 million for this service.

A summary of all expenditures on waste treatment in 1966 is as follows:

EXPENDITURES FOR WASTE TREATMENT BY
THE MEAT PACKING INDUSTRY, 1966

Replacement Value of Treatment Facilities Millions of Dollars	Annual Equivalent Millions Of Dollars	Annual O & M Costs Millions Of Dollars	Annual Payments To Municipalities Millions Of Dollars	Total Payments For Waste Treatment Millions Of Dollars
35	3.5	3.5	6	13

PROFILE OF THE "MEAT PACKING" INDUSTRY

INTRODUCTION

Definition of Meat Packing

"Meat Packing" is defined for purposes of this report to include all plants engaged in slaughtering and/or processing of the "red" meat animals; that is, SIC categories 2011 and 2013. The aggregation of the four-digit SIC categories was necessary because of the lack of waste strength information for the latter category, sausage and other prepared meat products (SIC 2013).

There are three different types of plants which are included in the category described in this report as "meat packing": the slaughter house or abattoir, the meat packing plant, and the meat processing plant.

1. A slaughtering plant is a killing and dressing plant which does almost no processing of by-products.

2. A meat packing plant is both a slaughtering house and a meat processing plant. Packing houses will often be involved in the cooking, curing, smoking and pickling of meat, the manufacture of sausage, the rendering of edible fats into lard and edible tallow, and the rendering of inedible fats into greases.

3. A meat processing plant does no slaughter at all.

Measure of Plant and Industry Size

Since animal slaughter and/or meat production are the primary factors determining wastewater volumes and pollution loads of the meat packing industry, it will be necessary to examine the size and structure of the meat packing industry in order to estimate the total wasteload of the industry. Neither value-added nor sales are adequate measures of plant or industry size from which to estimate plant or industry wasteload because these measures may not reflect pollution loads. For example, those plants and/or areas with high beef sales may have a low beef packing wasteload because there is little slaughtering. Thus, animal slaughter data are more relevant measures of plant and industry size than meat production or value-added statistics, as pollution loads are related primarily to the slaughtering aspect of the

production process. Technically, data pertaining to meat production or value-added may include the processing of imported dressed carcasses and, hence, overstate the pollution load. Total liveweight, then, is the measure of size which will be utilized in this study, primarily because this measure makes possible the meaningful addition of unlike species. Two cattle plus two hogs is not as meaningful an aggregate as two thousand pounds of cattle plus five hundred pounds of hogs. Total liveweight killed per year will be used as the measure of meat packing size as well as of the industry size.

Slaughter Data Available

The three types of slaughter data available which can be used to measure industry size are shown for 1966 in Table 1. The most inclusive category is total slaughter which is composed of farm slaughter and total commercial slaughter. Federally inspected slaughter and state or locally inspected slaughter constitute total commercial slaughter. The preferred category for measuring industry size is total commercial slaughter.

Total commercial slaughter is preferred to total slaughter as a measure of industry size related to pollution load. Total slaughter is only slightly larger than total commercial slaughter, the difference being the amount of farm slaughter. Farm slaughter in all cases is a very small and continually decreasing proportion of total slaughter. In 1965 less than two and one-half per cent of all animal slaughter took place on farms. Such an insignificant proportion of the total can be ignored without affecting the results. Even more important, however, is the fact that farm slaughter is not geographically concentrated and, therefore, poses no significant pollution problem.

Total commercial slaughter is also preferred to federally inspected slaughter as a measurement of size. Although more information is generally available about federally inspected slaughter than about total commercial slaughter, the latter is a more acceptable indicator of size because federally inspected slaughter represents only about eighty-five per cent of total commercial slaughter.

Table 2 shows the number of plants by type of inspection and total liveweight killed by type of inspection for the years 1960 and 1965. Notice that less than twenty per cent of commercial slaughter plants are federally inspected, yet these plants kill almost eighty-five per cent of the liveweight slaughtered. These statistics are a clear illustration of the dangers of basing meat packing statistics upon the number of plants.

TABLE 1

TOTAL ANIMAL SLAUGHTER, UNITED STATES, 1966

	Thousands of Animals					Millions of Pounds of Liveweight				
	Cattle	Hogs	Sheep	Calves	Total	Cattle	Hogs	Sheep	Calves	Total
Federally Inspected	27,319	63,729	11,553	4,432	107,033	28,161	15,542	1,185	890	45,778
Other	6,408	10,282	1,184	2,215	20,089	5,923	2,364	118	673	9,078
Total Commercial	33,727	74,011	12,737	6,647	127,122	34,085	17,906	1,303	1,563	54,857
Farm	442	1,313	264	214	2,233	386	324	23	84	817
Total	34,169	75,324	13,001	6,861	129,355	34,471	18,230	1,326	1,647	55,674

Sources: United States Department of Agriculture, Livestock and Meat Statistics, Supplement to 1966 Statistical Bulletin #333 (Washington: Government Printing Office, 1967), p. 63.

United States Department of Agriculture, Livestock Slaughter: 1966, Statistical Reporting Service (Washington: Government Printing Office, 1967), pp. 9-10.

TABLE 2
NUMBER OF PLANTS AND LIVEWEIGHT SLAUGHTERED
BY TYPE OF INSPECTION, 1960 AND 1965

Type of Inspection	No. of Plants		Liveweight Slaughtered mil. of lbs.		Per Cent of Total Commercial Slaughter Plants by Type of Inspection		Per Cent of Total Liveweight Slaughtered By Type of Inspection	
	1960	1965	1960	1965	1960	1965	1960	1965
Federally Inspected	530	570	38,319	44,569	16.9	19.3	80.9	84.3
Other Commercial	2,614	2,387	9,062	8,319	83.1	80.7	19.1	15.7
Total Commercial	3,144	2,957	47,381	55,888	100.0	100.0	100.0	100.0

Commercial slaughter data by type of animal are available on a regional or national basis in two forms: the number of animals killed and the total liveweight of animals slaughtered.

Definition of Small, Medium, and Large Plants

In the meat packing industry itself, there exists a lack of agreement as to the correct size designation of a plant in terms of small, medium, or large. National packers will define small differently than independent packers will. A "national" meat packer* would probably specify any plant killing less than one hundred million pounds per year as small. Thus, the national packer tends to estimate size in terms of the "national" meat packing industry. "National" meat packers define the size of plants differently, depending upon the type of animal killed. In general, a plant engaged in the killing of cattle and classified as a medium-sized plant, will handle two times the liveweight as a similarly designated plant killing hogs. A small plant in terms of cattle would be one whose annual kill is less than twenty-five million pounds. A small plant in terms of hogs would be one whose annual kill is twelve or thirteen million pounds.

In spite of the lack of consistency concerning size definition on the part of the "national" packer, in this report the size of plants will be defined in terms of annual liveweight slaughter. This definition of size allows for a meaningful comparison between a plant killing four species of animals and a plant killing only one species.

A small meat packing plant will be defined as one in which the annual liveweight kill is less than twenty-five million pounds, a medium plant, as one in which the annual liveweight kill is approximately one hundred million pounds, and a large plant, as one in which the annual liveweight kill is two hundred million pounds or more. See Table 3. Tables 4 and 5 describe the characteristics of the federally inspected meat packing industry by size class for the years 1964, 1965, and 1966. Table 5 summarizes the characteristics of the Federally Inspected meat packing industry by the size classes to be utilized in this report, that is, small, medium, and large.

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*Firms are designated as "national" packers who have national systems of distribution, widely known brand names, and national programs of advertising and promotion. National packers would include such firms as Armour & Co., Swift & Co., Wilson & Co., and eight or ten others, such as Cudahy, Hormel, Morrell, Oscar Mayer, and Rath. (1)

TABLE 3

DEFINITION OF PLANT SIZE: SMALL, MEDIUM, LARGE
MEAT PACKING INDUSTRY

Plant Size in Annual Liveweight Killed[a] (Mil. lbs.)	Equivalent Size in Terms of Daily Kill				
	Liveweight (Thou. lbs.)	Cattle[b] (No. head)	Hogs[c] (No. head)	Cattle & Hogs[d] (No. head)	
Small 25	95,000	95	380	48	190
Medium 100	379,000	379	1,156	190	758
Large 200	758,000	758	3,032	379	1,516

[a]In terms of a range in Annual Liveweight Killed, plant sizes would be as follows:

Small: 0 - 25 millions of pounds
Medium: 25 - 200 millions of pounds
Large: 200 - up.

[b]Cattle average 1000 lbs. per head.

[c]Hogs average 250 lbs. per head.

[d]Liveweight divided equally between cattle and hogs.

TABLE 4

DISTRIBUTION OF FEDERALLY INSPECTED ANIMAL SLAUGHTER BY SIZE OF PLANT, UNITED STATES, 1964, 1965, 1966

Size Categories Millions of Lbs. of Live-weight Slaughter Per Year	Number of Plants			Total Liveweight Killed Per Year Thousands of Pounds			Per Cent of Total United States Slaughter			Cumulative Per Cent of United States Slaughter		
	64	65	66	64	65	66	64	65	66	64	65	66
Less than 1.0	28	23	31	11,949	10,048	13,203	0.03	0.02	0.02	A	A	A
1.0 - 9.9	82	87	93	413,144	472,861	509,455	0.9	1.06	1.09	0.9	1.1	1.1
10.0 - 24.9	116	115	115	1,989,547	1,953,478	1,914,579	4.3	4.4	4.1	5.2	5.5	5.2
25.0 - 49.9	123	123	120	4,443,503	4,428,521	4,336,618	9.7	9.9	9.3	14.9	15.4	14.5
50.0 - 74.9	80	92	82	4,844,958	5,575,723	4,863,133	10.6	12.5	10.5	25.5	27.9	25.0
75.0 - 99.9	49	43	54	4,277,829	3,723,624	4,643,365	9.3	8.4	10.0	34.8	36.3	35.0
100.0 - 124.9	38	36	36	4,288,931	4,020,078	3,971,762	9.3	9.0	8.5	44.1	45.3	43.5
125.0 - 149.9	17	16	18	2,360,995	2,191,114	2,533,839	5.1	4.9	5.4	49.2	50.2	48.9
150.0 - 174.9	10	16	14	1,587,716	2,565,988	2,300,519	3.5	5.8	4.9	52.7	56.0	53.8
175.0 - 199.9	9	13	11	1,695,668	2,417,670	2,067,862	3.7	5.4	4.4	56.4	61.4	58.2
200.0 - 224.9	9	6	5	1,863,796	1,267,080	1,049,608	4.1	2.8	2.3	60.5	64.2	60.5
225.0 - 249.9	6	3	6	1,427,201	712,434	1,426,076	3.1	1.6	3.1	63.6	65.8	63.6
250.0 - 274.9	2	3	6	532,428	787,983	1,560,481	1.2	1.8	3.4	64.8	67.6	67.0
275.0 - 299.9	2	11	9	573,352	3,172,842	2,575,372	1.2	7.1	5.5	66.0	74.7	72.5
300.0 - 324.9	9	3	8	2,817,276	942,940	2,467,298	6.1	2.1	5.3	72.1	76.8	77.8
325.0 - 349.9	0	3	1	---------	1,015,125	348,094	---	2.3	0.8	72.1	79.1	78.6
350.0 - 374.9	2	1	2	720,598	352,943	715,899	1.6	0.8	1.5	73.7	79.9	80.1
375.0 - 399.9	4	1	2	1,584,519	384,584	775,291	3.5	0.9	1.7	77.2	80.8	81.8
400.0 - 499.0	6	8	7	2,723,781	3,580,250	3,052,937	5.9	8.0	6.6	83.1	88.8	88.4
500.0 - 599.0	5	4	6	2,665,446	2,267,343	3,357,831	5.8	5.1	7.2	88.9	93.9	95.6
Above 600.0	7	4	3	5,068,706	2,726,313	2,071,254	11.1	6.1	4.4	100.0	100.0	100.0
Above 400.0	18	16	16	10,457,933	8,573,905	8,482,073	22.8	19.2	18.2	100.0	100.0	100.0
All Plants	604	611	629	45,891,344	44,568,941	46,554,527						

A, less than .05 Per Cent

Source: United States Department of Agriculture, unpublished data.

TABLE 5

Number of Plants and Total Liveweight Killed by Size Group
Federally Inspected Plants, United States, 1966

Size Class TLWK/Year (Mil. of lbs)	No. of Plants	Per Cent of Plants	TLWK/Year (Mil. of lbs)	Per Cent of Total Slaughtered
0- 24.9	239	38.0	2,437	5.2
25-199.9	335	53.3	24,718	53.0
200 and up	55	8.7	19,399	41.8
All Plants	629	100.0	46,555	100.0

Source: United States Department of Agriculture, unpublished data.

Finally, it should be noted that this report has defined the medium-sized plant in such a manner that the range includes both the average-size plant under federal inspection as well as the median-size plant. The average size plant under federal inspection is one whose annual kill is approximately seventy-four million pounds. The median-size plant under federal inspection is one whose annual kill is approximately thirty-eight million pounds. To the extent that the definition of medium-size is such that it includes both the average and median-size plants, it is a reasonable definition.

Slaughter characteristics of Federally Inspected Meat Packing Plants by Type of Plant, that is, by type of animals killed are shown in Tables 6 and 7. The increasing percentage of total liveweight slaughtered, which is handled by the specialized plants or single species plants, is shown in Table 6. The average and median plant size for each type of plant is shown in Table 7.

Source of Data

The data referred to in this report as "questionnaire data" or "sample data" is information collected by the author under a grant from the National Science Foundation. These data were the basis of her doctoral dissertation at the University of Missouri. The data referred to as "questionnaire data" actually came from the following three sources:

1. A four week program of sample collection and analysis at four Kansas meat packing plants.

2. Files of meat packing companies related to wastewater characteristics and waste treatment facilities.

3. Questionnaire responses from federally inspected meat packing companies and some locally inspected plants in the Midwest which had not been contacted under either of the above programs.

Approximately six hundred meat packing establishments were contacted personally or by correspondence. Questionnaires were sent to those firms which were not contacted under the sampling program or the plant visitation program. The nationwide mailing list was obtained from the February-March 1967 issue of the USDA Bulletin: "Working Reference of Livestock Regulatory Establishments, Circuits, and Officials." In total there were 284 responses.

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TABLE 6

SLAUGHTER CHARACTERISTICS OF FEDERALLY INSPECTED MEAT PACKING PLANTS BY TYPE OF PLANT, UNITED STATES, 1964, 1965, 1966

Year	Cattle	Calves	Sheep	Hogs	Cattle Calves	Cattle Sheep	Cattle Hogs	Calves Sheep	Calves Hogs	Sheep Hogs	Cattle Calves Sheep	Cattle Calves Hogs	Cattle Sheep Hogs	Calves Sheep Hogs	Cattle Calves Sheep Hogs	United States Total
Number of Plants																
1950	34	2	0	37	49	5	21	4	1	1	68	55	3	2	175	457
1954	64	2	2	41	68	1	25	2	1	1	66	56	6	1	143	479
1958	97	4	1	43	70	5	34	2	0	1	69	48	8	2	127	511
1962	127	3	3	60	77	16	52	7	0	2	71	42	22	1	84	567
1964	170	3	4	77	83	13	61	6	1	1	50	31	15	3	86	604
1965	183	2	6	65	85	15	60	10	0	4	47	32	26	2	74	611
1966	183	2	4	66	85	15	70	4	2	6	44	39	18	5	86	629
Total Liveweight Slaughtered by Type of Plant (Millions of Pounds)																
1964	10,274	11	103	5,379	3,033	1,118	6,978	123	58	18	1,741	3,553	3,394	18	10,089	45,891
1965	11,494	12	180	4,512	3,045	1,083	6,376	109	---	65	1,688	2,468	3,900	294	9,341	44,569
1966	12,110	13	66	4,905	2,920	1,421	8,130	80	136	256	1,377	2,542	3,982	128	8,488	46,555
Per Cent of Total Slaughter by Type of Plant																
1964	22.4	A	0.2	11.7	6.6	2.5	15.2	0.3	0.1	A	3.8	7.8	7.4	A	22.0	100.0
1965	25.8	A	0.4	10.1	6.8	2.4	14.3	0.2	0.0	0.2	3.8	5.5	8.8	0.7	21.0	100.0
1966	26.0	A	0.1	10.5	6.3	3.1	17.5	0.2	0.3	0.5	3.0	5.5	8.5	0.3	18.2	100.0

A, Less than .05 Per Cent.

Sources: Willis E. Anthony, United States Department of Agriculture, Structural Changes in the Federally Inspected Livestock Slaughter Industry, 1950-62, Economic Research Service, Report No. 83 (Washington: Government Printing Office, 1966), p. 69.

United States Department of Agriculture, unpublished data.

TABLE 7

SIZE CHARACTERISTICS OF FEDERALLY INSPECTED MEAT PACKING PLANTS BY TYPE OF PLANT
THOUSANDS OF POUNDS

Type of Animals Slaughtered	Year	No. of Plants	Size Range Smallest	Size Range Largest	Average Me	Median
All Plants	1964	604	1	872,562	75,979	36,805
	1965	611	18	808,356	72,944	38,069
	1966	629	3	856,853	74,014	38,179
Cattle Only	1964	170	32	391,984	60,435	43,768
	1965	183	37	405,270	62,811	42,725
	1966	183	3	401,058	66,177	42,405
Calves Only	1964	3	1	7,229	3,729	3,960
	1965	2	3,979	7,949	5,964	5,964
	1966	2	5,597	7,251	6,424	6,424
Sheep Only	1964	4	2,000	53,246	25,768	28,655
	1965	6	5,388	63,925	30,061	23,913
	1966	4	329	47,303	16,550	9,283
Hogs Only	1964	77	1	394,691	69,860	51,989
	1965	65	18	299,459	69,411	53,270
	1966	66	147	313,357	74,319	46,555
Cattle, Calves	1964	83	159	193,815	36,543	21,205
	1965	85	1,592	178,674	35,821	24,807
	1966	85	686	141,355	34,352	28,245
Cattle, Sheep	1964	13	10,144	316,900	85,998	73,731
	1965	15	10,639	287,689	72,218	60,015
	1966	15	10,492	303,657	94,748	72,685
Cattle, Hogs	1964	61	2,197	764,701	48,945	64,702
	1965	60	405	625,073	48,429	58,232
	1966	70	323	612,968	56,628	79,519
Calves, Sheep	1964	6	2,584	53,650	20,500	28,655
	1965	10	899	50,685	10,944	6,825
	1966	4	6,974	46,833	20,072	13,241
Calves, Hogs	1964	1	58,396	58,396	58,397	58,396
	1965	0	------	------	------	------
	1966	2	19,193	116,335	67,764	67,764
Sheep, Hogs	1964	1	17,575	17,575	17,575	17,575
	1965	4	2,172	51,674	16,196	5,469
	1966	6	6,278	83,435	42,656	47,872
Cattle, Calves and Sheep	1964	50	502	195,263	34,828	19,545
	1965	47	1,879	214,067	35,917	17,623
	1966	44	1,948	183,863	31,295	17,012
Cattle, Calves and Hogs	1964	31	141	543,624	114,615	69,086
	1965	32	3,252	220,478	77,117	133,133
	1966	39	757	429,725	65,192	404,120
Cattle, Sheep and Hogs	1964	15	80	715,078	226,297	112,482
	1965	26	124	583,948	150,016	90,140
	1966	18	135	601,433	221,230	130,498
Calves, Sheep and Hogs	1964	3	1,237	14,478	6,052	244,262
	1965	2	920	293,353	147,137	294,273
	1966	5	499	79,450	25,558	13,079
All 4 Species	1964	87	114	872,562	117,311	34,750
	1965	74	202	808,356	126,231	35,874
	1966	86	125	856,853	98,694	29,792

Source: United States Department of Agriculture, unpublished Data.

These 284 responses could be categorized as follows:

Slaughtering and Processing Plants		219
With wasteload (BOD) data	66	
With no wasteload (BOD) data	153	
Processing Only		20
With wasteload data	0	
With no wasteload data	20	
No Information		25
Firm out of Business, etc.		
Total		284

The basic assumption upon which this entire report rests is that the usable sample of 219 plants is representative of the meat packing industry. Table 8 compares the sample to the federally inspected portion of the meat packing industry. The sample appears to be representative of the federally inspected portion of the meat packing industry. It will be recalled that plants under federal inspection kill eighty-five per cent of all liveweight slaughtered in the United States and that most commercial establishments which are not under federal inspection are small plants. It is quite possible that our sample is under represented so far as numbers of very small plants are concerned; however, those small plants who did respond to the questionnaire seem to be typical of the small plants in that their process and subprocess mix are those expected of the very small plant. Small plants will have a higher proportion of their group which do not collect blood and many will not be engaged in extensive by-product recovery.

