EPA-660/2-74-031
May 1974

Environmental Protection Technology Series

Water and Waste Management In Poultry Processing

Office of Research and Development
U.S. Environmental Protection Agency
Washington, D.C. 20460

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WATER AND WASTE MANAGEMENT IN POULTRY PROCESSING

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Prepared for
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D. C. 20460

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 - Price $2.50

ABSTRACT

A typical broiler processing plant was used to evaluate changes in equipment and processing techniques to reduce water use and waste load. Production at the plant was through two processing lines and totaled approximately 70,000 broilers per day. Benchmark results indicated a water use of 12.28 gallons per bird received which was reduced by 32 percent to 7.81 gallons per bird received. Benchmark results indicated a daily waste load of 3970 lbs BOD_5 which was reduced by 66 percent to 1355 lbs BOD_5. Changes made are detailed and economic analysis showed all to be profitable for the plant with an average annual net savings of $4.08 per 1000 broilers processed. An initial investment of $93,065 was needed. Annual operating costs were $31,023 with annual net savings of $72,193. A water and waste management program is detailed. Microbiological analyses indicated no deterioration in product quality as a result of the changes.

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FIGURES

FIGURES (cont.)

FIGURES (cont.)

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TABLES (continued)

TABLES (continued)

TABLES (continued)

ACKNOWLEDGMENTS

Special appreciation is expressed to the entire Gold Kist organization which contributed in so many ways to the success of this project. Especial gratitude is expressed for the cooperation and understanding of Mr. W. C. Pulliam, Manager of the Poultry Division and to Mr. Harold Chitwood, Manager of the Poultry Processing Plants. The knowledge and advise of Mr. W. J. Camp, Head of Engineering and Dr. Jim Marion, Microbiologist, were invaluable in the planning and execution of the plant work.

The project team cannot forget the efforts of Professor David H. Howells for it was his efforts and funding by the Water Resources Research Institute of the University of North Carolina which initiated these efforts.

The cooperation forged at the campus of North Carolina State University by Dr. W. M. Roberts, Head, Department of Food Science and Dr. Touissant, Head, Department of Economics was instrumental in assisting this project.

The USDA, CMS inspection staff was most cordial and assisted in assuring product quality during all stages of testing. The rule variance for the Special Study was also valuable as important research was accomplished.

The City of Durham, particularly Mr. Leslie Matthews, Head of Industrial Waste provided historical data and experiences that greatly assisted in the completion of the project.

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The authors greatly appreciate the efforts of Ann LaPrade who tirelessly typed and retyped this manuscript. We will remain indebted to her for the energy and enthusiasm she showed throughout the completion of this report.

SECTION I

CONCLUSIONS

1. Most equipment and processes in a poultry processing plant can be modified to reduce water requirements (water use per unit of time). Waterborne wastes can be reduced by improved waste recovery methods and through reduced water usage.

2. Changes made during the study were effective in reducing waste loads and water use; however, maintaining lower levels of water use and waterborne wastes requires a continuing commitment to water and waste management.

3. The average daily potable water use of 850,000 gallons per day (GPD) was reduced by 32%. Water use per bird declined from 12.28 to 7.81 gallons. A calculated achievable water use per bird was 6.2 gallons.

4. The plants final effluent daily waste load of 3970 lbs BOD_5 was reduced by 66%. The pounds of BOD_5/1000 broilers declined from 57.4 to 18.4. BOD_5 concentration in the final effluent decreased, during reductions in water use, from 580 mg/l to 282 mg/l. The greater reduction observed in waste load (66%) than in BOD_5 concentration (52%) was the result of: (1) increased efficiencies of waste recovery due to reduced hydraulic loading of offal and feather screens and air flotation cell (2) improved practices of employees in water use and waste reduction and (3) reduced use of water may have decreased the loss of organics due to less washing of viscera and other waterborne matter.

5. The dollar benefits from water flow modifications were approximately tripled due to the complementarity of water and waste reductions.

6. The microbiological quality of the final carcass was not lowered during water reductions.

7. Discharges of grease and feathers had been nuisance items at the Durham municipal wastewater treatment plant. The grease concentration was reduced 57% and feathers and solids in the poultry processing plant effluent were controlled.