Wasteloads Measured by BOD

Because of the short time available for data collection and data analysis, it was decided to use "organic load" as the measure of wastewater strength. "Organic load" will be measured in terms of biochemical oxygen demand (BOD). To be more specific, the organic load was measured in five-day, twenty degree centigrade BOD. The five-day designation refers to the usual incubation period and the twenty degree centigrade to the temperature maintained during incubation. This particular form of the BOD test, as well as the BOD test itself, was chosen because it is the one most generally used.

The reliance upon one measure of wastewater strength (BOD) does not imply that this indicator is the only one or even

Table 8

NUMBER OF PLANTS AND ANNUAL LIVE WEIGHT KILLED BY SIZE CLASS, 1966
ALL FEDERALLY INSPECTED PLANTS AND ALL PLANTS
RESPONDING TO QUESTIONNAIRE

Size Class	USDA Data Total Federally Inspected Slaughter		Questionnaire Data		Sample as Per Cent of Federally Inspected Slaughter	
TLWK/yr. Mil. of Lbs.	No. of Plants	TLWK/yr. Mil. of Lbs.	No. of Plants	TLWK/yr. Mil. of Lbs.	No. of Plants	TLWK/yr. Mil. of Lbs.
0.0- 0.9	31	13	7	3	23%	23%
1.0- 9.9	93	509	26	134	28%	26%
10.0- 24.9	115	1,915	33	526	29%	27%
25.0- 49.9	120	4,337	30	1,094	25%	25%
50.0- 74.9	82	4,863	21	1,253	26%	26%
75.0- 99.9	54	4,643	21	1,863	39%	40%
100.0-124.9	36	3,972	21	2,378	58%	60%
125.0-149.9	18	2,534	10	1,392	56%	55%
150.0-174.9	14	2,301	11	1,810	79%	79%
175.0-199.9	11	2,068	3	546	27%	26%
200.0-224.9	5	1,050	3	659	60%	63%
225.0-249.9	6	1,426	3	698	50%	49%
250.0-274.9	6	1,560	4	1,044	67%	67%
275.0-299.9	9	2,575	2	569	22%	22%
300.0-324.9	8	2,467	6	1,889	75%	77%
325.0-349.9	1	348	1	343	100%	100%
350.0-374.9	2	716	2	719	100%	100%
375.0-399.9	2	775	1	386	50%	50%
400.0-499.9	7	3,053	6	2,648	86%	87%
500.0-599.9	6	3,358	5	2,880	83%	86%
Above 600.0	3	2,071	3	2,159	100%	100%
Total	629	46,554	219	24,995	35%	54%

the best one. In many instances total solids may be an equally important measure of meat packing wasteload. BOD was chosen because it is one of the most important, commonly used measures of wastewater strength. Additional studies of meat packing wastewater should include analysis at least of total solids and suspended solids.

The BOD test is a time consuming, expensive, and delicate test of wastewater strength. These characteristics of the test may be one explanation of the lack of information concerning the strength of industrial wastewater.

Relationships Between BOD, Wastewater, and Plant Size

Relationships between wasteload per unit, plant size, and wastewater per unit, (two variables at a time) are shown graphically in Figures 2, 3, and 4. All data shown graphically are "questionnaire data."

Figure 2 shows the relationship between wasteload per thousand pounds of liveweight killed and plant size. Plant size is measured by annual liveweight killed in millions of pounds. The BOD per thousand pounds varies from a low of approximately three pounds to a high of thirty-seven pounds. There is no discernible pattern relating BOD per thousand pounds of liveweight killed to plant size.

Figure 3 shows the relationship between wastewater per unit of product and plant size. If one were to eliminate those plants whose wastewater averages above 3000 gal. per thousand pounds of liveweight, there seems to be a pattern in which the wastewater per unit of product increases with plant size. This relationship is to be expected in that larger plants will tend to have more processing which would increase their water and wastewater use per thousand pounds of liveweight.

Figure 4 shows the relationship between wasteload per unit of product and wastewater use per unit of product by type of technology. The visually obvious direct relationship between wasteload and wastewater per unit of product is unexpected from a theoretical point of view. The formula by which the wasteload per unit of product is obtained is:

$$\text{BOD in lbs/1000 lbs LWK} = \frac{(\text{BOD in mg/l})\ (8.34)\ (\text{Wastewater in MGD})}{(\text{TLWK in 1000 lbs/day})}$$

FIGURE 2

RELATIONSHIP BETWEEN WASTELOAD PER 1000 POUNDS OF LIVEWEIGHT KILLED AND PLANT SIZE, 1966

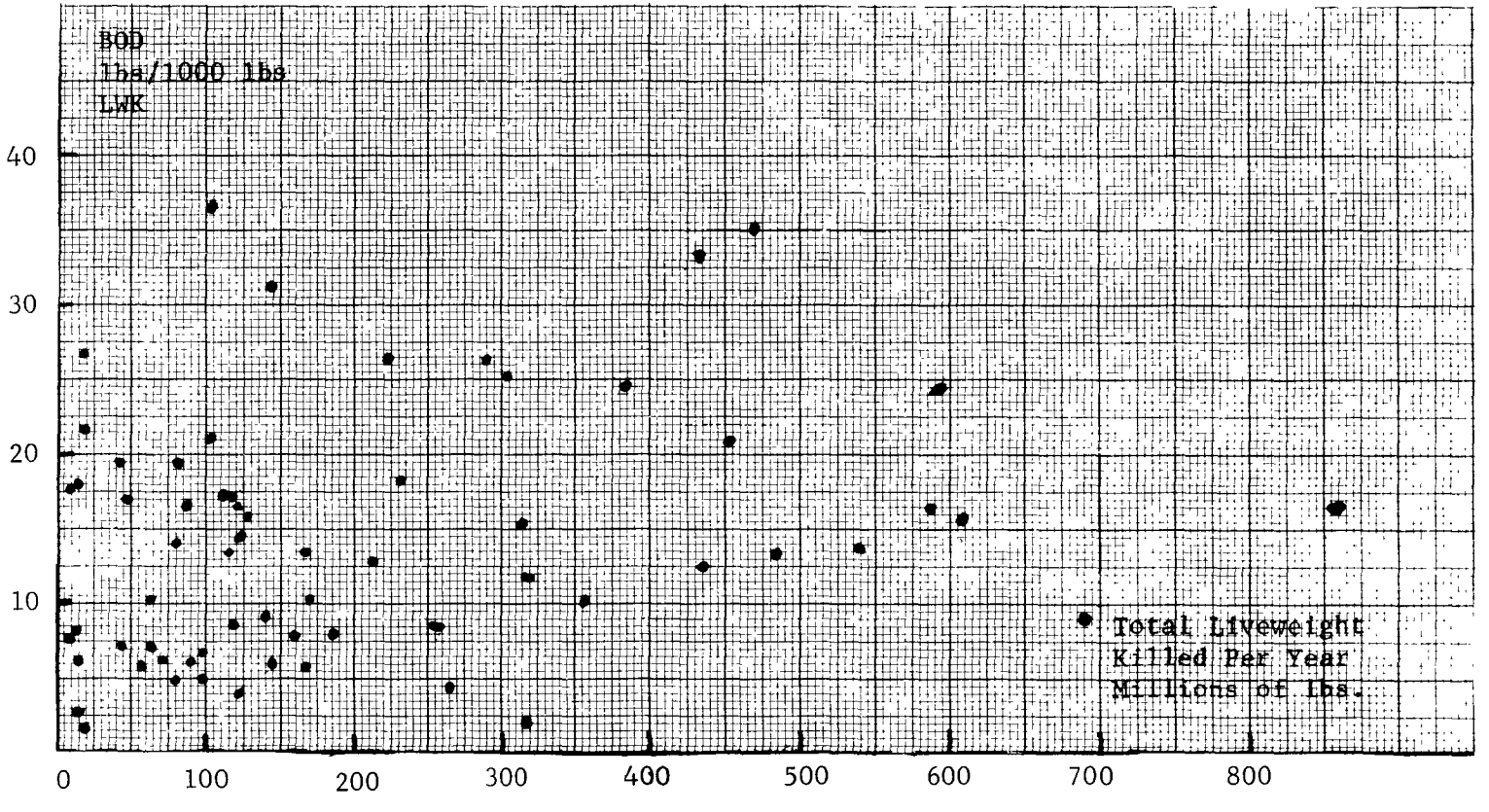
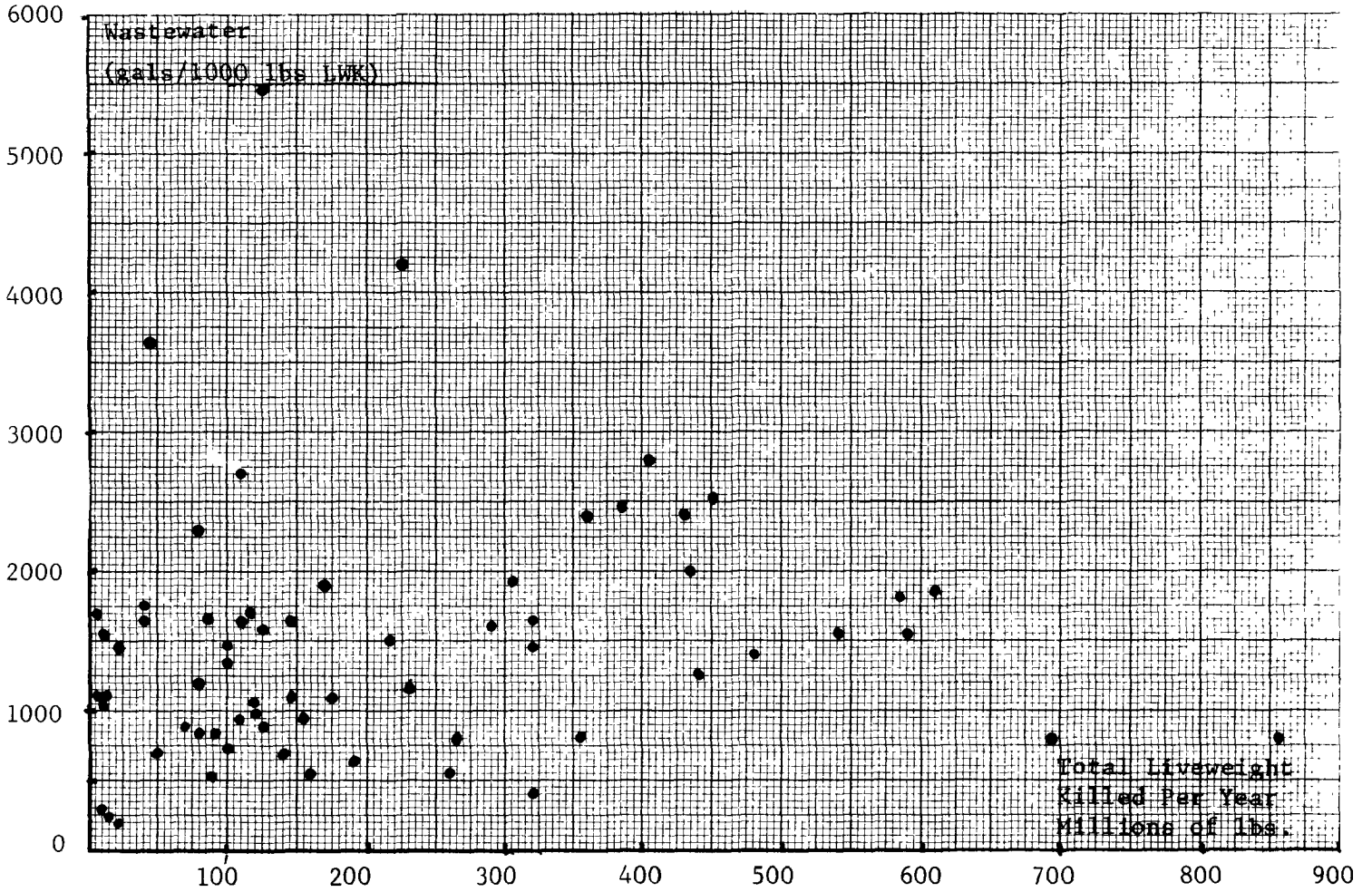


FIGURE 3

RELATIONSHIP BETWEEN WASTEWATER PER 1000 POUNDS OF LIVEWEIGHT KILLED AND PLANT SIZE, 1966

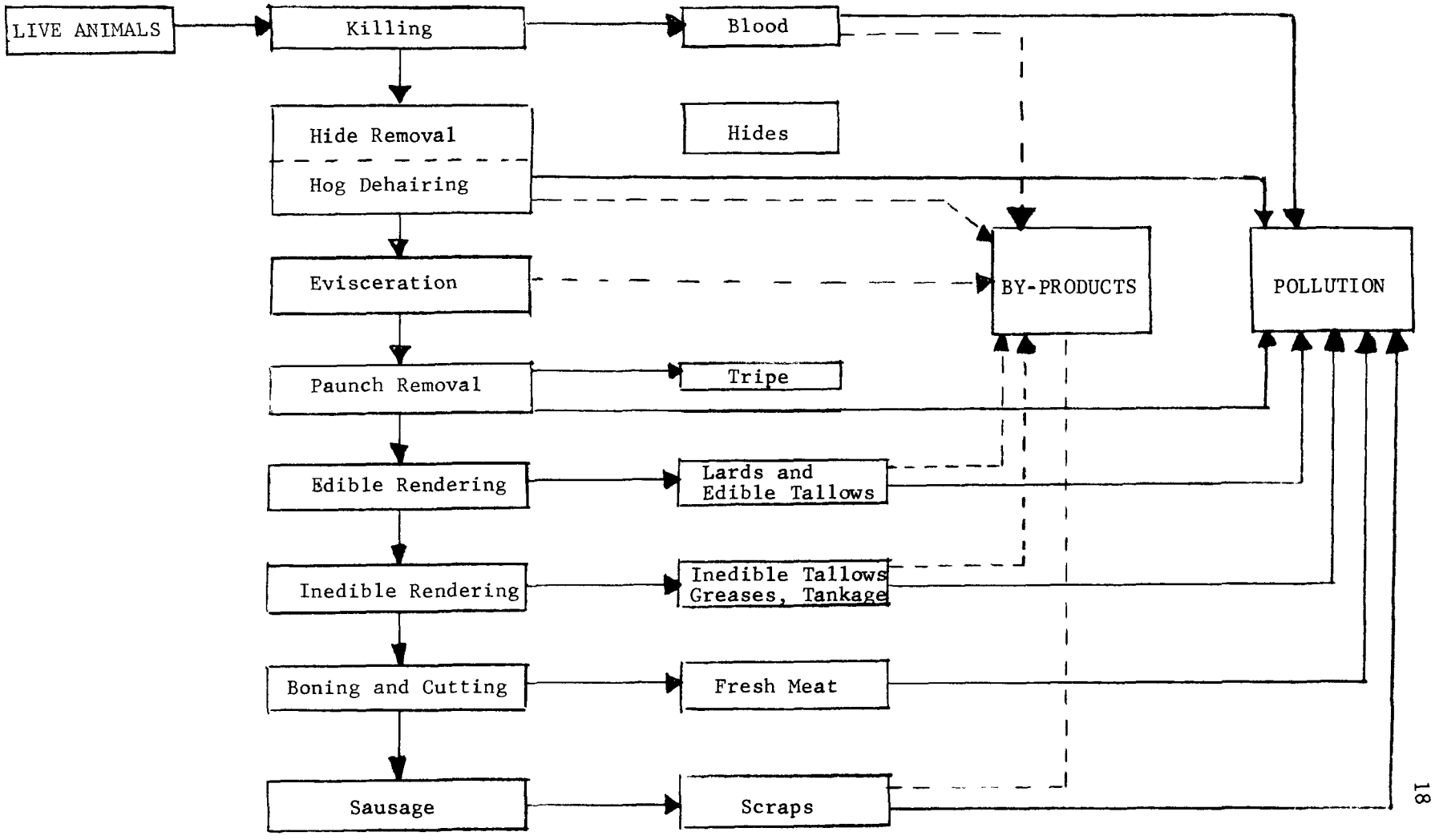


As wastewater per unit of product increases, one would simply expect the BOD concentration in mg/l to be lowered but the BOD in pounds per thousand pounds to be unaffected. The empirical study of over sixty plants indicates that there is a direct relationship between BOD per thousand pounds liveweight and wastewater per thousand pounds liveweight. As wastewater use per unit increases, so does the wasteload per unit. This relationship is reasonable if the amount of wastewater per unit of product is some kind of index of the plant's "wastewater consciousness." "Wastewater consciousness" would probably mean that greater attention is given to dry cleanup and to the recovery of all scraps and trimmings for by-product manufacture. On this basis, then, the direct relationship between wastewater per unit and wasteload per unit seems reasonable.

In Figure 4 technology has been indicated according to the subprocess mix as shown on page 25. It is encouraging to note that new technology is associated with both lower wastewater and wasteload per unit of product according to Figure 4.

Figure 1

FUNDAMENTAL INDUSTRY PROCESSES



FUNDAMENTAL INDUSTRY PROCESSES

In the meat packing industry cattle, hogs, sheep, and calves are first brought to the packing house. There they are held for a few hours, often to the accompaniment of "muzak," before stunning and sticking.

Meat Packing Processes

I. Stunning, Sticking, and Bleeding

Animals are taken from the holding area, and immediately prior to their entering the kill area, they are immobilized by chemical, mechanical, or electrical means. Cattle are suspended by their hind legs from an overhead rail for sticking and bleeding. The immobilized hogs are positioned on a conveyor, so their heads are over the bleeding trough, which is a drain constructed underneath the conveyor, for collection of blood.

II. Removal of Outer Covering

A. Cattle: Hide Removal

Mechanical hide-removers are used in most meat packing plants to separate the hide from the carcass. These mechanical devices are designed to handle approximately fifty to sixty head per hour or approximately one hundred million pounds per year. The introduction of the mechanical hide-remover appears to be an important factor in the determination of plant size. Most new cattle plants will be killing an even multiple of the fifty to sixty head per hour. That is, the high cost of the mechanical hide remover dictates that if it is desired to increase the rate of kill to more than 60 head per hour the increase will necessarily be to 100 or 120 per hour. In terms of a liveweight equivalent, this means that the size of cattle plants will be 100 million pounds per year, 200 million pounds per year, 300 million pounds per year, etc.

B. Hogs: Hair Removal

Hair is removed from the hog carcass without skinning. Hair is loosened in a scalding vat or tub where the water is kept at about 140 degrees F. The hair is then removed by scraping. In larger plants this hair is removed by mechanical scrapers. After removal, hair may be sold, hauled to offsite disposal, or dissolved in a caustic solution. The trend seems to be towards sale of the hog hair because it can be used in the manufacture of foam rubber.

III. Evisceration

Viscera are removed and distributed to the proper channel, depending upon whether they will become an edible or an inedible product. Hearts, stomachs and lower digestive tracts are usually the edible items.

IV. Washing

Washing of the carcass and the internal organs takes place throughout the meat packing process. This process of washing is described in detail in the next section.

V. Paunch Removal

The method by which this process is carried out will determine its wasteload contribution, and these methods are discussed in detail in the following section.

VI. Rendering

In general, there are two types of rendering: edible and inedible. Edible rendering is the process by which fats are converted into lard and edible tallow. Edible rendering is applied primarily to hog fats but also to some beef fat. Inedible rendering is the process by which scraps, trimmings, and inedible organs (heads, feet, etc.) are converted into inedible fats, which are used in soap, in the manufacturing of grease, and in animal feeds. Inedible rendering also provides an outlet for those parts of an animal which have been condemned by federal meat inspectors. Through rendering, condemned material is sterilized and converted into a recoverable product.

VII. Sausage

Sausage manufacture consists of preparing the filling from meat and stuffing the casings. Repeated washing of the utensils and area are the main contributors to waste from this process.

Many conclusions about meat packing industry activity which are based upon the number of plants, will be misleading because of the structure of this industry. Even the most casual analysis of the data shown in Table 2 will illustrate the misleading nature of these data. General information based upon the number of plants is misleading because of the extremely large number of very small meat packing plants. Meat Packing plants range in size from plants whose annual kill is less than one million pounds to those plants whose annual kill is over eight hundred million pounds. Twenty per cent of all meat packing plants in 1966 belonged to the size category in which annual kill was less than ten million pounds.

Meat Packing Processes Related to BOD

Six fundamental industry processes which can be carried out in several ways have been identified. The method by which a fundamental process is executed is defined as a subprocess. Those processes whose subprocess choice determines its pollution contribution have been identified in Table 9. Table 9 further shows the percentage distribution of the subprocesses among meat packing plants.

Only those distributions of plants by subprocess in the Killing, Washing, and Cleanup sections include all meat packing plants. The remaining categories should be interpreted as the distribution of plants among the subprocesses when that fundamental process is part of the packing plant's operation. The fundamental process of Paunch Handling will serve to illustrate this interpretation. In 1967, according to Table 9, of all plants handling paunch material, (that is, those plants killing cattle and/or calves) sixteen per cent employed the dry dumping method, seventy one per cent used wet dumping, and the remaining thirteen per cent allowed paunch material to be dumped into the sewer.

The percentage of plants employing the indicated subproceses were estimated for the years 1950, 1963, 1967, 1972, and 1977. The estimates for 1967 are based upon "questionnaire data" and should be the most reliable of all estimates. Historically estimates are based upon conversations with meat packers. The projected percentage distributions assume continued efforts on the part of industry to reduce wastewater flow and/or wastewater strength.

Interpretation of Conclusions Based Upon the Number of Plants

Many conclusions about meat packing industry activity which are based upon the number of plants, will be misleading because of the structure of this industry. As mentioned earlier, even the most casual analysis of the data shown in Table 2 illustrates the misleading nature of these data. General information based upon the number of plants is misleading because of the extremely large number of very small meat packing plants. Meat packing plants range in size from plants whose annual kill is less than one million pounds to those plants whose annual kill is over eight hundred million pounds. Twenty per cent of all meat packing plants in 1966 belonged to the size category in which annual kill was less than ten million pounds. These one hundred twenty four plants together handled only one per cent of total liveweight slaughtered that year. To the extent that an estimate of industry participation is based upon the percent of plants participating, the participation is likely to be understated. The extent of the understatement will, of course, depend upon the number of very small plants in the estimate.

TABLE 9

Production Process and Significant Subprocesses	Estimated Percentage of Plants Employing Indicated Subprocess 1950	1963	1967	1972	1977
I. KILLING AND BLEEDING					
1. Recovery of all blood	70	80	83	90	99
2. Recovery of no blood	30	20	17	10	1
II. WASHING OF CARCASS					
1. Interruptable water flow (Lever type valves on water hoses and/or automated washing mechanisms causing water to shut off when no animals are present)	0	5	25	80	90
2. Continuous water flow (In washing mechanisms or hoses)	100	95	75	20	10
III. PAUNCH REMOVAL					
1. Dry dumping of paunch material followed by off-site disposal	0	5	16	25	35
2. Wet dumping of paunch material followed by off-site disposal	50	70	71	70	65
3. Dumping of all paunch material into sewer	50	25	13	5	0
IV. EDIBLE RENDERING					
1. Dry rendering	20	30	40	50	60
2. Wet rendering with no evaporation of tank water	40	30	26	10	0
3. Low temperature rendering	0	10	19	25	30
4. Wet rendering followed by evaporation of tank water	40	30	15	15	10
V. INEDIBLE RENDERING					
1. Dry rendering	70	74	80	80	80
2. Wet rendering with no evaporation of tank water	15	13	9	5	0
3. Continuous rendering	0	3	5	10	19
4. Wet rendering followed by evaporation of tank water	15	10	6	5	1
VI. CLEANUP					
1. Dry cleanup followed by wet cleanup	0	5	10	30	60
2. Wet cleanup	100	95	90	70	40

Definition of Technology by Subprocess Mix

Three levels of technology were specified in terms of the process or subprocesses. The latest method of performing a fundamental process was categorized as "advanced" technology. The oldest methods still utilized were designated as "old" technology. The most widely used method was characterized as "typical" technology. In general, the different methods of paunch handling, edible rendering, inedible rendering, carcass washing and cleanup can be designated as "typical," "old" or "advanced" technology.

An "old" plant is one in which all rendering is wet with no evaporation of "stick water;" paunch material is washed into the sewer and cleanup is wet.

A "typical" plant is one in which rendering is either "wet with evaporation of stick water" or dry. Paunch material will be dumped wet but screened and disposed of offsite.

An "advanced" plant is one whose edible rendering is low temperature and whose inedible rendering is dry. Paunch material will be dumped dry and conveyed dry to trucks for offsite dumping. Cleanup will be dry followed by wet.

Any plant which did not collect blood was automatically listed as "old" technology, regardless of the type of rendering, paunch handling, etc.

When the method of edible rendering was a different technology from that of inedible rendering, the assignment of technology was based upon the animal mixture. If only cattle were killed, the inedible rendering was felt to be the determining factor. If hogs dominated, then the edible rendering method became the deciding factor.

All "questionnaire" plants were categorized according to their subprocess mix as having "old," "typical" and "advanced" technology. It was assumed that the "questionnaire" plants were representative of the entire meat packing industry in terms of subprocess mix. Table 10 shows the percentage distribution of plants by technology level for 1967.

Relationship Between Technology and Plant Size

Table 10 further shows the percentage distribution within a given technology level by size of plant. In 1967, eighty per cent of all plants employed subprocesses classified as "typical." Half of these plants were medium size plants, according to Table

10. Or it could be stated that forty per cent of all plants were medium sized using "typical" technology.

It is interesting to note that of those few plants with "advanced" technology only six per cent are small plants, while close to thirty per cent of those plants with "old" technology are small.

TABLE 10

Technology Levels and the Associated Typical Subprocesses	Estimated Per Cent of Plants by Type of Technology*	1967 Proportion of Plants of this Type by size			Size Range of Plants by Type of Technology Mil. Lbs. LWK/yr.*
		Sm.	Med.	Lar.*	
"TYPICAL TECHNOLOGY"	80	.05	.50	.45	1-800+
1. Recovery of all blood 2. Wet dumping of paunch material followed by hauling away of the gross paunch material 3. Edible rendering--dry rendering or wet rendering with evaporation of tank water 4. Inedible rendering--dry rendering 5. Wet cleanup					
"OLD TECHNOLOGY"	10	.28	.36	.36	1-500
1. Recovery of all blood 2. Washing of all paunch material down the sewer 3. Edible rendering--wet with no evaporation of tank water 4. Inedible rendering--wet with no evaporation of tank water 5. Wet cleanup					
"ADVANCED TECHNOLOGY"	10	.06	.47	.47	15-500
1. Recovery of all blood 2. Dry dumping of the paunch material followed by the hauling of the gross material away from the plant premises 3. Edible rendering--low temperature 4. Inedible rendering--continuous 5. Dry cleanup followed by wet cleanup					

*Based solely upon "Questionnaire Data."

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I. Killing and Bleeding

Because blood is one of the major sources of BOD, the recovery of blood is an important subprocess to the process of killing. Failure to recover blood increases the BOD by seventy-two per cent. In other words blood recovery can cause the BOD to decrease by forty-two per cent. (2)

A. Blood Recovery 1966, 1967

By 1967, according to survey results, four out of every five packing plants in the United States recover blood. Plants which allow blood to escape directly into the sewer are usually small in size. Of all plants that do not recover blood, seventy per cent are small plants. Twenty-four per cent are at the lower end of the range of medium sized plants, and six per cent fall in the middle of the range of the medium sized plants. As shown in Table 10 only eighty-three per cent of meat packing plants attempted to and/or accomplished recovery of all blood. This statistic on blood recovery provides an excellent example of understatement of the meat packing industry's adoption of waste reducing subprocesses. On a total liveweight basis more than ninety-six per cent of the meat packing industry is practicing blood recovery. Since failure to recover blood is a major source of BOD, face-value acceptance of Table 10 percentages will overestimate the pollution load.

B. Blood Recovery 1950, 1963

The consensus of opinion among "national" packers is that although medium and large-sized plants would have attempted to recover blood as early as 1950, recovery methods were less than they are today. Improvements in the design of the kill area have increased the percentage of blood recovered from the animals. In 1950 it was estimated that seventy per cent of all plants recovered blood. This percentage represents two factors: a larger proportion of packing plants not recovering blood as well as a less efficient recovery on the part of those packers who did attempt to recover blood.

C. Blood Recovery 1972, 1977

It seems likely that concern with the water pollution effects of no blood recovery will force the adoption of this subprocess upon all meat packers.

II. Paunch Material

In ruminants (cattle, calves, and sheep) the paunch or first stomach contains a large amount of undigested material. The paunch content of a one thousand pound cow might weigh from sixty to ninety pounds, and at the packing house the paunch is opened and the contents removed. The method by which the contents of the paunch are removed and the ultimate disposal of the contents will affect the wasteload of a particular packing plant. Combinations of the various methods of removing the undigested material from the paunch with those methods of ultimate disposal have led to the differentiation of three alternative subprocesses.

A. Dry Dumping

The first subprocess is designated as "dry dumping of paunch material and offsite disposal." This method of paunch handling is one in which the undigested material (hay, corn, straw, and grain) is dumped into a hopper and conveyed by mechanical means to a truck. The hauling of this material to its offsite disposal may be at the expense of the packer or may be provided free of charge in exchange for receipt of the paunch material. Paunch material may be used as land fill or soil conditioner. Recent attempts to process paunch material into animal feed have met with only partial success.

Dry dumping and offsite disposal represents "advanced technology" in the handling of paunch material. The use of this method of handling may in part be dictated by waste treatment practices. After the gross material has been removed from the paunch, the paunch itself is cleaned with water. In some plants, the paunch is saved for tripe; in other plants where tripe is not processed, the paunch probably is used for inedible rendering.

B. Wet Dumping

The second subprocess is designated as "wet dumping of paunch material and offsite disposal of the gross paunch material." This process involves the use of water under pressure to flush the entire paunch or the dumping of the paunch contents into a flowing stream of water which will be passed over vibrating or rotating screens. Screening separates the coarse material from the fine. The gross material is then trucked away. The solution containing the suspended fine material plus any dissolved matter passes into the sewer. This subprocess is most typical of the meat packing industry today and probably represents an "intermediate stage" in terms of technology. The introduction of screens for separation of gross material was probably pollution oriented in that their use was caused by the desire to lower the total solids content of the wastewater.

C. Dumping into Sewer

The third alternative subprocess is one in which "all paunch contents are washed down the sewer." This subprocess represents the oldest form of technology and probably would have been practiced primarily by packers located along major rivers who in earlier times were less concerned with this polluting characteristic of meat packing wastewater than the inland packers.

III. Edible Rendering

There are five basic edible rendering processes: dry rendering, wet rendering, low temperature rendering, caustic rendering, and enzyme rendering.

The latter two types are insignificant relative to the others and will not be included in the tabulations. Very few rendering operations rupture fat tissues with a caustic, and it is therefore excluded. Enzyme rendering is excluded because it is still in the development stage.

Because of differing effects upon the waste loading, four subprocesses will be included in this study. These are [1] dry rendering, [2] wet rendering without evaporation of tank water, [3] low temperature rendering, and [4] wet rendering followed by evaporation of tank water. Each subprocess will be discussed in detail.

A. Dry Rendering

Dry rendering refers to the process in which fats are cooked in steam jacketed tanks under a vacuum.(3) A dry rendering system is usually more advantageous than a wet rendering one because of the increased recovery of protein material. Also, the dry rendering process does not contribute directly to water pollution, although the vapors from a dry rendering process may contribute to air pollution through the resulting unpleasant odors. These odors may be removed by washing the vapors. If wash water for this process is not recirculated it will contain some small amounts of pollution material, but compared with other sources of polluting material, this seems to be rather insignificant.

B. Wet Rendering

This process is often referred to as steam rendering because it is a process in which

> a large tank is loaded with fat and the tank sealed. Steam is introduced at some forty to sixty pounds gauge pressure and kept at the particular level chosen until the fats are completely freed from the tissues. On standing, three layers form in the tank. Fats are on top, water is largely in the middle of the tank, and slush is in the bottom. After the fats are drawn off, the water and slush are either run through some kind of centrifuge or press to separate the suspended solids from the liquid. This liquid is the tank water, which when concentrated to about thirity-five per cent moisture, is known in the trade as liquid stick.(4)

It has been estimated that seventy-five per cent of the total protein content of the rendering inputs is dissolved in tank water.(5) Tank water before evaporation is therefore a major source of BOD, and it has been estimated that tank water will contain on the average 32,000 ppm BOD.(6) The most polluting subprocess of edible rendering would be "wet rendering without evaporation of tank water." This process is typical of "older technology."

C. Wet Rendering Followed by Evaporation of Tank Water

Because of the relatively high protein and solids content of the tank water, it is usually economically desirable to concentrate the tank water. The concentrated material, which is the by-product of edible rendering, can be sold to pharmaceutical houses for use in some products. The high protein content of the evaporated tank water in any case would be a source of protein which could be used to upgrade tankage, but even though this tank water is evaporated, it is estimated that as much as fifty per cent of the protein content will be lost to the sewer. Therefore, this subprocess is the second highest polluting method of rendering edible materials. This subprocess is a modification of the "older technology," and it is doubtful if a new packing plant would install this type of edible rendering equipment.

D. Low Temperature Rendering

This name is applied to the edible rendering process which produces a mechanical breakdown of the fatty tissues. No water is added, and the maximum temperature is 118°F. Because no water is added to the fat-yielding tissues, there is a minimum of water pollution arising from this subprocess. This process represents the latest technology in edible rendering.

IV. Inedible Rendering

There are four subprocesses or methods of rendering inedible material; [1] dry rendering, [2] wet rendering with no evaporation of tank water, [3] continuous rendering, and [4] wet rendering followed by evaporation of tank water.

A. Dry Rendering

See description of this subprocess under edible rendering.

B. Wet Rendering

See description of this subprocess under edible rendering.

C. Continuous Rendering

There are several patented processes for continuous rendering of inedible material. Almost all of the patented continuous rendering processes are considered dry rendering.

D. Wet Rendering Followed by Evaporation of Tank Water

See description of this subprocess under edible rendering.

GROSS POLLUTION QUANTITIES

Per Unit Wasteloads and Wastewater Volumes by Technology

All "questionnaire" plants with wastewater strength data were categorized by type of technology.

The number of plants of each type in the sample, the range, and average values of the waste characteristics by type of technology are shown in Table 11.

Once the "sample" plants had been identified by technology level, the plants in each technology group were analyzed to determine the average pounds of BOD per thousand pounds liveweight killed. A simple average BOD per unit of product was obtained as well as a weighted average with total liveweight killed serving as the weight. In all cases the weighted average BOD was slightly larger than the simple average. In all future calculations the weighted average BOD will be used.

Notice that all wasteloads in Table 11 are "post catch basin" wasteloads. These wasteloads must be increased by a factor of 1.33 in order to represent the gross wasteload per thousand pounds liveweight killed. Table 12 shows the "pre-catch basin" wasteloads per unit of product.

The "pre-catch basin" wasteload per unit of product should be used to estimate all gross wasteloads. All estimates of gross wasteloads should be based upon the weighted average BOD and wastewater values per unit of product. An assumed distribution of slaughter by technology is also necessary to determine a gross wasteload.

Table 13 shows the effect of technology upon wasteload and wastewater volume per unit of product in an index form. "Old" technology is the base. Advancing technology has a slightly greater effect upon wastewater volume than upon BOD, according to Table 13.

Effect of Plant Size and Technology on Wastewater Use

Table 14 shows wastewater volume per unit of product by level of technology and by plant size. As explained earlier, wastewater per unit of product declines as technology advances. According to Table 14, this relationship applies to small and to medium plants but not to large plants. The paucity of large

TABLE 11

WASTELOAD AND WASTEWATER PER THOUSAND POUNDS LIVEWEIGHT KILLED BY TYPE OF TECHNOLOGY, 1966[a] (POST CATCH BASIN WASTELOADS)

Type of Technology	No. of Plants	Size of Plant in Annual Liveweight Killed (mil. of lbs.)		Wasteload lbs. BOD/1000 lbs. Liveweight Killed			Wastewater gal./1000 lbs. Liveweight Killed		
		Range	Ave.	Range	Ave.	Wt. Ave.[b]	Range	Ave.	Wt. Ave.
"Typical Technology"	22	12-800	235	2.2-24.6	13.9	14.4	375-3668	1352	1294
"Old Technology"	14	8-500	164	8.6-36.4	19.4	20.2	937-2694	1960	2112
"Advanced Technology"	17	8-700	194	1.9-25.2	8.9	11.3	125-2507	923	1116

[a]Technology is defined by the subprocess mix as indicated in Table 10. There will be a higher proportion of single specie plants in the category "Advanced Technology" than in the other two categories.

[b]Weighted by annual liveweight killed.

NOTE: Since all "questionnaire data" BOD values were measures of effluent strength, the above BOD values must be adjusted to eliminate the pollution reducing effect of the "catch basin." It will be assumed that "catch basins," on the average, will reduce BOD by approximately 25 per cent. To adjust the above BOD values to a "gross" BOD value, increase each BOD value in the above table by thirty-three per cent.

TABLE 12

WASTELOAD AND WASTEWATER PER THOUSAND POUNDS LIVEWEIGHT KILLED BY TYPE OF TECHNOLOGY, 1966[a]
(PRE-CATCH BASIN WASTELOADS)

Type of Technology	No. of Plants	Size of Plant in Annual Liveweight Killed (mil. of lbs.)		Wasteload lbs. BOD/1000 lbs. Liveweight Killed			Wastewater gal./1000 lbs. Liveweight Killed		
		Range	Ave.	Range	Ave.	Wt. Ave.[b]	Range	Ave.	Wt. Ave.
"Typical Technology"	22	12-800	235	2.9-32.8	18.5	19.2	375-3668	1352	1294
"Old Technology"	14	8-500	164	11.4-48.5	25.9	26.9	937-2694	1960	2112
"Advanced Technology"	17	8-700	194	2.5-33.6	11.9	15.1	125-2507	923	1116

[a] Technology is defined by the subprocess mix as indicated in Table 10. There will be a higher proportion of single specie plants in the category "Advanced Technology" than in the other two categories.

[b] Weighted by annual liveweight killed.

NOTE: Since all "questionnaire data" BOD values were measures of effluent strength, the above BOD values were adjusted to eliminate the pollution reducing effect of the "catch basin." It was assumed that "catch basins," on the average, reduced BOD by approximately 25 per cent. The above wasteloads were obtained by multiplying the wasteloads in Table 11 by 1.33.

Table 13

WASTELOAD AND WASTEWATER INDEX BY TECHNOLOGY

	Waste Characteristics Per 1000 lbs. LWK		Index of Waste ("Old" = 100)	
	BOD in lbs.	Wastewater in gals.	BOD	Wastewater
"Old Technology"	20.2	2112	100	100
"Typical Technology"	14.4	1294	71	61
"Advanced Technology"	11.3	1116	56	53

Based on "questionnaire data" in which plants were classified as "old," "typical," or "advanced" on the basis of their subprocess mix. (See Tables 11 or 12)

TABLE 14

WASTEWATER USE PER UNIT OF PRODUCT BY TYPE OF TECHNOLOGY AND PLANT SIZE, 1966
(GALLONS/1000 LBS. LIVEWEIGHT KILLED)

Plant Size	Old Technology	Typical Technology	Advanced Technology	All Plants*
Small	1,529	760	356	1,320
Medium	1,756	1,340	855	1,486
Large	2,262	1,293	1,990	1,326
All Plants*	2,112	1,294	1,116	1,410

*Average weighted by total liveweight killed.

plants classified as having "advanced" technology in the "questionnaire sample" probably accounts for the wastewater use per unit of product being higher at the "advanced" level of technology than at the "typical" level of technology.

Small plants used the least amount of wastewater per unit of product---probably because small plants tend to do less processing than mediun or large plants. Medium-sized plants use the largest amount of wastewater per unit of product. Large plants according to Table 13 use slightly less wastewater per unit than medium-sized plants but more than small plants. It is probable that this relationship is due in part to the distribution of plants by technology and size in the sample. Most of the sample firms had "typical" technology and most of these firms were medium or large in size. There was almost no difference in the wastewater use per unit of product between large and medium plants of "typical" technology. There is little reason to expect that there should be. Until the percentage of large plants with "advanced" technology increases, there is not sufficient evidence to predict the effect of size upon wastewater use in this category.