8. Water flow modifications included the use of high efficiency nozzles in product washing equipment and hand washing operations, reuse of water, new plant clean-up equipment, improved feather flowaway and cycling of the side pan wash water. The impact of these changes was to reduce annual water use by 74.3 million gallons. The average cost of reducing water use was 8.6 cents per 1000 gallons which compared favorably with the water and sewer rate of 44 cents per 1000 gallons.

9. The features common to each of the flow modifications were: (1) Water flow rates were reduced. (2) There was a net addition to income as a result of reduced costs. (3) The initial costs or investment could be recovered within the first year; and (4) Initial investment was small compared with the total net benefits.

10. Improved regulation of wastewater flows and lowered hydraulic loading improved the performance and efficiency of offal and feather screens. Because of technical linkage between water usage and waste reductions, water flow modification will reduce investment requirements in waste treatment and other facilities because hydraulic loading is an important design parameter.

11. The return per dollar of annual cost for selected changes was $29.96 for handwash nozzles, $7.50 for the final bird wash, $6.80 for blood collection, and $4.86 for cycling the side pan wash and $9.68 for plant clean-up.

12. Total investment for the changes was $93,065. This included $20,754 for water and waste monitoring. Total annual capital and operation costs including the salary of a full time water and waste manager was $31,023. Monitoring costs and the salary of the water-waste manager are included because the termination of monitoring coincided with the termination of employment of the water-waste supervisor and marked the end of the water and waste reductions in the poultry processing plant.

13. Annual benefits (increased revenues and reduced costs) associated with the changes were \$103,216. The net annual savings was \$72,193 or \$2.33 net annual benefits per dollar of annual cost.

14. Whole bird washer water provided a substitute for chiller water reuse in the scald vat with no decrease in microbiological quality.

15. The reuse of combined chiller and final bird wash waters for the flushing of gizzards in the gizzard splitting machines had no detrimental effect on the microbiological quality of the gizzards or whole birds.

SECTION II

RECOMMENDATIONS

1. A well planned water conservation program should be instituted in every poultry processing plant. The program, if properly understood and managed by both the plant and USDA inspection staff, would provide for minimum water use while maintaining a wholesome and quality product. This will require the following as detailed in SECTION VII - PUBLICATIONS AND MANAGEMENT PROGRAM.

    a. Full time water and waste supervisor.
    b. Water and wastewater monitoring and control program.
    c. Training program for employees.
    d. Close coordination and support of regulatory agencies.

2. Significant further water and waste reductions will be possible in poultry processing. Specific areas needing attention include:

    a. Parameters should be identified and evaluated for the control of continuous use water. Modification of traditional plant design and equipment providing for continuous water use may be required.
    b. Research should be undertaken on the collection and recovery of grease for human consumption from chilling and other process waters.
    c. Chemical and microbiological parameters should be identified for measuring the quality of poultry products. Also, the possible relationship between product quality parameters and poultry wash water parameters should be investigated.
    d. Industry - University - Regulatory teams should continue to evaluate the current controversial practice of chilling of poultry in a chiller, the water pick-up practices currently allowed by regulations and utilized by industry, and characteristics of product chilled by other than immersion chillers.

e. Current potable water use practices for chilling and scalding should be evaluated for possible water use reductions.
f. A CIP (cleaning in place) system should be developed for poultry processing to reduce water use, facilitate waste recovery, improve sanitation, decrease the use of detergents and sanitizers and reduce labor for clean-up operations. Process and equipment redesign will be required.

3. The results of this study should be used to improve equipment and processes to minimize water use and wastes. Specific areas are:

   a. feather removal systems
   b. blood collection systems including cutting equipment and stunners
   c. gizzard splitters
   d. cleaners
   e. washers
   f. flumes
   g. offal handling equipment
   h. coop cleaners

4. It is further recommended that state and federal agencies fund additional investigations in water use and waste reductions in poultry processing plants.

SECTION III

INTRODUCTION

BACKGROUND

Water has many uses in poultry processing including scalding, product preparation, cooling the whole birds and parts, transporting wastes and cleanup. Wastes added in these processes result in high-strength effluent when compared to normal municipal waste waters. Most of these wastes are highly degradable by biological and chemical waste treatment processes. A study[1] predicted that water used for poultry processing would total 26 billion gallons in 1970 with a BOD_5 discharge of some 147 million pounds.