Gross Wasteloads in Base Year: 1963

The annual gross wasteload is a function of annual production (liveweight slaughter) and the assumed distribution of technology. Tables 15 and 16 depict the daily and yearly gross wasteloads for the base year, 1963. Table 15 shows "post catch basin" wasteloads and Table 16 shows "pre catch basin" wasteloads. The latter, of course, is the more accurate representation of the "gross" wasteload.

Gross Wasteload and Wastewater Volumes: 1963-1977

Gross wasteloads and wastwater volumes have been estimated from meat production data for selected years between 1963 and 1977.

Production or slaughter projections by type of animal are shown in Figure 5. For reasons described earlier, value-added is not a satisfactory measure of production upon which to base pollution estimates. Slaughter projections were based upon assumed rates of population growth and per capita consumption of meat which in turn were based upon assumed elasticities of demand for meat and assumed changes in per capita income and meat prices.(7)

TABLE 15

TOTAL WASTELOAD QUANTITIES AND TOTAL WASTEWATER VOLUME--MEAT PACKING INDUSTRY, 1963[a]
(POST CATCH BASIN WASTELOADS)

Level of Technology	Total Comm. Slaughter bil of lbs		BOD lbs/1000 lbs LWK		Wastewater gals/1000 lbs LWK		Total BOD Per Year mil lbs		Total WW Per Year mil gal		Total BOD Per Day mil lbs		Total WW Per Day mil day	
	Percent. Distrib.	Bil of lbs of LWK	Ave	Wt Ave[b]	Ave	Wt Ave	Ave BOD	Wt Ave BOD	Ave	Wt Ave	Ave BOD	Wt Ave BOD	Ave BOD	Wt Ave BOD
"Typical"	65	33.0	13.9	14.4	1352	1294	459	475	44,616	42,702	1.74	1.80	169	162
"Old"	30	15.3	19.4	20.2	1960	2112	297	309	29,988	32,314	1.12	1.17	114	122
"Advanced"	5	2.5	8.9	11.3	923	1116	22	28	2,308	2,790	.08	.11	9	11
TOTAL	100	50.8					778	812	76,912	77,806	2.94	3.08	292	295

a. 1963 slaughter was 50.8 billion pounds

b. weighted by total liveweight kill

NOTE: Since all "questionnaire data" BOD values were measures of effluent strength, the above BOD values must be adjusted to eliminate the pollution reducing effect of the "catch basin." It will be assumed that "catch basins," on the average, will reduce BOD by approximately 25 per cent. To adjust the above BOD values to a "gross" BOD value, increase each BOD value in the above table by thirty-three per cent.

TABLE 16

TOTAL WASTELOAD QUANTITIES AND TOTAL WASTEWATER VOLUME--MEAT PACKING INDUSTRY, 1963[a]
(PRE-CATCH BASIN WASTELOADS)

Level of Technology	Total Comm. slaughter bil of lbs		BOD lbs/1000 lbs LWK		Wastewater gals/1000 lbs LWK		Total BOD Per Year mil lbs		Total WW Per Year mil gal		Total BOD Per Day mil lbs		Total WW Per Day mil gal	
	Percent. Distrib.	Bil of lbs of LWK	Ave	Wt Ave[b]	Ave	Wt Ave	Ave BOD	Wt Ave BOD	Ave	Wt Ave	Ave BOD	Wt Ave BOD	Ave BOD	Wt Ave BOD
"Typical	65	33.0	18.5	19.2	1352	1294	612	633	44,616	42,702	2.32	2.40	169	162
"Old"	30	15.3	25.9	26.9	1960	2112	396	412	29,988	32,314	1.49	1.56	114	122
"Advanced"	5	2.5	11.9	15.1	923	1116	29	37	2,308	2,790	.11	.15	9	11
TOTAL	100	50.8					1,037	1,082			3.92	4.11	292	295

a. 1963 slaughter was 50.8 billion pounds

b. weighted by total liveweight kill

NOTE: Since all "questionnaire data" BOD values were measures of "catch basin" effluent strength, the above BOD values were adjusted to eliminate the pollution reducing effect of the "catch basin." It was assumed that "catch basins," on the average, reduced BOD by approximately 25 per cent. The above wasteloads were obtained by multiplying the wasteloads in Table 14 by 1.33.

FIGURE 5

TOTAL COMMERCIAL SLAUGHTER
UNITED STATES, 1950-1977

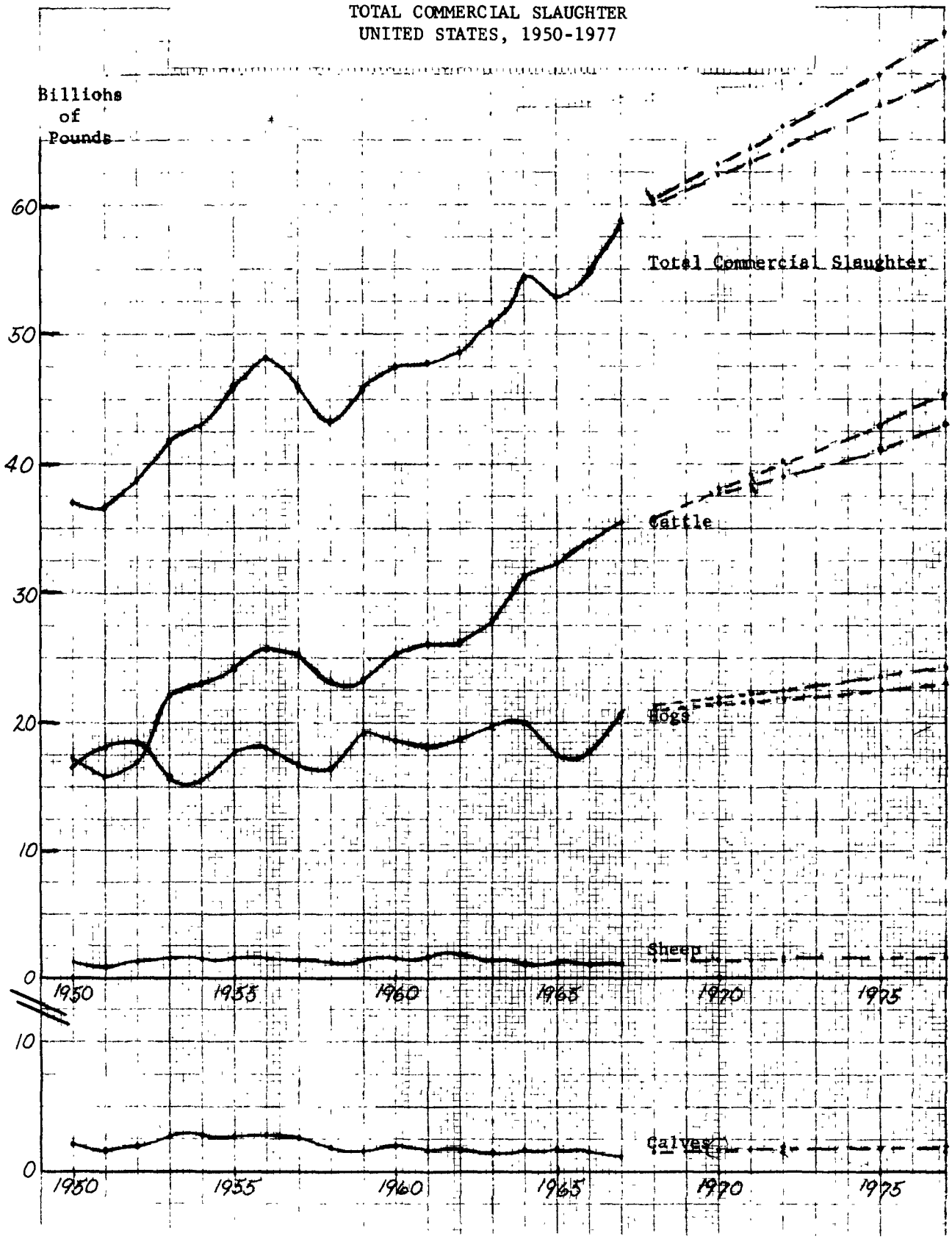

TABLE 17

PRODUCTION, GROSS WASTELOADS AND WASTEWATER VOLUMES
1963, 1966, 1967 AND PROJECTIONS TO 1977
(POST CATCH BASIN WASTELOADS)

Year	Total Comm. Slaughter Bil. of Pounds Per Year	Wasteload per unit[a] lbs BOD/ 1000 lbs LWK	Wastewater per unit[a] gals/1000 lbs LWK	Total Wasteload Per Year Mil. lbs BOD	Total Wastewater Per Year MGY
1963[b]	50.8	15.99	1531	812	77,806
1966[c]	54.9	14.05	1322	771	72,578
1967[c]	57.0	14.05	1322	801	75,354
1968[c]	60.2	14.05	1322	846	79,584
1969[c]	61.4	14.05	1322	863	81,171
1970[c]	62.8	14.05	1322	882	83,022
1971[c]	63.9	14.05	1322	898	84,476
1972[c]	65.2	14.05	1322	916	86,194
1977[d]	71.6	12.85	1205	920	86,278

a. Wasteload or wastewater per unit is the weighted average BOD per thousand pounds liveweight killed shown in Table 11 by type of technology, which has been averaged according to the assumed distribution of technology levels.

b. 1963 Assumes 65 per cent of the industry has "Typical Technology." 30 per cent of the industry has "Old Technology." 5 per cent of the industry has "Advanced Technology."

c. 1966-1972
Assumes 60 per cent of the industry has "Typical Technology." 30 per cent of the industry has "Advanced Technology." 10 per cent of the industry has "Old Technology."

d. 1977 Assumes 50 per cent of the industry has "Typical Technology." 50 per cent of the industry has "Advanced Technology." 0 per cent of the industry has "Old Technology."

TABLE 18

PRODUCTION, GROSS WASTELOADS AND WASTEWATER VOLUMES
1963, 1966, 1967 AND PROJECTIONS TO 1977
(PRE-CATCH BASIN WASTELOADS)

Year	Total Comm. Slaughter Bil. of Pounds Per Year	Wasteload per unit[a] lbs BOD/ 1000 lbs LWK	Wastewater per unit[a] gals/1000 lbs LWK	Total Wasteload Per Year Mil. lbs BOD	Total Wastewater Per Year MGY
1963[b]	50.8	21.32	1531	1083	77,806
1966[c]	54.9	18.73	1322	1028	72,578
1967[c]	57.0	18.73	1322	1068	75,354
1968[c]	60.2	18.73	1322	1128	79,584
1969[c]	61.4	18.73	1322	1151	81,171
1970[c]	62.8	18.73	1322	1176	83,022
1971[c]	63.9	18.73	1322	1197	84,476
1972[c]	65.2	18.73	1322	1221	86,194
1977[d]	71.6	17.13	1205	1227	86,278

a. Wasteload or wastewater per unit is the weighted average BOD per thousand pounds liveweight killed shown in Table 12 by type of technology which has been averaged, according to the assumed distribution of technology levels.

b. 1963 Assumes 65 per cent of the industry has "Typical Technology." 30 per cent of the industry has "Old Technology." 5 per cent of the industry has "Advanced Technology."

c. 1966-1972
Assumes 60 per cent of the industry has "Typical Technology." 30 per cent of the industry has "Advanced Technology." 10 per cent of the industry has "Old Technology."

d. 1977 Assumes 50 per cent of the industry has "Typical Technology." 50 per cent of the industry has "Advanced Technology." 0 per cent of the industry has "Old Technology."

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The weighted average "pre-catch basin" wasteloads shown in Table 12 were used in making the projections of gross wasteloads shown in Table 17.

Seasonal Changes

Seasonal changes are minimal and can safely be ignored.

REDUCTION OF GROSS WASTELOADS

Gross pollution loads can be reduced in three ways: 1. change of subprocess; 2. use of industry-owned waste treatment facilities; and 3. use of municipal waste treatment facilities. Any of these three methods can be used singly or in combination with one or both of the other methods. Each of these methods will be discussed in turn.

POLLUTION REDUCTION THROUGH SUBPROCESS CHANGE

Table 19 shows the percentage reduction in BOD which could be expected with the specified change in subprocess.

Washing of Carcass

Washwater is dispensed through the use of hoses and/or mechanical washers. The use of mechanical, or cabinet washers, is essentially a process by which the packer substitutes water volume for labor. Cabinet washers may be the continuous flow or the interruptable flow type. The latter is regulated in such a way that when the chain conveying the animal stops, the water is turned off. Hoses almost always are equipped with some kind of valve for regulating flow but the valve is not necessarily used. The use of the valves is almost always dependent upon the "water-use-consciousness" of the plant supervisors. In many instances hoses equipped with valves have been found to have been altered by plant workers so that the valves remain open all the time. This practice has turned an interruptable flow device into a continuous flow device.

Change from Continuous Flow Hoses to Interruptable Flow Cabinet

Theoretically the change to mechanical washers will not effect the wasteload per unit of product; that is, the BOD per thousand pounds liveweight killed. This change does imply an increase in the wastewater volume per unit of product. An open hose carries about fifteen gallons per minute. The concentration of BOD in mg/l should be lower with the use of mechanical washers and higher with the use of hand washers or hoses. With concentration varying indirectly with wastewater use, the BOD per unit of of product should be unaffected. In practice, however, it was often found that wastewater use per unit is directly related to wasteload per unit. [See Figure 4 and discussion following.]

TABLE 19

Changes in Subprocesses and Their Effect Upon Wasteload and Wastewater Volume*

Subprocess Change	Per Cent Wasteload Reduction Associated With Indicated Change of Subprocess
I. KILLING AND BLEEDING	
Change subprocess from recovery of no blood to recovery of all blood.	42
II. WASHING OF CARCASS	
Change from a system of continuous water flow to one of "interruptable" water flow.	See Text
III. PAUNCH REMOVAL	
A. Change subprocess of dumping all paunch material into sewer to wet dumping of paunch material with off-site disposal.	See Text
B. Change subprocess of wet dumping of paunch material with off-site disposal to dry dumping of paunch material with offsite disposal.	5
C. Change subprocess of dumping all paunch material into the sewer to dry dumping of paunch material with offsite disposal.	10
IV. EDIBLE RENDERING	
A. Change subprocess of wet rendering with no evaporation of tank water to one in which tank water is evaporated.	50
B. Change subprocess of wet rendering with no evaporation of tank water to subprocess of dry rendering.	60
C. Change from a system of wet rendering with no evaporation of tank water to subprocess of low temperature rendering.	60

TABLE 19 (cont'd)

Changes in Subprocesses (cont'd)

Subprocess Change	Per Cent Wasteload Reduction Associated With Indicated Change of Subprocess
V. INEDIBLE RENDERING	
A. Change subprocess of wet rendering with no evaporation of tank water to one in which tank water is evaporated.	50
B. Change subprocess of wet rendering with no evaporation of tank water to continuous rendering.	60
C. Change subprocess from wet rendering with no evaporation of tank water to continuous rendering.	60
VI. CLEANUP	
Change subprocess of primarily wet cleanup to one of dry cleanup followed by wet cleanup.	10

*Only those subprocess changes which will alter wasteload are considered.

The direct relationship between wasteload and wastewater per unit of product makes sense if wastewater use per unit of product is interpreted to be an index of "water" and "wastewater consciousness," which leads to waste saving practices within the plant.

Paunch Material

Paunch material is troublesome primarily because it increases greatly the total solids concentration in packing plant effluent. Should all plants now dumping all paunch material directly in the sewer abandon this practice, fifty to sixty pounds of solids per thousand pounds of liveweight killed would be eliminated from the wastewater.

Paunch material presents a waste treatment problem because this undigested material is not eadily handled by a bacteriological treatment facility. For some reason the bugs do not like paunch material. The difficulty in handling this material at end-of-line treatment plants dictates that this material be separated from other waste material and disposed of separately.

In those cases where the paunch is wet dumped, elimination of the wet dumping and wet transfer of this material should reduce the BOD content by at least five per cent. It is the elimination of the paunch "fines" from the effluent that should cause the five per cent reduction.

Edible Rendering

The unevaporated tank water, which is a by-product of the wet rendering system, is a main source of BOD. The installation of evaporating equipment should reduce the BOD of the wastewater by approximately fifty per cent. Even when great care is taken to evaporate this tank water, it is estimated by those in the meat packing industry that some BOD will be lost to the sewer. Therefore, it was estimated that the substitution of the process of dry rendering for one of wet rendering without evaporation, would result in a sixty per cent reduction in BOD.

INDUSTRY OWNED WASTE TREATMENT FACILITIES

Types of Waste Treatment Facilities

A brief description of those types of waste treatment facilities utilized by meat packing plants follows:

"Catch Basins"

"Catch basins" are gravity settling tanks with grease skimming. Larger packing plants have utilized "catch basins" because of the economic value of the recovered grease. The effectiveness of this means of treatment will depend upon the size of the tank and the dention time. Several years ago the Meat Packing Industry made a study of the detention time which maximized the economic return of use of the catch basins. The detention time was about twenty minutes. From a waste reduction standpoint the detention time should be twice as long for maximum efficiency. To the extent that meatpackers are still following the twenty minute guide in designing "catch basins," full waste reduction potentiol is not realized.

There is one immediate implication: to inform the packing industry of the detention time necessary to achieve maximum waste reduction.

Air Flotation

Air Flotation is a treatment process in which a coagulation agent such a ferric chloride or alum is added to the wastewater, which is then subjected to air pressure in an enclosed chamber. The wastewater is left in the chamber for a few minutes and then released to atmospheric pressure. This method is supposed to be especially good for treatment of wastes which contain quantities of fat and protein. The introduction of the air aids the oxidation of the organic material with the iron salts acting as catalyst. The air further aids by bringing flock and colloidal matter to the surface where it can be skimmed off. There is lack of agreement within the meat packing industry as to the success of this method of treatment; however, one of the "national" packing companies has installed this method of treatment in approximately half of its plants.

Trickling Filters

A trickling filter is a bed of coarse, rough, impervious material over which wastewater is sprayed or distributed. The wastewater trickles downward through the filter in contact with the air. Organisms attached to the material of the filter oxidize the organic matter in the wastewater. It is necessary to see that solid materials are screened or settled out before the wastewater is distributed onto the filter in order to prevent clogging of the filter. Very cold weather may interfere with the working of this system. When operating efficiently, a ninety per cent BOD removal can be expected.

Lagoon Systems

According to Eckenfelder there are three types of lagoons: aerobic ponds, facultative ponds, and anaerobic ponds.(8)

The aerobic pond depends upon algae to supply oxygen to satisfy the BOD. Because the algae are dependent upon sunlight to produce oxygen the pond must be shallow; that is, less than eighteen inches. This type of pond has often been used to treat meat packing waste. An eighty per cent BOD reduction can be obtained.

Facultative Ponds

This pond is much deeper, and there will be two layers: an aerobic surface layer and an anaerobic bottom layer. Depth of ponds will vary from three feet to six feet and an eighty per cent BOD removal can be expected.

Anaerobic Ponds

These are loaded to such an extent that anaerobic conditions exist throughout. These ponds are usually much deeper so that there is a high volume to surface area ratio, which will help to maintain the temperature of the waste. Anaerobic decomposition requires high temperatures for efficient decomposition of the material. Meat packing waste is especially suited to anaerobic decomposition because it is a very strong waste and comes from the packing house at a temperature of eighty degrees.

The more common practice is to use an anaerobic-aerobic pond system in series using the aerobic pond as a polishing pond. Because sample data are extremely limited as to the actual BOD loading which went into the meat packing lagoons and the BOD

reduction obtained, we have lumped all three lagoon systems together in tabulating the data and we have assumed an arbitrary figure of ninety per cent BOD reduction.

Activated Sludge

The activated sludge process involves the aeration of screened, presettled wastewater mixed with a small volume of activated sludge which has been collected in a sedimentation basin shortly before it is mixed with the sewage preceding aeration.(9) There are a very few activated sludge plants specially devoted to the treatment of meat packing waste, primarily because of the high capital cost of the system and the necessity to have well-trained personnel supervising the operation of the process. When used, however, it is assumed that a ninety-five per cent BOD reduction could be obtained.

Channel Aeration

This process is really a modification of the activated sludge process or, more specifically, the extended aeration activated sludge process where a cage rotor is used as the aerating device. The Pasveer concept is to put the wastewater in an oval ditch and use the cage rotor to aerate the liquid and at the same time cause it to flow around the oval. This process was developed in Holland and is now and has been utilized on a pilot plant scale at one plant in the United States. The full scale plant will be built at one of the major packing plants. The simplicity and efficiency of this system make it a promising addition to the methods of treating meat packing waste.

Anaerobic Contact

Again it will be mentioned that the anaerobic digestion process is especially suited to meat packing waste because of its relatively high organic content and high temperatures. The high organic content means that relatively large amounts of methane gas will be released which can be utilized as a source of heat. Anaerobic contact process separates seed organisms and recirculates them to the digestor. When operating efficiently, this process requires retention periods of six to twelve hours. Waste flows into an equalizer tank, from there into a digestor and then through a vacuum degasifier which removes residual gases to facilitate settling, and finally into a settling basin from which the sludge is removed and returned to the digestor as seed. This method of decomposition is usually followed by polishing lagoons or by other secondary treatment methods to achieve further decomposition of the organic material.

Utilization of Waste Treatment Facilities

Estimates of utilization of waste treatment facilities by type of facilities have been made for the years 1950, 1963, 1967, 1972, and 1977. These estimates are shown in Table 20.

The 1967 estimates were based upon the "questionnaire" data and should be considered more reliable than estimates for other years. Past and future estimates are admittedly guesses. Literature dealing with meat packing waste treatment and conversations with waste experts in the meat packing industry were used to gain insight into past experience.

Future estimates will reflect the assumption of increased use of industry-owned treatment facilities. Future estimates indicate shift in the treatment mix, indicating increased use of methods especially suited for the degradation of meat packing wastewater; that is, wastewater with high concentrations of BOD and high temperatures. Future estimates further assume that only those meat packing plants utilizing municipal waste treatment facilities will be allowed to operate no more than "catch basins" or air flotation units.

TABLE 20
UTILIZATION OF WASTE TREATMENT FACILITIES

Type of Waste Treatment Facility	Estimated Percentage of Plants Employing Waste Treatment Process				
	1950	1963	1967	1972	1977
"Catch Basin" Only (Sedimentation and Grease Skimming)	60	50	46	10	10
Air Flotation	0	5	8	20	20
It is assumed that a "catch basin" will precede the following methods of treatment.					
Lagoon Systems	10	15	17	20	14
Trickling Filter	1	3	3	3	2
Activated Sludge	1	2	3	3	1
Anaerobic Contact (Followed by Lagoons, Activated Sludge, or Trickling Filter)	0	5	6	20	25
Channel Aeration (Pasveer Process)	0	0	2	5	10
Joint Industrial	0	1	2	10	15
Other (Including Chemical Treatment)	8	4	4	8	2
TOTAL (Plants With Some Type of Treatment Facility	80	85	91	99	99
No Treatment Facilities	20	15	10	1	1
TOTAL	100	100	100	100	100

MUNICIPAL TREATMENT OF MEAT PACKING WASTEWATER

Many meat packing plants use municipal waste treatment facilities for the treatment of wastewater. Some plants will pretreat the wastewater before disposing of it into municipal sewers; other plants have no pretreatment.

Table 21 shows the estimated annual wastewater discharge of meat packing plants into the municipal sewerage system by size class. These estimates were based upon information obtained from the "questionnaire data." The total gallons discharged by medium and large plants were approximately equal. The twenty-five billion gallons from large plants represented a much higher proportion of their total discharge than did that from medium plants. Seventy per cent of all meat packing wastewater is discharged to the municipal sewerage system.

Table 22 contains estimates of the per cent of wastewater discharged to municipal treatment facilities in selected years. The projected percentages for 1972 and 1977 show increased use of municipal treatment facilities.

TABLE 21

QUANTITY OF WASTEWATER FROM MEAT PACKING PLANTS, QUANTITY AND PER CENT DISCHARGED TO MUNICIPAL TREATMENT FACILITIES, BY PLANT SIZE, 1967

Plant Size	Gross Wastewater Emerging From Plant (mil. gal. per year)	Wastewater Discharged to Municipal Facilities (mil. gal. per year)	Per Cent of Gross Wastewater Discharged to Municipal Facilities
Small	3,768	2,449	65
Medium	42,198	24,897	59
Large	29,388	25,568	87
TOTAL	75,354	52,914	70

TABLE 22

PER CENT OF MEATPACKING WASTEWATER DISCHARGED TO MUNICIPAL TREATMENT FACILITIES

Year	Per Cent
1950	35
1963	50
1966	70
1972	80
1977	85

NET POLLUTION QUANTITIES

1963

A detailed estimate of gross wasteload reduction achieved by industry's use of its own waste treatment facilities is shown in Table 23 for the base year, 1963, by type of treatment facility. These estimates were derived by combining the theoretical percentage BOD reduction reduction associated with a particular type of treatment. The implicit assumption was that the per cent of plants and the per cent of liveweight slaughtered associated with a given treatment process would be the same. While it is obvious that they are not, lack of time prevented the development of a distribution of liveweight slaughtered by type of industry-owned waste treatment facilities. In 1963, lagoons were the dominant method of providing secondary treatment to meat packing wastewater. Fifteen per cent of all meat packing plants provided no waste treatment at all.

1966

By size of plant, Table 24 shows the wasteload reduction achieved through the use of industry or municipal waste treatment. The gross wasteload was reduced almost equally with each type of waste treatment. Industry's waste treatment removed 339 million pounds of BOD and municipal treatment removed 380 million pounds. Altogether the gross wasteload was reduced sixty-eight per cent. All estimates in Table 24 were based upon "questionnaire data."

TABLE 23

NET POLLUTION LOAD AFTER INDUSTRY WASTE TREATMENT
1963

Treatment Method[a]	Theoretical Waste Reduction Per Cent BOD Removed	% of Plants Employing Method of Waste Treatment	Gross Pollution Removed by Treatment mil lbs BOD[b]	Net Pollution Load mil lbs BOD
"Catch Basin" only	25	50	135	
Air Flotation Unit	50	5	27	
Lagoons a. Aerobic and Facultative (80) b. Anaerobic (80) c. Anaerobic-Aerobic (94)	90	15	146	
Trickling Filter	90	3	29	
Activated Sludge	95	2	21	
Channel Aeration	80-95	0	0	
Anaerobic Contact Plus a. Trickling Filter b. Activated Sludge c. Lagoons	95	5	48	
Other (including Chemical and Joint Industrial)	70	5	38	
TOTAL		85	444	638

a. All treatment methods except the "catch basins only" and "air flotation" are assumed to be preceded by "catch basins."

b. Gross pollution load is 1082 million pounds of BOD.

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TABLE 24
GROSS AND NET POLLUTANT QUANTITIES
BY PLANT SIZE, 1966

Plant Size	Gross Wasteload mil lbs BOD/yr	BOD Reduction By Packing Plant Waste Treatment	BOD Wasteload After Packing Plant Treatment mil lbs	Per Cent Reduction By Packing Plant Waste Treatment	BOD Reduction By Municipal Treatment mil lbs	Per Cent of Net Wasteload Reduced By Municipal Treatment	BOD Wasteload to Water Courses mil lbs	Per Cent of Overall Reduction of Gross Wasteload
Small	44	23	21	52	9	45	11	74
Medium	519	143	376	28	160	43	236	54
Large	465	173	292	37	211	72	87	81
Total	1028	339	689	33	380	56	334	68

TABLE 25

NET POLLUTANTS: BASE YEAR AND PROJECTED YEARS

Year	Gross Wasteload (Pre-catch basin) mil lbs. BOD[b]	Per Cent Reduction due to Process Changes	Net Wasteload After Process Changes	Per Cent Reduction by Plant Treat-ment Mil lbs. BOD	Net Wasteload After Plant Treat-ment Mil lbs.	Per Cent Wastewater Treated by Municipal Facilities	Per Cent BOD Reduction[b]	Net Wasteload to Watercourses Mil lbs. BOD Per Year
1963	1082	a	1082	30	757	50	40	454
1966	1028	a	1028	33	689	70	56	303
1968	1128	a	1128	38	699	72	58.6	296
1969	1150	a	1150	43	656	74	59.2	274
1970	1176	a	1176	47.5	617	76	61.8	242
1971	1197	a	1197	50	599	78	62.4	225
1972	1221	a	1221	55	549	80	64	198
1977	1226	a	1226	62	460	85	68	147

[a]Process changes are implicit in the technology levels.

[b]Assumes the ratio between the per cent of wastewater treated by municipal treatment facilities and the per cent of wasteload reduction achieved by use of municipal facilities is the same as existed in 1966.

COSTS OF POLLUTION REDUCTION

Cost of Pollution Reduction by Subprocess Change

Capital and operation and maintenance costs have been estimated for three subprocess changes. These costs are shown in Table 26. None of these costs should be interpreted as anything but "ball park" estimates. The salvage value of the "more polluting" rendering system which is being replaced by a "less polluting" rendering system would constitute one adjustment of the costs shown in Table 26. The physical layout of the meat packing plant would influence greatly the installation portion of the capital costs listed.

Costs shown in Table 26 would require additional adjustment if, for example, there is increased revenue due to higher prices received for animal feed as a result of its increased protein content because of the addition of dried and processed evaporated "stick water." Adjustments of the cost estimates would also be required. The enforcement of "dry cleanup" may result in lower water use per unit of product and thus lower total water costs. These are only two examples of possible cost adjustments which should be included in the analysis of alternatives for a specific plant. Geographical location affects construction costs and labor costs and refinements of this nature would also be necessary.

Costs of Pollution Reduction by Industrial Waste Treatment

Costs of treatment by type of waste treatment process were developed for the "typical" small, medium, and large plant. Plant size in annual liveweight killed and wastewater flow associated with the typical plant in a size class are indicated at the top of Table 27. The costs of treatment were based upon the average cost per thousand gallons experienced by plants in our "sample" with occasional adjustments by engineering cost estimates. (10) The lagooning cost data from the "sample" was felt to be especially unreliable since land costs were not consistently included in the reporting of capital costs.

Costs of Municipal Treatment of Meat Packing Wastewater

It is impossible to estimate for a given size of plant the charges which must be paid to the municipality for its treatment of the industry's wastewater. These charges vary greatly from one city to another. If the meat packing plants in the "questionnaire sample" are representative of the entire industry, the entire meat packing industry paid six million dollars in 1967 to municipalities for waste treatment services.

TABLE 26

COST OF WASTE REDUCTION BY SUBPROCESS CHANGE

Subprocess Change	Small Plant 20 mil.lbs/yr. LWK		Medium Plant 100 mil.lbs/yr. LWK		Large Plant 300 mil.lbs/yr. LWK	
	Cap. Costs $	O. & M. Costs $	Cap. Costs $	O. & M. Costs $	Cap. Costs $	O. & M. Costs $
Add Evaporator to Wet Rendering System[a]	30,000	2,000	70,000	5,000	140,000	10,000
Change To Nonpolluting Rendering System[b]	60,000	-----	120,000	-----	200,000	------
Precede Wet Cleanup With Dry Cleanup[c]	0	8,000	0	40,000	0	100,000

[a]The addition of an evaporator will cut BOD by 50%. The economic life is assumed to be fifteen years.

[b]The complete changing of the rendering system would reduce BOD by 60%. The economic life is assumed to be fifteen years.

[c]Dry cleanup would reduce BOD by 10%. To be effective this subprocess would require constant enforcement.

TABLE 26

COST OF WASTE TREATMENT FACILITIES

Type of Treatment Facility	Small Plant 20 mil.lbs/yr. LWK 33 MGY Wastewater 0.125 MGD Wastewater		Medium Plant 100 mil.lbs/yr. LWK 143 MGY Wastewater 0.54 MGD Wastewater		Large Plant 300 mil.lbs/yr. LWK 444 MGY Wastewater 1.68 MGD Wastewater	
	Cap. Costs $	O. & M. Costs $	Cap. Costs $	O. & M. Costs $	Cap. Costs $	O. & M. Costs $
"Catch Basin" Only	12,000	1,000	35,000	10,000	250,000	18,000
Air Flotation			60,000	13,000	150,000	30,000
It is assumed that a "catch basin" will precede the following methods of treatment.						
Lagoon Systems			215,000	11,000	415,000	21,000
Trickling Filter	70,000	21,000	700,000	30,000	900,000	35,000
Activated Sludge	275,000	65,000			1,900,000	150,000
Anaerobic Contact (Followed by Lagoons, Activated Sludge, or Trickling Filter)			410,000	20,000	630,000	30,000
Channel Aeration (Pasveer Process)			15,000	6,000	350,000	20,000

Industry Investment in Waste Treatment Facilities, 1967

The estimates of capital and operation and maintenance expenditures on waste treatment facilities by the Meat Packing Industry require explanation. These estimates were based upon "questionnaire data." The average capital investment [measured in terms of 1967 replacement cost] per plant was determined for each size group and then inflated to reflect the number of plants under federal inspection. The number of federally inspected plants seems more appropriate than all plants because of the extremely small size of the non-federally inspected plants. The use of plant numbers rather than liveweight killed introduces a source of error, but since the plants have been grouped by size class, the error should not be significant. Since federally inspected plants kill eighty-five per cent of the liveweight, the estimated costs for the entire federally inspected sector of the industry were increased by 17.6 per cent to account for the remaining liveweight slaughter in locally inspected plants. The 1967 replacement value of waste treatment facilities would then be approximately thirty-five million dollars.

The estimate of industry investment is felt to be an extremely conservative estimate. Several meat packing companies have arrangements with municipalities whereby the city owns the facility but the packing plant in effect guarantees to cover the operating and amortization costs. Such facilities are often especially designed units to handle meat packing wastes yet the legal arrangement precludes their inclusion in Table 28.

Operation and maintenance costs for the federally inspected sector were likewise inflated to account for the remaining liveweight. Total operation and maintenance costs for 1966 were $3.5 million.

Industry Expenditures for Waste Treatment, 1966

Table 29 summarizes all expenditures on waste treatment in 1966. The capital expenditures are expressed as an annual average payment assuming a fifteen year life and interest rate of six per cent. Total expenditures then were approximately thirteen million dollars.

TABLE 28

CAPITAL AND OPERATING AND MAINTENANCE COSTS OF WASTE TREATMENT FACILITIES BY SIZE CLASSIFICATION
(ACTUAL SAMPLE DATA AND DATA PROJECTED FOR ALL FEDERALLY INSPECTED MEAT PACKING PLANTS)

Type of Treatment	Small 0-24.9 Mil. lbs. Annual Kill			Medium 25-199.9 Mil. lbs. Annual Kill			Large 200-Up Mil. lbs. Annual Kill			All Plants		
	No. of Plants	Capital Costs	O. & M. Costs	No. of Plants	Capital Costs	O. & M. Costs	No. of Plants	Capital Costs	O. & M. Costs	No. of Plants	Capital Costs	O. & M. Costs
SKIMMING & CATCH BASINS ONLY												
Sample Plants:Average		4,014	270		15,052	6,436		66.071	10,000		20,482	5,474
Sample Plants:Total	12	48,168	3,240	33	496,716	212,388	18	1,189,278	180,000	63	1,734,162	395,628
Federally Inspected Plants:Total	45	180,630	12,150	107	1,610,564	688,652	29	1,916,059	290,000	181	3,707,253	990,802
TRICKLING FILTER												
Sample Plants:Average		40,000	4,250		250,000	10,000		160.000	70,000		112,500	16,646
Sample Plants:Total	2	80,000	8,500	1	250,000	10,000	1	160,000	70,000	4	490,000	88,500
Federally Inspected Plants:Total	7	280,000	29,750	3	750,000	30,000	2	320,000	140,000	12	1,350,000	199,750
ACTIVATED SLUDGE												
Sample Plants:Average		150,000	35,000		20,000	3,000					85,000	19,000
Sample Plants:Total	2	300,000	70,000	2	40,000	3,000				4	340,000	73,000
Federally Inspected Plants:Total	7	1,050,000	245,000	7	140,000	21,000				14	1,190,000	266,000
LAGOONS-ANAEROBIC AND/OR AEROBIC												
Sample Plants:Average		16,800	878		100,333	6,810		1,000,000	68,000		87,640	5,843
Sample Plants:Total	9	151,200	7,902	14	1,404,662	95,340	1	1,000,000	68,000	24	2,555,862	171,242
Federally Inspected Plants:Total	34	571,200	89,852	46	4,615,318	313,260	2	2,000,000	136,000	82	7,186,518	479,112
ANAEROBIC DIGESTION												
Sample Plants:Average					55,000	3,365		200,000	5,000		71,731	3,571
Sample Plants:Total				7	385,000	23,695	2	400,000	10,000	9	785,000	33,695
Federally Inspected Plants:Total				23	1,265,000	77,855	3	600,000	15,000	26	1,865,000	92,855
CHEMICAL TREATMENT												
Sample Plants:Average		1,000	100		70,000	8,000					44,909	5,127
Sample Plants:Total	1	1,000	100	2	140,000	16,000				3	141,000	16,100
Federally Inspected Plants:Total	4	4,000	400	7	490,000	56,000				11	494,000	56,400
JOINT INDUSTRY												
Sample Plants:Average					1,750,000	83,000					1,750,000	83,000
Sample Plants:Total				2	3,500,000	166,000				2	3,500,000	166,000
Federally Inspected Plants:Total				7	12,250,000	581,000				7	12,250,000	581,000
AIR FLOTATION												
Sample Plants:Average		23,500	4,250		25,000	6,500		100,000	10,000		31,500	6,341
Sample Plants:Total	2	47,000	8,500	7	175,000	45,500	2	200.000	20,000	11	422,000	74,000
Federally Inspected Plants:Total	7	164,500	29,750	23	575,000	149,500	3	300,000	30,000	33	1,039,500	209,250
OTHER												
Sample Plants:Average		500	1,650		55,000	3,745					26,452	2,648
Sample Plants:Total	3	1,500	4,950	3	165,000	11,235				6	166,500	16,185
Federally Inspected Plants:Total	11	5,500	18,150	10	550,000	37,450				21	555,500	55,600
GRAND TOTAL												
Sample Plants:Average		19,616	3,174		95,476	8,304		131,694	15,667		76,583	7,521
Sample Plants:Total	31	628,868	103,192	71	6,556,378	583,158	24	2,949,278	348,000	126	10,134,524	1,034,350
Federally Inspected Plants:Total	115	2,255,830	365,052	233	22,245,882	1,954,717	39	5,136,059	611,000	387	29,637,771	2,930,769

TABLE 29

EXPENDITURES FOR WASTE TREATMENT BY
THE MEAT PACKING INDUSTRY, 1966

Replacement Value of Treatment Facilities Millions of Dollars	Annual Equivalent Millions Of Dollars	Annual O & M Costs Millions Of Dollars	Annual Payments To Municipalities Millions Of Dollars	Total Payments For Waste Treatment Millions of Dollars
35	3.5	3.5	6	13

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PART II

POULTRY PROCESSING PROFILE

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POULTRY PROCESSING SUMMARY

Measure of Plant and Industry Size

Since the number of birds slaughtered is the most important factor determining wastewater volumes and pollution loads of the poultry processing industry, pounds liveweight killed and the number of birds killed will be used to measure the plant and industry size. Value-added and sales have been rejected as measures of plant and industry size since neither of these two numbers give a base for pollution estimates.

Definition of Small, Medium, and Large Poultry Processing Plants

For purposes of this report, plant size will be defined in terms of daily number of birds slaughtered and daily liveweight slaughtered.

A small plant is one whose daily liveweight kill is less than 100,000 pounds or less than 25,000 birds processed per day. This measure is applied to all processing plants studied.

In 1966 approximately thirty-nine per cent of total liveweight slaughtered was done by plants which are classified as small. For projection purposes the typical small plant will be one whose daily liveweight kill is sixty-thousand pounds.

A medium plant is one whose daily liveweight kill is less than 380,000 pounds of less than 95,000 birds. The medium plants killed approximately fifty-two per cent of the total liveweight in 1966.

Large plants would include all plants processing over 95,000 birds per day or 380,00 pounds of liveweight per day. Large plants killed approximately nine per cent of the total liveweight in 1966. This sector of the industry is expected to experience the most growth in the next ten years at the expense of the small sector.

Source of Data

Much of the information is based upon the questionnaire responses received from poultry packers who killed almost thirty per cent of all birds processed in 1966. It is assumed that this portion of the poultry processors is typical of the entire industry.

Processes and Pollutants

Those processes, which have substantial impact upon wasteloads, have been identified for further analysis. These processes are:

1. Blood Recovery
2. Screening of feathers
3. Cleanup

1. Blood recovery can reduce wasteloads by approximately thirty-eight per cent. With only fifty-six per cent of all plants recovering blood in 1966, this subprocess is potentially an area where substantial pollution reduction could occur.