Relatively low water and sewer costs and the absence of restrictions and surcharges on waste loadings have resulted in a low priority on research and the development of information on water and waste management in poultry processing. Information on in-plant water and waste reduction methods has been limited. More importantly, traditional production techniques have not been engineered for water and waste management.

The concern of poultry processors in providing clean, good tasting poultry products coupled with the government's legal authority to insure the sanitary processing of broilers has further increased the use of water in processes throughout the plant. The large volumes of water use and wastes in poultry processing have become a problem for a number of municipalities.

The costs of upgrading and maintaining the water quality of our streams is currently the responsibility of the users--municipalities and industry. Enforcement of water-quality standards places important restraints on discharging wastes to surface waters and streams. These restraints are of much concern to the poultry processing industry which is highly competitive and growing rapidly.

This study was undertaken with the belief that water and waste management techniques provide an economical way for any poultry processing plant to obtain per unit reductions in water use and wastes discharged in the plant effluent. Also, most poultry processing plant managers do not know how much water they are using, where they are using it, when they are using it, and in some cases, why they are using it. Water, traditionally a resource of minor cost and great convenience, has not occupied the attention of either managers or their employees. Wasteful water practices were known to be common throughout the industry.

POULTRY PROCESSING INDUSTRY

Poultry processing is a vital link in the poultry industry of the United States. Poultry processing plants perform the functions of slaughtering and eviseration of broilers, turkeys, mature chickens and other classes of poultry. Plants may engage in cutting up of these animals; and also, further processing may be executed with canning, freezing or cooking into specialty items. The term poultry processing as used for the remainder of this report will refer to the slaughtering, evisceration and cutting of broilers.

The poultry firm is characterized today by vertically integrated operations from laying flocks through hatchery, feed mill, growing operations, processing, selling to the rendering of offal and feather by-products. Broiler processing in the United States developed very rapidly during the past two decades. Annual production increased from 632 million birds in 1950 to over three billion birds in 1972, Table 1. Annual per capita consumption of fresh dressed poultry has risen from about 9 pounds to over 38 pounds during this same period.

There are over 400 federally inspected broiler slaughtering plants in the U.S. Approximately 218 plants are in the South Atlantic and South Central Regions, Table 2. In these two regions, 9 percent of the plants slaughtered less than 10 million pounds of live weight in 1970, 58 percent processed between 10 and 50 million pounds per plant in 1970, and 33 percent processed 50 million pounds or more. These two regions accounted for 86.8 percent of the total U.S. broiler production in 1970. The 1971 live weight average was 3.7 pounds per bird. The percentage of total broiler kill that was Federally inspected was approximately 80 percent in 1970.

The large size and concentration of the poultry processing industry becomes important in view of its waste generation. In poultry processing, inedible materials such as feathers, blood, dirt, and viscera are removed from the carcass to make it acceptable for human consumption. Large quantities of water are used to both wash and clean the poultry in processing and also to transport large amounts of waste to screening and ultimate disposal. The highly organic

Table 1. BROILER PRODUCTION, PER CAPITA CONSUMPTION AND AVERAGE PRICES FOR SELECTED YEARS[a]

Year	Production		Consumption	Prices[a,b]		
	Number Produced	Live Weight	Per Capita	Received by Producer	Wholesale	Retail
	(millions)	(million pounds)	(pounds)	(cents per pound)		
1934	34	97	0.5	19.3	-	-
1940	143	413	2.0	17.3	-	-
1945	366	1,107	5.0	29.5	-	-
1950	632	1,945	8.7	27.4	41.2	59.5
1955	1,092	3,350	13.8	25.2	39.7	55.9
1960	1,795	6,017	23.3	16.9	32.2	42.7
1965	2,334	6,907	29.4	15.0	29.4	39.0
1970	2,987	10,819	38.3	13.6	26.4	40.5
1972	3,075	11,478	-	14.1	-	-

[a]U.S. Department of Agriculture, "Poultry and Egg Situation," ERS Report No. PES 264, November 1970, p. 12 and "Chickens and Eggs", SRS Pou. 2-3 (73), April, 1973.