2. Defeathering has a pollution potential of great magnitude because of the volume of feathers involved. Because feathers are not easily degradable by biological waste treatment, processing plants must use screens to separate the feathers from the wastewater.

3. Dry cleanup of manure and feathers preceding the wet cleanup can reduce both the solids and BOD concentration of the wastewater.

Effect of Technology on Wasteloads

Technology has been defined in terms of the subprocess mix. The three levels of technology: "Old," "Typical," and "Advanced" are defined as follows:

"Old Technology" (41% of all plants in 1966)

1. Holding of live poultry in storage batteries
2. Recovery of no blood
3. Nonflow-away system for removal of feathers and offal from processing area
4. Removal of carcass body heat by submission in portable vat containing ice and water
5. Shipment of processed poultry in ice
6. Dry cleanup followed by wet cleanup

"Typical Technology" (56% of all plants in 1966)

1. Direct placement of birds on conveyor from receiving truck
2. Recovery of all blood due to immobilization of birds
3. Flow-away system for removal of feathers and offal from the processing area
4. Shipment of processed poultry in ice
5. Wet cleanup of plant

"Advanced Technology" (3% of all plants in 1966)

1. Direct placement of birds on conveyor from receiving truck
2. Recovery of all blood due to immobilization of birds
3. Flow-away system for removal of feathers and offal from the processing area
4. Removal of carcass body heat by submission into mechanical chilling tanks containing refrigerated water
5. Shipment of processed poultry frozen
6. Wet cleanup of plant

Technology is directly related to wasteload reduction. The major reduction occurs as technology changes from "old" to "typical." The waste reduction in this change is caused by the introduction of blood recovery into the subprocess mix. This change in technology also brings the "flow-away" system into existence with the consequent increase in wastewater per unit of product.

The change from "typical" to "advanced" technology sees only a very slight lowering of wasteload, due primarily to the introduction of dry cleanup on a limited scale. The reduction of wastewater per unit of product is caused by increased reuse of wastewater.

The effects of technology upon wasteload and wastewater volume are summarized in the following table.

WASTELOAD AND WASTEWATER VOLUME PER 1000 BIRDS
BY TYPE OF TECHNOLOGY, 1966

Type of Technology	Wasteload lbs BOD/1000 birds	Wastewater gals/1000 birds
"Old Technology"	31.7	4,000
"Typical Technology"	26.2	10,400
"Advanced Technology"	26.0	7,300

Waste Reduction by Subprocess Change

Although subprocess change can be an effective means of wasteload reduction, it is often economically unfeasible for an individual plant. The poultry processing industry has four types of subprocess changes available to them; Cleanup, Blood Collection, the method of Eviseration, and By-Product recovery. The two most predominant subprocess changes are cleanup and blood collection, the latter achieving the highest per cent of pollution reduction.

Waste Reduction by Use of Waste Treatment Facilities

The most common method of waste treatment used by the poultry processor is municipal treatment. Since the poultry industry is a low profit margin industry the costs of private treatment tend to be prohibitive for the poultry processor. The plants of the typical and advanced technology levels wh ch employ the flow-away system of feather and offal removal use a screening process to remove feathers and solids from the plant effluent. The majority of processing plants (eighty per cent) this is the only type of treatment employed by the plant. All futher treatment is done by the municipality. A table of waste treatment charges is shown on page 46 of this report. A table on the cost of private treatment is shown on page 47.

PROFILE OF THE "POULTRY PACKING" INDUSTRY

INTRODUCTION

Definition of Poultry

"Poultry Processing" is defined for purposes of this report to include all plants engaged in slaughtering, dressing, and packing of poultry. The deletion of small game dressing and egg breaking was necessitated because of the lack of information for these categories.

Two types of plants are considered in this report. The turkey processing plant and the chicken/broiler processing plant. Both plants are engaged in the slaughtering and packaging of their respective products. The two types of plants were considered separately because of the seasonal operation of the turkey processor.

Poultry processing is carried out under government supervision for interstate commerce shipments. The industry is characterized by a large number of small, independent local processors, usually not being government inspected. For this reason average figures had to be used many places in the report because of the lack of adequate information.

It should be noted by the reader that this classification as defined above differs from the SIC classification number 2015 used by the Federal Government.

Measure of Plant and Industry Size

Poultry processors typically indicate size of plant by refering to the number of birds processed per time period. The literature in the field, therefore, incorporates this measurement of size. The water use and pollution per bird for a broiler processor will differ from that of the turkey processor. Total liveweight, therefore, is used as the common denominator for the calculations in this report.

Since the majority of poultry statistics are in numbers of birds processed, a conversion factor had to be developed for converting numbers of birds to liveweight figures. The conversion factor utilized in this report is 4.25. When the number of birds is multiplied by 4.25, the result is liveweight in pounds. This factor is accurate only when applied to annual data because of the

seasonal effect of turkey processing.

The multiplication factor is constructed in a manner which considers the seasonal load of turkey processors, whose product is the heaviest. The 4.25 conversion factor is weighted by the number of birds of each type killed in 1965. The use of this same conversion factor for projections of poultry production implies the same distribution of total birds as existed in 1965. This assumption appears reasonable since the product mix of the industry is becoming stabilized. The number of chickens produced should continue to decline until the 0.5 million pounds per year level is reached. The 1965 ratio of broilers to turkeys is assumed to continue, as can be seen in Figure 1.

The dictionary of relevant terms should be consulted for average weight per bird by type of bird. However, since this report is primarily concerned with aggregate figures, the application of these individual weight figures to tables in this report is not relevant. Total liveweight, then, in annual figures is the measure of size which will be utilized in this study.

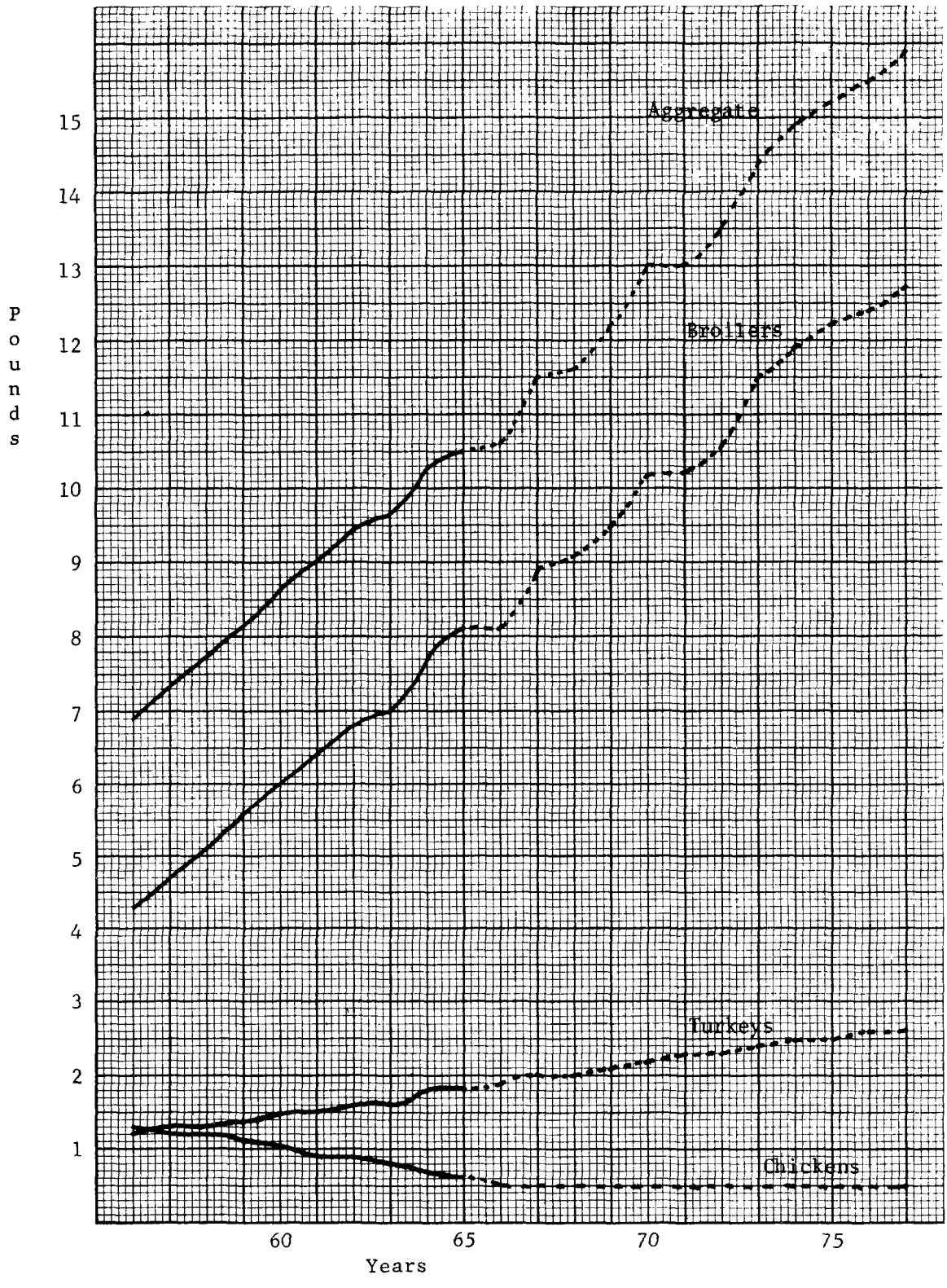
Definition of Relevant Terms

In the interest of clarity the definitions of terms to be used throughout this report are given below.

Eviscerated poultry....poultry which has had its head, feet, and viscera removed.
Offal.....includes head, feet, and viscera.
Viscera.....the heart, lungs, liver, and intestines of the bird.
Broiler.....a bird grown eight to nine weeks with a liveweight of approximately 3.5 pounds.
Chicken.....a catch-all classification of poultry with an average weight of approximately 4.8 pounds.
Turkey.....a type of poultry with the average weight of 14.1 pounds. In this report turkeys can weigh anywhere from eight to thirty pounds, the heavier birds being less popular than those of lighter weight.

FIGURE 1

POULTRY PRODUCTION IN THE UNITED STATES
1956 TO 1965 ACTUAL, 1966 TO 1977 PROJECTED
(In Billions of Pounds of Liveweight)



Source of Data

Questionnaires were sent to the poultry processors. A sample was selected from each state and weighted to reflect the position of the state, as compared with total U.S. production. The names and addresses of plants were obtained from the: "Who's Who in the Egg and Poultry Industries," published by the Watt Publishing Co., Mount Morris, Illinois, 1967 edition. The questionnaire received a forty-one per cent response which represented twenty-eight per cent of the total number of birds processed in 1966. This indicates that a large percentage of the large processors did not answer. Nevertheless, it is assumed that the sample obtained was sufficiently large and typical to justify its use as basis for this report.

Structure and Characteristics of the Poultry Processing Industry

The poultry processing industry has undergone a process of vertical integration. The integration process has been carried out to ensure the constant supply of uniformly high quality birds. The process of integration has enabled the processor to avail himself of the economies achieved by scheduling production at near optimum capacity.

Vertical integration was preceded by a change in the form of the marketable product. When the "cold pack" or eviscerated bird replaced the "New York Dressed" bird, it was possible to freeze and store processed poultry. The change in the dressing process also made it possible for the processor to locate farther from the market areas. Therefore, it can be stated that the dressing change helped to speed up the integration process.

An Agricultural Marketing Service study lists the six following points as contributing factors for the growing integration of the poultry industry.(1)

1. the opportunity to increase profits by lowering costs through more efficient coordination of both the production and marketing processes.

2. the need for outside financing and technical assistance for many producers.

3. the increasing awareness among retailers of the need for uniformly high quality. . . (poultry).

4. the increasing size of retail operations which give retailers greater power in enforcing their demands.

5. the inability of pricing methods to bring forth production of uniformly high quality . . . (broilers) and a uniform seasonal distribution of volumes and sizes.

6. the inability, in many instances, to obtain the benefits from larger sales of feed by developing contractual arrangements.

The integration process is proceeding at a rapid pace in most regions; however, the large producing regions are showing the greatest amount in change.

Finally, it should be noted that the shift from the "New York Dressed" poultry, where only blood and feathers are removed, to cold pack or eviscerated poultry in 1955-1957 presented the industry with its first waste disposal problems. Now, 1967, it is all but impossible to find "New York Dressed" poultry in the market place. The effect upon the processing industry has been the development of poultry by-product rendering facilities to handle the increased amounts of waste material created through the sale of eviscerated poultry.

Growth of the Poultry Processing Industry

Since 1950 the poultry processing industry has undergone radical change which has been and is being reflected in the product produced by this industry and in the structure of the industry.

The following two tables, Tables 1 and 2, depict the characteristics and growth of the poultry industry by type of bird. The two tables consider weight changes, regional growth patterns, and the breakdown of the industry's three component parts. The component parts are chickens which represent the smallest per cent in total weight killed, turkeys which constitute the smallest per cent in numbers killed, and broilers which comprise the largest per cent of the industry in both liveweight and numbers killed.

Table 1 shows the characteristics of poultry production in the United States for 1965. The numbers of birds and liveweight slaughtered by type of bird are shown.

Table 2 shows the growth of the poultry processing industry over the past fifteen years. The same information is presented in graphic form in Figure 1.

TABLE 1

1965 POULTRY SLAUGHTER BY TYPE OF BIRD
(Numbers of birds and total liveweight)

Type of Bird	Millions of Birds Per Year	Millions of Pounds Per Year	Per Cent of Total Birds Killed by Type	Per Cent of Total Liveweight Killed by Type
Broilers	2,333	8,146	89	78
Chickens	195	640	7	6
Turkeys	104	1,751	4	16
U.S. Total	2,632	10,938	100	100

TABLE 2

POULTRY PRODUCTION IN THE UNITED STATES, 1950 TO 1965
(Millions of Pounds Liveweight)

Year	Broilers	Chickens	Turkeys	Total
1950	1,938	1,872	815	4,625
1951	2,463	1,875	911	5,249
1952	2,699	1,767	946	5,411
1953	2,932	1,713	1,080	5,725
1954	3,267	1,661	1,076	6,004
1955	3,350	1,230	1,080	5,660
1956	4,270	1,203	1,249	6,772
1957	4,683	1,008	1,342	7,033
1958	5,431	1,050	1,316	7,797
1959	5,763	1,062	1,379	8,204
1960	6,017	903	1,488	8,408
1961	6,841	947	1,885	9,673
1962	6,917	908	1,628	9,453
1963	7,284	913	1,676	9,873
1964	7,524	943	1,791	10,258
1965	8,106	946	1,885	10,937

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The industry has undergone a tremendous phase of integration in the past ten years. With profit margins decreasing as a result of falling market prices, the poultry processor was forced into cutting costs in order to survive. Because economies of scale existed, costs were reduced by increasing the size of processing plants. Growth of the processing plant was accompanied by vertical integration within the industry, since large processors required large numbers of high quality, uniformly sized birds delivered on predetermined schedules to meet the demands of faster, mechanized equipment. In order to guarantee the regular delivery of birds, the processor gained control of poultry growing and distribution channels. Thus, the processing industry moved closer to its source of supply, the South Atlantic and Central Atlantic States.

Regional Distribution of the Poultry Industry

Poultry is processed in every state, but nine states produce and process approximately seventy-five per cent of the nation's broilers and seventy per cent of the nation's chickens. The nine states are Alabama, Arkansas, Delaware, Georgia, Maryland, Mississippi, North Carolina, Texas, and Virginia. Table 3 gives the breakdown of states contained within each poultry region as defined by the U.S.D.A. As the industry has grown over the past decade, processing plants have become larger, and the industry in general has become more centralized. Shifts in regional development of broiler production can be seen in Table 4.

The industry's low profit margin will exclude the survival of all but the large processor. As noted before, the survival of large processors is due to the tremendous economies of scale experienced in both the growing and processing industry. Thus, it is expected that the South Atlantic, South Central, and Western regions will continue to grow at the expense of other regions.

Wastewater Characteristics to be Considered

Because of the short time available for data collection and data analysis, it was decided to use "organic load" as the measure of wastewater strength. "Organic load" will be measured in terms of biochemical oxygen demand (BOD). To be more specific, the organic load was measured in five-day, twenty degree centigrade BOD. The five-day designation refers to the usual incubation period and the twenty degree centigrade to the temperature maintained during incubation. This particular form of the BOD test, as well as the BOD test itself, was chosen because it is the one most generally used.

TABLE 3

STATES IN POULTRY REGIONS

North Atlantic	Western	East North Central
Maine	Idaho	Ohio
New Hampshire	Colorado	Indiana
Vermont	Arizona	Illinois
Massachusetts	Utah	Michigan
Rhode Island	Washington	Wisconsin
Connecticut	Oregon	
New York	California	
New Jersey		
Pennsylvania		
South Atlantic	**South Central**	**West North Central**
Delaware	Kentucky	Minnesota
Maryland	Tennessee	Iowa
Virginia	Alabama	Missouri
West Virginia	Mississippi	Nebraska
North Carolina	Arkansas	Kansas
South Carolina	Louisiana	
Georgia	Oklahoma	
Florida	Texas	

TABLE 4

BROILER PRODUCTION BY REGION
(Figures in Millions)

Region	1950		1965	
	Number	Pounds	Number	Pounds
North Atlantic	76.9	238.4	137.2	480.2
East North Central	57.1	177.0	51.4	179.9
West North Central	28.3	87.7	45.2	158.2
South Atlantic	299.4	928.1	987.1	3,454.9
South Central	123.3	382.2	1,011.3	3,539.5
West	45.7	141.7	99.1	346.8
United States	630.8	1,955.1	2,332.6	8,159.5

The reliance upon one measure of wastewater strength (BOD) does not imply that this indicator is the only one or even the best one. In many instances total solids may be an equally important measure of meat packing waste. BOD was chosen because it is one of the most important and most commonly used measures of wastewater strength. Additional studies of poultry processing wastewater should include at least total solids and suspended solids.

The BOD test is a time consuming, expensive, and delicate test of wastewater strength. These characteristics of the test may be one explanation of the lack of information concerning the strength of industrial wastewater.

The poultry processing industry has one unique waste problem, that is, feathers. A large volume of feathers are accumulated during processing, and these feathers must be disposed of by means other than biological sewage treatment. This report has treated the problem of feather disposal separately from the problem of wastewater disposal as BOD loads do not include feathers. It is assumed that feathers will be removed by a screening process along with other solid materials such as heads and feet.

Effects of Plant Size and Technology Upon Wasteload and Wastewater

I. Plant Size

The size of the plant is directly related to the volume of wastewater produced. The chicken and broiler processing plants of typical and advanced technology use approximately nine gallons of water per bird processed. The nine gallons include processing, cooling, and clean-up water. About 8.75 gallons of the process water emerges from the plant as wastewater. The remaining .25 gallons is absorbed by the bird and/or evaporated during processing. The size of a poultry processing plant is defined in terms of the number of birds processed by the plant during a one year period. Therefore, the volume of wastewater emerging from a processing plant is directly related to the plant size. Effluent volumes from turkey processing plants are estimated to be approximately four times larger than broiler processing plants handling the same number of birds per year. The factor of four is due to the large size of the turkey compared with that of a chicken or broiler. Size in this instance constitutes both inches and weight. Plants with "old technology" in general use about two-thirds as much water as more advanced processing plants.

II. Technology

"Technology" affects both the wasteload volume and wastewater per unit of product.

A. Wasteload

The wasteload, measured in BOD per unit of product, depends upon the technology level of the processing plant. "Old technology" plants are characterized by low water use and no collection of blood. Low water use results from the absence of a flow-away system for feather and offal removal. The absence of blood collection increases the BOD strength of the wastewater by more than fifty per cent.

Typical and advanced technology plants are characterized by the presence of a flow-away system for feather and offal removal and of blood collection methods. The blood collection process alone can reduce BOD loads by thirty-eight per cent, but the per cent of reduction achieved will depend upon the efficiency of the blood collection method employed. (3)

B. Wastewater

It was stated previously that the "technology level" affected in an indirect manner the volume of wastewater effluent. The "old technology" plant has low volume effluents because of the absence of the flow-away system. Plants of "typical technology" use the most water per unit of product while plants of the "advanced technology" use a slightly smaller amount per unit of product. The reason for the reduced water use in "advanced" plants is that water is reused within the processing operation.

III. Miscellaneous

The United States Department of Agriculture regulations pertaining to the poultry processing industry also affect wastewater volumes. The U.S.D.A. regulations prescribe the minimum amount of chill tank overflow for each bird entering the tank. This regulation is generally considered excessive by most processors. Therefore, non-federally inspected plants usually have a lower volume of wastewater.

Plants employing the "older" level of technology tend to have the highest wasteload per unit of product because of the lack of blood collection. "Advanced technology" plants tend to have waste loads whose BOD per bird is reduced by the continuous

rescreening of wastewater that is required to permit the reuse of water within the plant. Thus the resulting wasteload is somewhat lower than that of plants with "typical technology."

The per cent of plants employing the various processing and subprocessing methods can be seen in Tables 5 and 6. Table 5 presents the per cent of plants employing each subprocess method from 1950 to 1967. The 1967 figures presented in Table 5 are the most reliable; the figures for other years are educated estimates, as indicated in table headings. Table 6 gives the per cent of plants employing each technology level in 1967 as ascertained from the questionnaire data.

TABLE 5

Production Process and Significant Subprocesses	Estimated Percentage of Plants Employing Process				
	1950	1963	1967	1972	1977
I. RECEIVING					
1. Direct placement of birds on conveyor	50	80	90	92	93
2. Birds retained in storage battery	50	20	10	8	7
II. KILLING AND BLEEDING					
1. Recovery of all blood	30	40	60	80	80
2. Recovery of no blood	70	60	40	20	20
III. FEATHER REMOVAL					
A. Scalding					
1. Immersion in scald tank	80	70	60	70	70
2. Spray scalding	20	30	40	30	30
B. Defeathering					
1. Line defeathering with continuous spray of water	50	65	80	82	85
2. Batch defeathering in cyclictype machines	50	35	20	18	15
C. Pin Feather Removal					
1. By hand	98	95	93	90	89
2. Wax stripping	2	5	7	10	11
IV. OFFAL REMOVAL					
1. Dry dumping of offal (Nonflow-away)	70	45	27	19	9
2. Wet dumping of offal (flow-away)	20	50	71	80	90
3. Dumping offal into sewer (possible side result of either non or flow-away system)	10	5	2	1	1
V. REUSE OF CHILL TANK OVER FLOW					
1. No reuse	80	70	54	45	25
2. Reuse--to supplement water flow-away system	20	30	46	55	75
VI. CLEANUP					
1. Dry cleanup followed by wet cleanup	80	50	29	20	10
2. Wet cleanup	20	50	71	80	90

TABLE 6

Technology Levels and the Associated Typical Subprocesses	Estimated Per Cent of Plants by Type of Technology	1967 Proportion of Plants of this Type by size			Size Range of Plants by Type of Technology Mil. Birds Per Day
		Sm.	Med.	Lar.	
"TYPICAL TECHNOLOGY"	56	.26	.66	.08	3-240
1. Direct placement of birds on conveyor from receiving truck					
2. Recovery of all blood due to immobilization of birds					
3. Flow-away system for removal of feathers and offal from the processing area					
4. Shipment of processed poultry in ice					
5. Wet cleanup of plant					
"OLD TECHNOLOGY"	41	.40	.55	.05	1-50
1. Holding of live poultry in storage batteries					
2. Recovery of no blood					
3. Nonflow-away system for removal of feathers and offal from processing area					
4. Removal of carcass body heat by submission in portable vat containing ice and water					
5. Shipment of processed poultry in ice					
6. Dry cleanup followed by wet cleanup					
"ADVANCED TECHNOLOGY	3	.05	.17	.77	20-300
1. Direct placement of birds on conveyor from receiving truck					
2. Recovery of all blood due to immobilization of birds					
3. Flow-away system for removal of feathers and offal from the processing area					
4. Removal of carcass body heat by submission into mechanical chilling tanks containing refrigerated water					
5. Shipment of processed poultry frozen					
6. Wet cleanup of plant					

FUNDAMENTAL INDUSTRY PROCESSES

Graphic Representation of Basic Processes

Figures 2 and 3, give a graphic representation of poultry processing. Figure 2 shows the major steps in poultry processing, the major sources of pollution, and by-products.

Figure 3 shows each processing step and its place in the process. The dotted line encloses those processes with which this report is concerned. As can be seen from Figure 3 these processes involve many steps, the majority of which contain pollution potential.

Poultry Processes

I. Receiving Live Poultry

Most processing plants receive their live birds by truck, and the coops containing the birds are moved directly from the truck to the processing line or to storage. In the past it was a common industrial practice to hold the birds in a storage area; storage time varied from a few hours to as long as one week. The changing face of the industry has proven storage uneconomical as well as unnecessary. Birds are grown under such controlled conditions today that those brought to the processing plant are within a specified weight and age range. The quality of the birds received remains at a constant level because of the controlled environment in which the birds live during their growing life, which is usually a period of eight to nine weeks.

At most poultry dressing establishments truck shipments of poultry are scheduled in a fashion that facilitates the direct movement of poultry from the delivering truck to the processing line. Smaller poultry operations may hold live birds for a few hours to ensure adequate numbers before beginning killing operations. Manure deposits accumulated during the holding period are an additional source of BOD.

The birds are removed from the coops and attached by their feet to shackles suspended from an overhead conveyor line. The conveyor line is moved at a prescribed rate of speed which is governed by the processing operation. Large dressing plants will have more than one conveyor serving the receiving and processing areas of the plant. The birds are moved directly from the receiving

FIGURE 2

POTENTIAL POLLUTION SOURCES

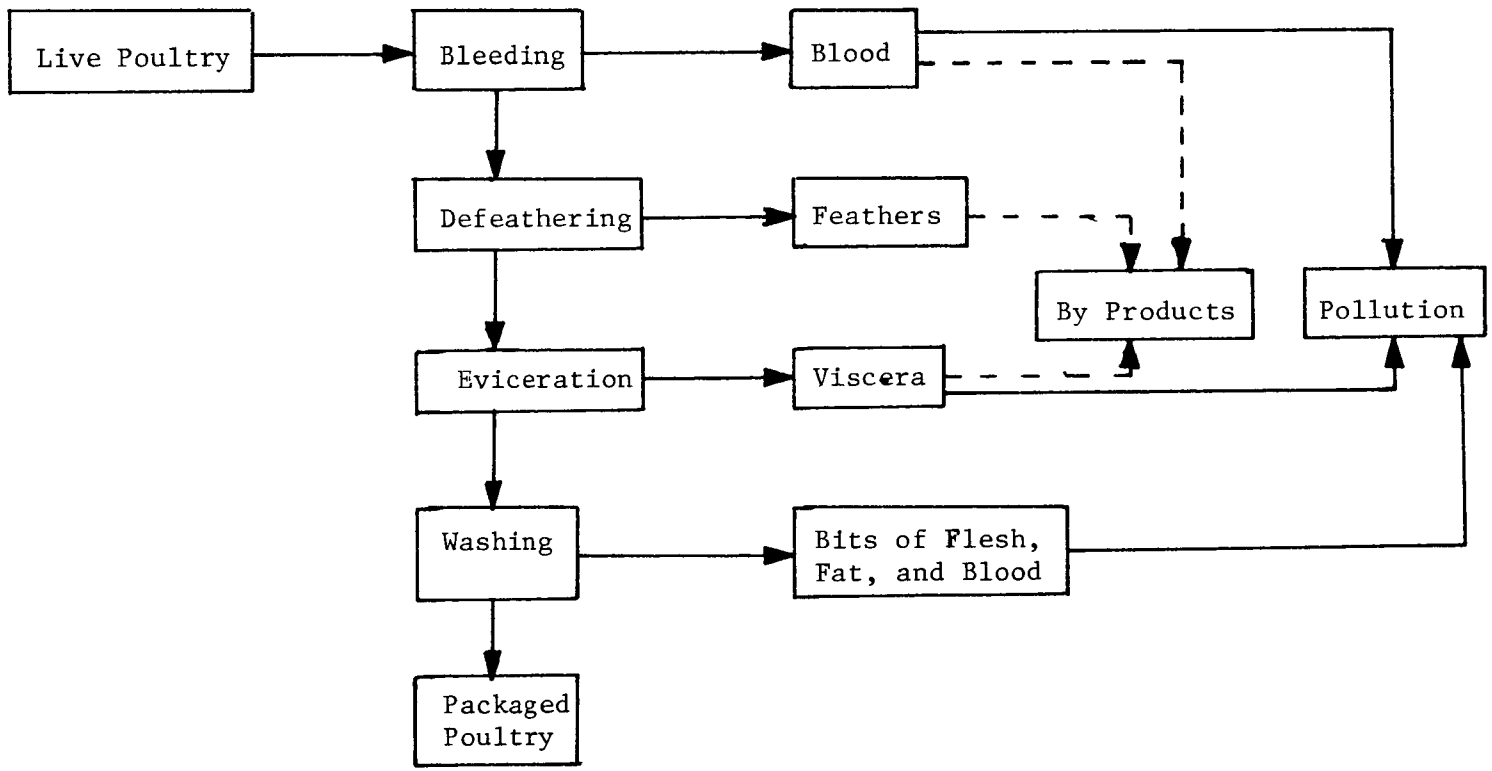
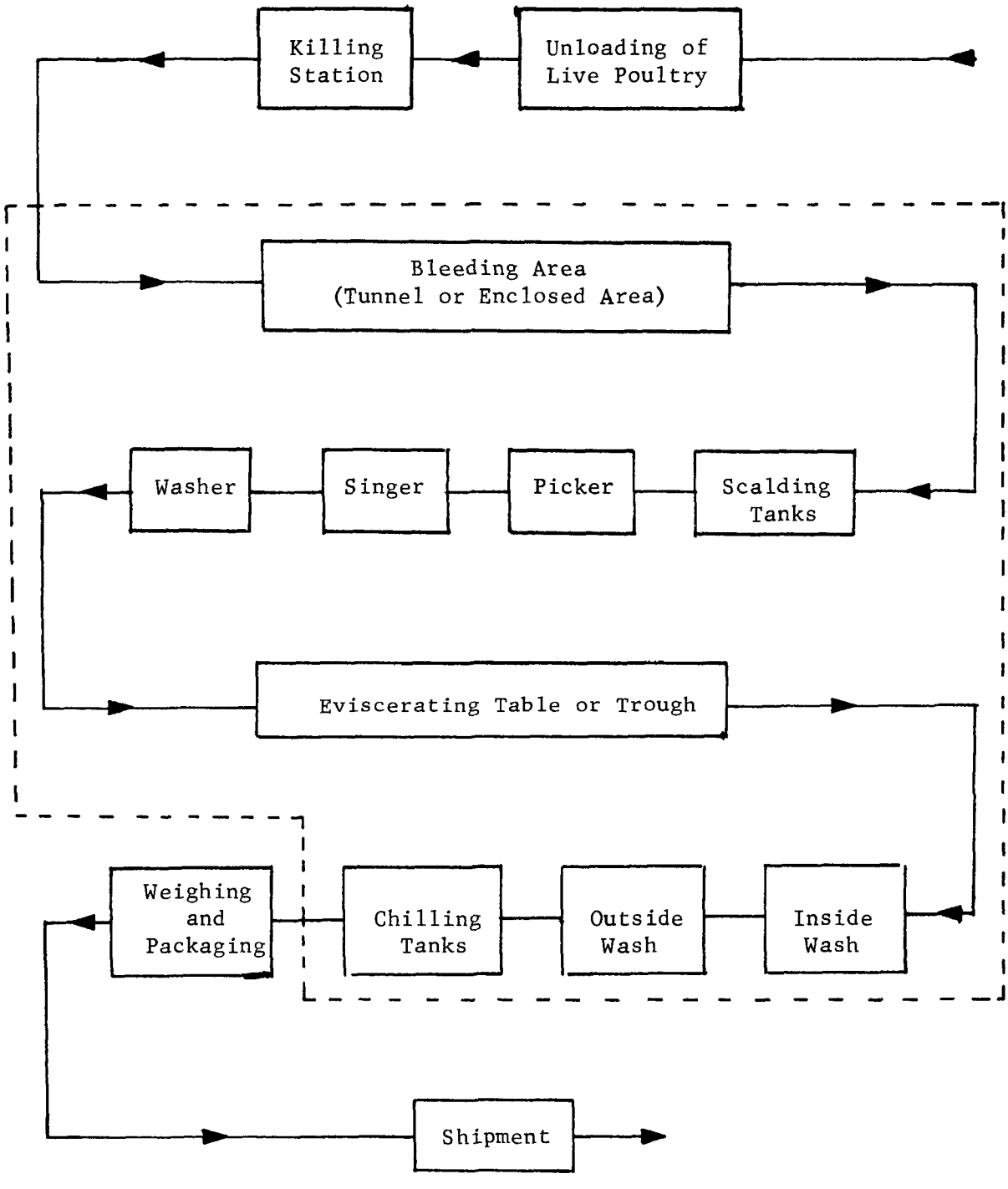


FIGURE 3

MAJOR STEPS IN POULTRY PROCESSING



The area enclosed by the dotted lines represents the processing area with the greatest pollution potential.

dock to the killing area by the conveyor.

II. Killing Operation

Poultry are slaughtered in several different ways: the two most common ways are debraining and severance of the jugular vein. This operation is not covered by government regulation and is left up to the processor as long as sanitation and health requirements are met. The larger dressing establishments collect the blood which after further processing becomes a salable by-product or is sold raw to a rendering plant. Some smaller plants flush the blood directly into the sewer, thus increasing the strength of the effluent. Sewage strength at least is doubled if all blood is allowed to enter the plant sewer. From the killing room the birds proceed through a bleeding chamber where blood is collected. Then they proceed to the scalding tanks.

III. Scalding Tanks

The scalding operation can be carried on in either one of two ways: the birds can be scalded by the use of a spray or scalded by immersion in a tank containing heated water. The latter operation is the most widely used method. Water temperature can range from approximately 128°F to 140°F, depending upon the type of scalding desired by the processor.(1) Water in the scalding tank is maintained at the desired temperature by the continuous addition of hot water; the rate of addition is approximately one-quarter to one-half gallon per bird. Excess water overflows into the sewer along with the tank drainings at the end of the processing period. The drain water will contain significant amounts of dirt and blood which add to sewage strength.

IV. Defeathering Operation

Feathers are mechanically removed from the birds immediately following the scalding operation. The feather removal process is carried out in several different fashions.

A. Batch Removal of Feathers

This is accomplished by removing the birds from the overhead conveyor, by hand, and placing them in a rotating cylindrical machine which removes the feathers. The cleaned birds are then gathered up by hand and resuspended from the moving overhead conveyor. This is not the usual method used because of the excessive amount of hand labor necessary to keep

a continuous, even flowing operation. The batch method is the most commonly used in small slaughtering operations.

B. Line Defeathering

This is the more popular method, since the bird remains suspended from the conveyor and is passed in front of rotating drums containing rubber fingers which beat the feathers off the bird. Continuous streams of water wash feathers from the carcass to a flume and then from the picking area to a central gathering location. A screening operation is then conducted to separate feathers and water. This operation will be discussed later.

Nonflow-away operations remove the feathers from the picking area by hand or by machine and deposit them in containers. Both operations require a wash down of the picking area at the end of the processing period.

After the picking operation has been completed, pin feathers are removed by hand or by wax stripping. Wax stripping increases the pollution problem in that some wax inadvertently escapes into the sewer. After stripping, the bird passes through an arc-gas flame to singe fine hair and remaining pin feathers. The bird is then passed through an "outside washer," a continuous spray of water tha washes the exterior surface of the carcass.

V. Evisceration

The evisceration area of the processing plant is enclosed and separated from the other portions of the plant to ensure sanitary operation and avoid contamination. The first step of evisceration is the removal of the lower leg portion. The birds are then suspended from the conveyor in a fashion which facilitates removal of viscera. Subsequent operations remove inner organs and separate the edibles (heart, liver, and gizzard) from the inedibles. Flow-away systems are employed by the great majority of processors because of the convenience offered in handling evisceration wastes. The only drawback of this system is the large amount of water required to accomplish the physical movement of the viscera.

When evisceration is completed the carcass is throughly washed by an "inside washer" which spray-washes the interior of the bird. The bird is then inspected by the U.S. Department of Agriculture to ensure that the final product meets all necessary health specifications.

If further processing is desired, the carcasses may be cut up and processed for special packages such as wings, breasts,

legs, etc. This operation may entail packaging and replacing of neck, heart, liver, and gizzard into the carcass.

VI. Packing

The cleaned and processed poultry are either chilled or frozen before shipment. The removal of animal hear is very important in the processing operation. At this point flavor and marketing life can be greatly reduced by improper handling of the chilling or freezing operation.

A. Chilling and Freezing Operations

In large portion federal rules and regulations govern chilling and freezing operations. Large poultry processors use two or three mechanical chill tanks in series for carcasses and a series of smaller tanks for giblets. Iced or refrigerated water is added to the first chill tank at a rate to reduce the carcass temperature to around 65°F.

> With respect to chilling systems using continuous chillers, the amount of water intake necessary to provide an overflow that will be sufficient to accomplish a sanitary operation shall not be less than one-half gallon per frying chicken in the first section of the chilling unit.(2)

The second and third chill tanks continue to lower the carcass heat to 34°F, a process which is accomplished in about thirty minutes. The U.S.D.A. allows recirculation of the water from the second and third tank to the first tank; however,

> Sufficient water or ice or ice and water shall be added to subsequent sections of the chilling system (tanks two and three) so that the chilling media in all sections is maintained reasonably clear and there shall be a continuous overflow from each section.(2)

Older plants generally do not have mechanical equipment for quick chilling, and they generally place birds in portable tubs containing ice and water. This operation is referred to as slow chilling.

After the birds and giblets are chilled, they are placed on a conveyor line to allow outer water to drain. The birds are then sized by weight, graded, and packed. Birds to be

frozen are generally wrapped in appropriate containers. The great majority of birds are packed in crates containing ice and then shipped in refrigerated trucks.

Poultry and Small Game Processes as Related to BOD

I. Blood Collection

Blood collection has the highest amount of pollution potential of any process within the plant. If all blood were allowed to enter the sewer, it would increase the BOD of plant effluent at the rate of forty pounds per thousand birds killed.(3) Blood collection which reaches an efficiency of ninety per cent will reduce the plant BOD by approximately thirty-eight per cent.

The plant sewer system will receive a "shock load" when the blood collection area is cleaned. This amount represents a very small amount of total collectable blood, but the pollution potential of blood is so great that it deserves mention. The entire clean-up operation of a typical plant will give a BOD loading factor of about four pounds per thousand birds.(3)

II. Scalding

The purpose of the scalding operation, as described in the first section, is to remove all dirt and blood from the exterior surface of the carcass and to loosen feathers. This process can be carried out in scalding tanks or sprayers.

A. Scalding Tanks

They present a "shock load" waste problem. Immersion of the birds will result in a build up of dirt and gum deposits in the tank bottom. These deposits have a high BOD and solids content. The dumping of the tank represents a "shock load" to the treatment facilities. When the tank water is drained at the end of the processing period, the plant effluent experiences a rise in strength which is incorporated into the clean-up period BOD figures in Table 7.

B. Spray Scalding

This method allows the same amount of dirt and gum to enter the plant effluent, but this amount is spread throughout the processing day.

TABLE 7

WASTE PRODUCTION BY PROCESS

Technology Levels	Wasteload lbs BOD/day(1)	Wastewater (mgd)
"Typical Technology" (125,000 Birds Per Day)		
Recovery of Blood and Flow-away System	2581	.93 -- 1.0
Wet Cleanup	1385	1.0 -- 1.6
Total	3966	
"Old Technology" (25,000 Birds Per Day)		
No Blood Recovery and Nonflow-away System	575	.065 -- .11
Dry Cleanup followed by Wet Cleanup	80	.032
Total	655	.065 -- .14
"Advanced Technology" (150,000 Birds Per Day)		
Recovery of Blood and Flow-away System	3322	.9 -- 1.2
Recirculation of Water	----	.02
Wet Cleanup	585	.27
Total	3907	.9 -- 1.3

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III. Defeathering

The defeathering process has a pollution potential of great magnitude because of the volume of feathers involved. One thousand birds will yield approximately seventy pounds of feathers. If no attempt is made to collect feathers, the sewage disposal problem becomes overwhelming for a plant killing twenty-five thousand birds per day. Such a plant would yield close to two thousand pounds of feathers per day.

The batch removal processes of defeathering involves the use of water to wash the feathers from the drum-like machine during the processing period. In the line defeathering method, water is used to wash feathers from the carcasses. There is no substantial pollution difference in these two methods of removing feathers.

Processing plants use screens to separate the feathers from the water, which emerges from the plant as wastewater. If the screens become plugged, the resulting overflow of the screens will carry feathers into the sewer.