[b]National Commission on Food Marketing, "Organization and Competition in the Poultry and Egg Industries," Technical Study No. 2, June 1966, p. 62.

Table 2. STATES IN POULTRY INSPECTION REGIONS

North Atlantic	Western	East North Central
Maine	Idaho	Ohio
New Hampshire	Colorado	Indiana
Vermont	Airzona	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	

nature of the waste may cause bacterial blooms, depressed oxygen levels, and severely disrupted biota where released directly to the environment. Waste discharged to a sewage treatment system may provide a substantial load in terms of population equivalent, escaping grease, escaping feathers and offal. These items can hamper treatment processes, and is subject to substantial sewer use surcharges by municipalities.

The average price received by producers has dropped from a high of 29.5 cents per pound in 1945 to 13.4 cents per pound in 1970. Data for selected years are summarized in Table 1. Inedible parts of a broiler such as feathers, feet, head and eviscera account for 25 percent of the live weight of the bird. Based on the average price paid to producers in 1970, the cost of the potentially marketable parts of a broiler averages 19.1 cents per pound which consists of 13.4 cents per pound to the grower for the live bird and 5.7 cents per pound for discarded offal, feathers and other parts. The wholesale price of 26.4 cents per pound includes the average cost of edible chicken meat, 19.1 cents per pound, and 7.3 cents per pound for processing, marketing and profits including live hauling, processing, selling and delivery to markets.

All activities in and around a poultry processing plant are regulated by the USDA. The Poultry Products Inspection Act was enacted in August of 1957 and became effective on January 1, 1959, to ensure the sale of wholesome poultry meat. The Consumer and Marketing Service* of the United States Department of Agriculture was given the responsibility for carrying out the provisions of the Act and promulgating such rules and regulations as needed to implement this Act. Three basic responsibilities under the Act are:

1. To inspect poultry for wholesomeness so as to determine its suitability for human food.

2. To ensure that poultry and poultry products are processed in a sanitary manner in an approved processing plant having proper facilities.

3. To ensure that the product is not adulterated in any manner.

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*Consumer Marketing Service now Animal and Plant Health Inspection Service, Meat and Poultry Inspection Division.

POULTRY PROCESSING OPERATIONS

A poultry processing plant has been defined by Porges and Struzeski[2] as a mechanical slaughterhouse in which live birds are converted to dressed products for sale to distributors. In this section the operations used to accomplish the above conversion will be discussed in relation to their water use and waste discharge characteristics.

The processing operations can be divided into thirteen distinct areas or activities as shown in Figure 1. These are receiving, killing, bleeding and blood recovery, scalding, defeathering, feather recovery, whole bird wash, evisceration, final wash, offal recovery, chilling, packing, and final wastewater collection and control. This listing roughly follows the path of the bird through the plant. A flow chart illustrating potable water flow into the processing scheme, using the path of the bird as orientation, is shown in Figure 2. The thirteen activities as detailed by Ward[3] follow.

Receiving Area

The live birds, contained in coops, are unloaded from incoming trucks and sent by conveyor to the coop unloading area. Here the birds are removed from the coops and are attached by their feet to shackles suspended from an overhead conveyor line. The empty, uncleaned coops are returned to the truck. This practice contributes to the number of loose feathers present around the outside of processing plants and along the route traveled by the trucks.

No water is used in this area except for cleanup purposes. Wastes from this area consist of loose feathers, manure and dirt.

Killing Station

The birds on the conveyor move from the receiving area to the killing station at a prescribed rate. They are usually slaughtered by cutting the jugular vein. Slitting the jugular vein is done either by hand or by machine. Stunning techniques are sometimes employed before or after killing.