An alternative to the above process is the use of line defeathering with mechanical conveying of feathers from the picking area to a truck. The few feathers which cling to the carcass are washed off with water. An advantage of this method over the process of flow-away with screening is that this method eliminates the chance of feather overflow into the sewer due to plugged screens.

Definition of Plant Size

Table 8 which was constructed from data received from questionnaire responses, defines plant sizes. It defines plant sizes in terms of small, medium, or large. The number and total liveweight of birds processed per day, the total liveweight in each size class as a per cent of total industry slaughter, and the number of pounds of liveweight killed for a typical plant in each class is presented. The "typical" plant in each size class is the plant size which will be used in estimating costs of pollution reduction later.

Table 9 shows the size range of plants by technology level and by size groups of small, medium, and large. The median size plant is also given for each size group by level of technology. An interesting characteristic of the median is that it tends to fall at the lower end of the size group in both the medium and large size groups. The reason for this is that processing plants for the most part tend to fall at the lower end of each size group bringing the median down. The few large plants in each size group account for the extremely wide range of the group but had little influence upon the median. For this reason the median, rather than the mean, was decided upon as the measure of central tendency. Notice that in all size groups the median size plant was larger as technology improved.

TABLE 8

DEFINITION OF PLANT SIZE IN NUMBER OF BIRDS PROCESSED PER DAY AND POUNDS LIVEWEIGHT

Plant Size	Range in Numbers of Birds Per Day	Range in Pounds Liveweight Per Day	1966 Per Cent of Total Liveweight Killed in Size Class	Typical Plant in Size Group Pounds Per Day
Small	0 to 25,000	0 to 100,000	39	60,000
Medium	25,000 to 95,000	100,000 to 380,000	52	200,000
Large	95,000 to 240,000	380,000 to 960,000	9	400,000

TABLE 9

DEFINITION OF PLANT SIZES BY TECHNOLOGY LEVELS
[Figures in 1000's of Birds]
(Daily Figures)

Plant Size	Old Technology (Range)	Median	Typical Technology (Range)	Median	Advanced Technology (Range)	Median
Small	1 to 3	2	3 to 10	5	10 to 25	15
Medium	25 to 35	30	35 to 45	40	45 to 95	50
Large	95 to 110	100	110 to 125	115	125 to 240	130

Gross Pollution Quantities

Per Unit Wasteloads and Wastewater Volumes by Technology

From the "questionnaire data" a wasteload and wastewater volumes per unit of product were developed for each of the three levels of technology. These per unit values are shown in Table 10.

The immense increase in wastewater per unit of product between "old" and "typical" technology was caused by the introduction of the flow-away system. The drop in water use per unit of product between "typical" and "advanced" was due to recirculation of water in "advanced" technology plants. In other words, process water was used more than once in the processing operation.

"Old" technology and "typical" technology differ in amount of wasteload because of their differences in terms of blood collection. The fact that blood is collected in "typical" technology and not in "old" technology constitutes the difference in wasteload reduction of these two technology levels. The slight decrease in wasteload between "typical" and "advanced" technology is the result of the continuous screening which is required by in-plant reuse of water which is assumed in "advanced" technology plants.

Table 10 also contains the per unit wasteload and wastewater in index form. "Old" technology was used as the base of 100. The index is presented to facilitate comparisons among technology levels.

TABLE 10

WASTE INDEX BY TECHNOLOGY, 1966

Type of Technology	Waste Characteristics Per 1000 Birds Killed		Index of Waste BOD	Index of Wastewater
	BOD in pounds	Wastewater in gallons		
"Old Technology"	31.7	4,000	100	100
"Typical Technology"	26.2	10,400	83	260
"Advanced Technology"	26.0	7,300	82	190

Gross Wasteloads 1963 - 1977

Table 11 presents annual poultry slaughter statistics and future slaughter projections. The slaughter projections were determined by the use of multiple linear regression techniques based on fifteen years of past slaughter statistics provided by the Department of Agriculture. The BOD wasteload projections were functions of the total slaughter and the per unit wasteload, which in turn was based upon an assumed distribution of technology.

Wastewater projections were done in the same manner. From 1970 to 1971 both production and gross wasteloads increase, while total wastewater volume decreases slightly. This decrease occurs because it is assumed that by 1971 all processing plants of major significance will be using "advanced" technology. It will be remembered that "advanced" technology plants have lower wastewater volume per unit of product than "typical" technology plants have.

Seasonal Variations

Seasonal variations in gross wasteload is due mainly to the turkey processing industry. The growth rate of this industry is directly correlated with population growth rates. Therefore, it is safe to assume that the wasteload of the turkey processors will always be a per cent of the total wasteload in any given year. The turkey processor experiences significant seasonal variations. Major processors are active only about one hundred days a year, during the months of October, November, and December. Their contributions to total wasteloads, thus, will be of significance during these three months. Seasonal variations in the turkey industry are expected to decline little, since the seasonal nature of turkey production stems from consumer demand.

Seasonal variations in the rest of the industry have been reduced to a point where they are no longer of importance. In the past, pre-1950, seasonal variations in the industry plus variations from year to year were common. Technological advances in the growing industry have caused these variations to all but disappear.

TABLE 11

ANNUAL POULTRY SLAUGHTER -- WASTELOADS AND WASTEWATER
1963, 1967, AND PROJECTIONS TO 1977

Year	Millions of Birds Slaughtered	BOD Millions of lbs/yr	Total Wastewater MG/yr
1963	2,419	105	18,206
1966	2,668	125	19,350
1968	2,941	135	23,524
1969	3,051	141	24,411
1970	3,262	147	26,098
1971	3,274	153	24,557
1972	3,385	159	25,388
1977	3,976	189	29,817

Pollution Reduction by Subprocess Change

Poultry processing wasteloads can be reduced by practicing good housekeeping methods. Some processing methods in themselves reduce wasteloads. When budget conditions permit, modifications of processing operations should be undertaken. "It is more economical to reduce the wastes as much as possible at the source than to treat the gross wastes." (1)

Wastewater from poultry processing plants is screened to remove solids from the effluent. The screening process is an essential part of the flow-away system especially when recirculation of water is practiced, but the practice has also been found useful in nonflow-away plants, especially during cleanup operations.

Cleanup

In the receiving area, there is an accumulation of dirt and manure on their floors during the handling period of live birds. The reduction in holding time for live birds has reduced the wasteload from this sector of the plant by as much as four per cent. (1) Dry cleaning of the receiving room floors in the typical plant could reduce BOD by one hundred twenty-five pounds per year.

Blood Collection

If a plant recovers all blood and exercises care in the cleanup of the bleeding area, BOD wasteload of the plant can be reduced by thirty-eight per cent.

Evisceration

Wasteloads from the evisceration and picking area are controlled primarily by screening. The screens must be kept clear to prevent overflows, which result in the dumping of feathers, offal, heads, and feet into the sewer system. In an "older" technology, nonflow-away system, care must be taken to ensure proper use of containers where viscera and feathers are collected. Containers must be emptied often enough to guard against overflows. Care must be taken to ensure that flow-away systems carry sufficient quantities of water to effectively carry viscera and feathers from the processing area.

By-Product Recovery

The utilization of by-products has proven economical to

processors. The sale of blood, viscera, and feathers to rendering firms or farmers has proven profitable to many poultry processors. In those areas where there are no rendering firms, the by-products are at least removed from the gross pollution load of the plant if they are given free in exchange for hauling them away.

Table 12 shows the percentage reduction in BOD which should accompany the specified change in subprocess.

Pollution Reduction by Industry Waste Treatment

Table 13 gives the breakdown of the types of treatment being used by poultry processors who have their own waste treatment facilities. It should be noted from the table that a general level of improvement is being experienced. To a large extent this is accounted for by the locational shift which has occurred within the industry. Treatment facilities were constructed along with the errection of new processing plants. It should be remembered that only ninety-five plants provided the basis for the distribution shown in Table 15. The implicit assumption is, therefore, that these plants are representative of the entire poultry industry.

Pollution Reduction by Municipal Waste Treatment

Table 14 shows the amount of wastewater treated by municipal treatment facilities by type of technology and by size of plant. The largest amount of wastewater comes from typical technology plants of medium size. Very little wastewater comes, for example, from "advanced" technology plants of small size because there are few such plants.

Table 15 shows the per cent of processing plant effluent which enters municipal treatment facilities in selected years. Note the increase experienced from the years 1950 to 1963. This change can be explained by the shift in industry location mentioned earlier.

TABLE 12

CHANGES IN SUBPROCESSES AND THEIR EFFECT UPON WASTELOAD AND WASTEWATER VOLUME

Subprocess Change	Per Cent Wasteload Reduction Associated With Indicated Change of Subprocess
I. Typical Technology	
A. Change subprocess from holding of birds in storage area to direct placement of birds on conveyor	4
B. Change subprocess from recovery of no blood to recovery of all blood	38
II. New Technology	
A. Change subprocess from holding of birds in storage area to direct placement of birds on conveyor	4
B. Change subprocess from recovery of no blood to recovery of all blood	38
C. Change subprocess from no reuse of water to reuse of water	1

TABLE 13

UTILIZATION OF WASTE TREATMENT FACILITIES

Type of Waste Treatment Facility	Estimated Percentage of Plants Employing Process				
	1950	1963	1967	1972	1977
Catch Basin Only (Grease and Solids Removal)	49	30	9	5	1
Lagoon Systems	30	40	49	50	57
Trickling Filter	20	25	34	--	34
Irrigation	1	3	8	--	9

TABLE 14

POULTRY PROCESSING WASTEWATER HANDLED BY MUNICIPAL TREATMENT FACILITIES BY TYPE OF TECHNOLOGY, 1966
(Figures in millions of gallons)

Type of Technology	Small	Medium	Large	Total
Old	1,254	2,318	228	3,800
Typical	2,193	5,230	1,012	8,435
Advanced	70	873	803	1,746
Total	3,517	8,421	2,043	13,981

TABLE 15

PER CENT OF POULTRY WASTEWATER DISCHARGED TO MUNICIPAL TREATMENT FACILITIES

Year	Per Cent
1950	50
1963	70
1967	72
1972	76
1977	80

Net Pollution

1963

The gross pollution load of the poultry processing industry is shown in Table 16 by source: blood collection and processing operations.

Pollution reduction of gross wasteload in the base year was the result of blood collection and private waste treatment of poultry processing plant wastewater. Blood collection removed approximately twenty-four million pounds of BOD while private waste treatment removed only about sixteen million pounds. Twelve of the sixteen million pound reduction was probably due to solids removal by screening. The remaining four million pounds BOD reduction would be due to some form of biological waste treatment.

The poultry processing industry is different from the meat packing industry in that the former relies primarily upon municipal treatment facilities to reduce wasteloads.

1963-1977, Selected Years

Table 17 gives gross and net pollution figures for selected years between 1963 and 1977. The gross pollution estimates assume that all processing plants of major blood collection is therefore the primary source of pollution reduction by subprocess change. It should be noted that the trend of poultry processors to rely upon municipal facilities is expected to continue. Private waste treatment tends to be too costly for this low profit margin industry.

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TABLE 16

1963 NET POLLUTANT QUANTITIES[a]

Source of Waste	Gross Pollution BOD in Millions of Pounds	Pollution Load After By-Product Recovery BOD in Millions of Pounds	Reduction of Pollution by Private Treatment BOD in Millions of Pounds[b]	Reduction of Pollution by Municipal Treatment BOD in Millions of Pounds	Wasteload Reaching Water Courses Net BOD in Millions of Pounds
Blood	40.0	16.4	3.68	8.7	4.02
Processing	65.4	65.4	11.99	30.32	22.09
TOTALS	105.4	81.8	15.67	39.02	26.11

a. The BOD figures used in this table were derived from the article "Wastes From Poultry Processing Plants" by John M. Bolton as the article appeared in the 13th Industrial Waste Conference at Purdue University, 1958. Mr. Bolton's figures were weighted by plant size then applied to the 1963 total slaughter figure. The six plants studied by Bolton were broken down into three groups representing old, typical, and advanced technology. The resulting weighted BOD figure then was applied to the appropriate portion of industry which was using the technology in 1963.

b. Private treatment is considered to be a screening process of varying degrees of sophistication.

TABLE 17

SUMMARY OF BASE YEAR AND NET PROJECTED WASTELOADS[a]
(Gross and Net Pollutants Measured in Millions of Pounds of BOD Per Year)

Year	Gross Pollutant	Per Cent Removal by Process Changes	Net Pollutant After Process Changes	Per Cent Removal by By-Product Recovery	Net Pollutant After Process Changes and By-Product Recovery	Per Cent Removal by Private Treatment[b]	Net Pollutant After Process Changes, By-Product Recovery and Private Treatment	Per Cent Removal by Municipal Treatment	Net Pollutant to water courses
1963	105.4	0	105.4	22.4	81.8	4.5	78.12	78	17.19
1968	134.5	0	134.5	25.0	100.9	5.0	95.9	79	20.14
1969	140.6	0	140.6	29.0	99.8	5.0	81.4	79	19.90
1970	146.6	0	146.6	34.0	96.8	7.0	90.0	81	17.1
1971	152.7	0	152.7	38.0	94.7	7.5	87.6	81	16.64
1972	158.7	0	158.7	39.0	96.8	8.0	89.1	85	13.37
1977	189.0	0	189.0	40.0	113.4	10.0	102.1	90	10.21

a. BOD per 1,000 birds is that shown in Table

b. Private Treatment is considered to be a screening process of varying degrees of sophistication.

COSTS OF POLLUTION REDUCTION

The basic assumption underlying this section of the report is that 522 processors of major significants were producing ninety per cent of the total poultry shipments in 1966. (4) This estimate of the number of plants seems reasonable in view of the number of plants data in the 1963 "Census of Manufacturers." At that time there were 2992 plants in the poultry processing category (SIC 2015). Sixty-seven per cent (2,016 plants) of these plants had fewer than twenty employees per plant and altogether sixty-seven per cent of the plants accounted for only four per cent of production measured by value of shipments. In 1963, 967 plants produced ninety-six per cent of the output. With the industry trend towards larger scale, high speed processing the assumption that 522 plants are producing ninety per cent of output in 1966 seems reasonable.

The remaining ten per cent of shipments come from plants which fall into one of three catégories. First, those plants engaged in small game dressing which are not analyzed. Second, plants engaged in the egg breaking industry and third, poultry processing plants which have gone out of business. It should be recalled at this point that the SIC classification 2015 includes the egg breaking and small game processing plants with poultry and turkey processing plants. These plants are of little significance in terms of pollution loads and have been ignored in this report

The 522 plants are divided into three categories: plants which discharge their waste to municipal treatment facilities, plants which treat their own waste in privately owned treatment facilities; and plants which have a combination of private and municipal treatment arrangement. Applying the distribution of plants responding to our questionnaire to the 522 poultry plants, there are:

1. ninety-five plants (18%) with their own waste treatment facilities,
2. four hundred and one plants (76%) using municipal treatment facilities,
3. twenty-six plants (6%) using both industrial and municipal waste treatment facilities.

Cost of Pollution Reduction by Subprocess Change

The operation and maintenance costs of subprocess changes which should reduce wasteloads are presented in Table 18.

Blood Recovery

Blood recovery is the most significant subprocess for reducing total plant wasteloads and will be used here to illustrate the weakness of estimates. The physical space necessary for blood recovery will depend on the speed at which the processing line is moving. The bird should remain in the bleeding area from one to two minutes. A bleeding cycle of longer duration will cause feather removal to be more difficult. The type of bleeding area will also effect cost; if a bleeding room is used, the capital cost will be low but labor cost will be high, since blood will have to be coagulated on the bleeding room floor and shoveled by hand into containers. Blood remaining on the floor will be washed into the sewer during the cleanup period. If a bleeding tunnel is used, the initial capital costs will be high but labor costs would be reduced. This process puts the birds through a tunnel type arrangement where several openings are located along the tunnel bottom for the collection of blood. At the end of the processing period the tunnel is washed and cleaned. The advantage of tunnel bleeding is that more blood is collected with the result that less blood reaches the sewer. Collection containers have to be emptied often enough to guard against contaminating overflows.

When bleeding areas of the type described are used, there are the factors of associated conveyor, time lost, and labor costs which must be considered in any estimation of costs involved in the operation. What must be guarded against is duplication of costs in the estimate. It is necessary for all plants to conduct the bleeding operation; therefore, plant space and processing time has to be set aside in any poultry slaughtering operation for the carrying out of this process. The difference between the plant which collects blood and the plant which does not, is whether or not the blood enters the sewer. The non-collection plant discharges the blood into the sewer while the collection plant disposes of blood in some other manner. Both types of plants will discharge blood into the sewer during cleanup operations in approximately the same amounts.

In conclusion, the estimates which are presented in Table 18 are based primarily on labor costs, with economic life representing the life of the physical plant. The actual cost to a plant which collects blood is low because the collected blood may be sold to a rendering firm. Rendering of poultry by-products is a complete business in itself, with different pollution potentials than the processing industry. Since about half of a bird's total liveweight is lost during the processing, the amount of material available for rendering is considerable, consisting of feathers, offal, and blood.

TABLE 18

COST AND ECONOMIC LIFE OF SUBPROCESSING METHODS EMPLOYED BY A MEDIUM SIZED PLANT USING A TYPICAL LEVEL OF TECHNOLOGY

Waste reduction techniques	Reduction of wasteload per cent	Capital cost dollars	Economic life years	Operation and Maintence cost in dollars per year
Dry cleaning of the receiving area	4	0	N/A	5,000
Blood Collection	38	-	20	10,000

Cost of Pollution Reduction by Industrial Waste Treatment

According to "questionnaire data" the average cost of a secondary sewage treatment plant was $60,000. An average cost of $60,000 and an estimated number of plants with their own waste treatment facilities (ninety-six plants) means an estimated industry investment in waste treatment facilities of almost six million dollars in 1966.

Operation and maintenance costs were estimated by the same method to be approximately one million dollars. The operation and maintenance are a higher percentage of the capital costs for poultry than for meat packing primarily because of the added expense of feather removal. If cost estimates are desired for specific types of waste treatment facilities, the meat packing section of this report should be consulted. The meat packing section also contains a description of each of the various types of waste treatment methods employed by both the poultry processor and the meat packer.

Cost of Municipal Treatment of Poultry Processing Wastewater

Poultry processors are different from meat packers in that they tend to either treat waste themselves <u>or</u> to use municipal treatment facilities but not both. Less than five per cent of the plants responding to the questionnaire used a method of joint treatment. This is partly explained by the shifting location of the industry in the past decade. In order for cities to attract poultry processing plants, the cities often agreed to provide treatment facilities for the processing plants' waste. This was one of the criteria processors specified when relocating.

The average annual amount paid to the municipality by a plant of a certain size was obtained in the following manner: The questionnaire asked each processor to report waste treatment charges paid to municipalities. Respondents were classified into three size groups and the average annual payment by plants in each group was determined. The average charge was then assumed to apply to all processors in the appropriate size group. Table 20 shows the average payment by a poultry processing plant, by size of plant and the total payment by the industry for the year, 1966. In 1966 it was estimated that processors paid approximately $4.6 million to municipalities to obtain waste treatment.

TABLE 19

COST AND ECONOMIC LIFE OF TREATMENT FACILITIES EMPLOYED BY A MEDIUM SIZED PLANT USING A TYPICAL LEVEL OF TECHNOLOGY

Waste Treatment Method	Reduction of Wasteload	Capital Cost in Dollars	Economic Life in Years	Operation and Maintenance Cost in Dollars
Screening	95% removal of solids	10,000	8	5,000
Secondary sewage treatment	85% removal of BOD	60,000	15	8-10,000

TABLE 20

WASTE TREATMENT CHARGES
PAID TO MUNICIPALITIES IN 1966

Size Group	Number of Plants in Size Group	Average Annual Payment by Processors in the Size Group	Total Annual Payments by all Plants in Size Group in Thousands of Dollars
Small	140	$ 8,828	$1,042
Medium	239	12,544	2,998
Large	44	13,108	578
Total	401		4,616

TABLE 21

INDUSTRY EXPENDITURES FOR WASTE TREATMENT, 1966

Replacement Value of Treatment Facilities in Millions of Dollars	Annual Equivalent in Millions of Dollars	Annual O. & M. Costs in Millions of Dollars	Annual Payments to Municipalities in Millions of Dollars	Total Payments for Waste Treatment in Millions of Dollars
6	0.6	1	4	6.6

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