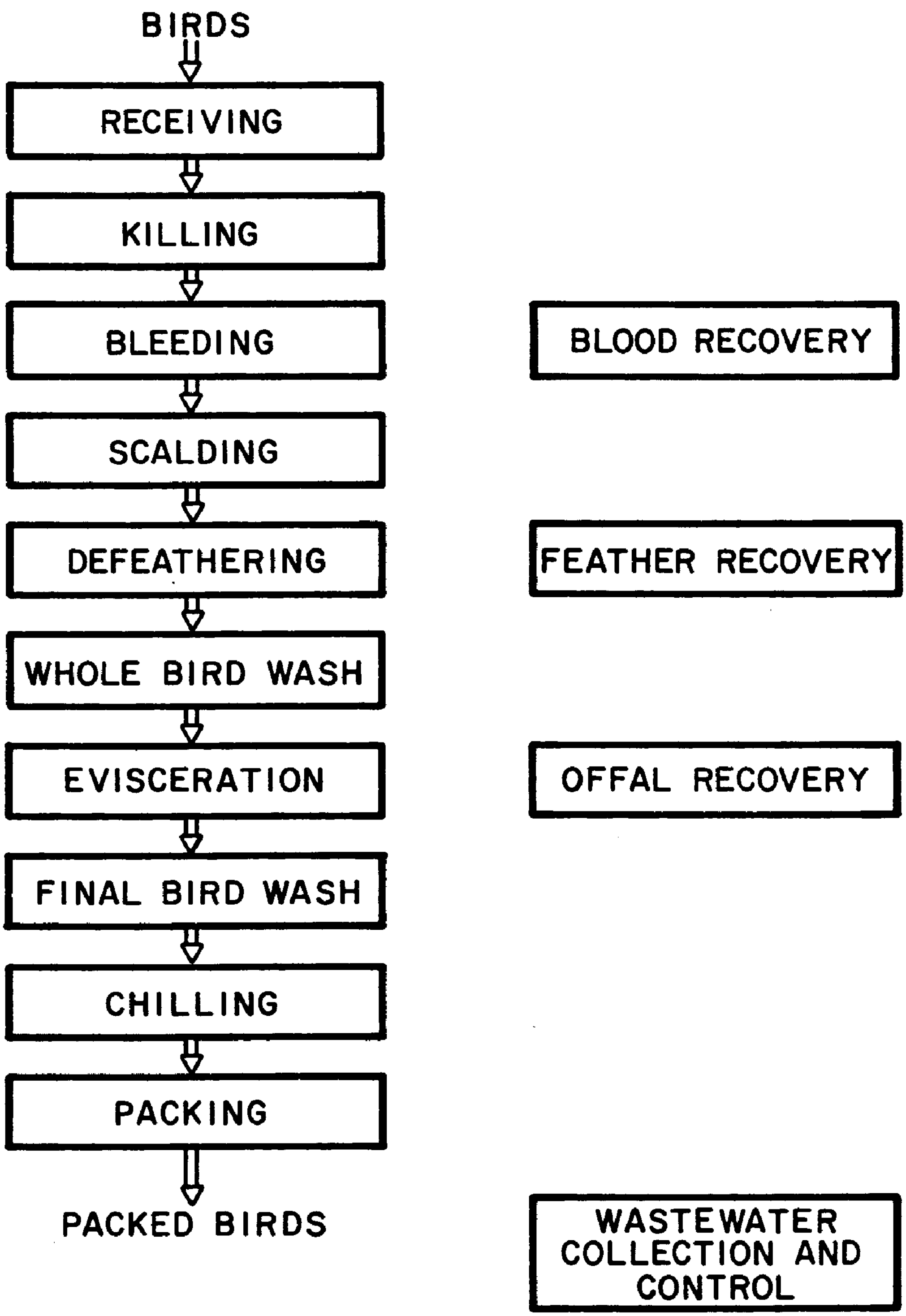


Figure 1. Broiler processing operations

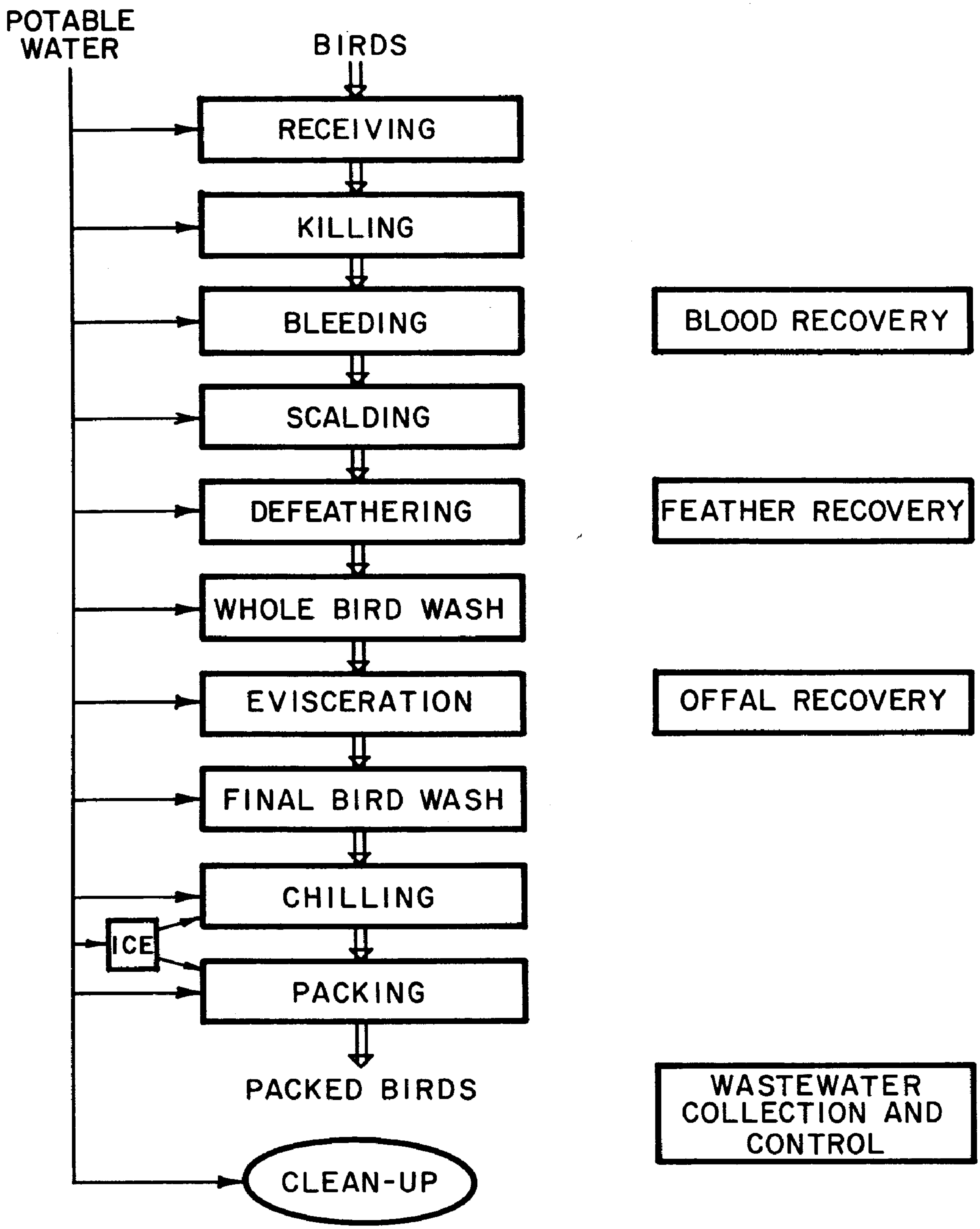


Figure 2. Major potable water uses in broiler processing

Water is used at the killing station when a machine is employed to do the slaughtering. It is used to wet the feathers in order to provide an accurate cut. Wastes generated at the killing station consist of some blood and feathers which usually enter the waste stream of the plant during cleanup.

Bleeding and Blood Recovery

After the birds have been slaughtered, the conveyor line continues and immediately carries them into the blood tunnel (a restricted area) where blood is allowed to drain from the birds for approximately 1.5 to 2 minutes. Blood is allowed to collect in the tunnel and is removed at the end of the processing day. The blood is usually sold to a renderer. If not, it is discharged to the sewer.

During actual processing operations, no water is used and little or no wastes are discharged from the blood tunnel. However, the waste load can be high if blood serum is allowed to drain freely away from the tunnel.

Scalding

The birds, still on the overhead conveyor, enter the scalder after leaving the blood tunnel. This is usually a large tank of water with a temperature of 128 to 140 degrees F. A few plants use a spray scald. The birds remain in the scald tank for approximately one to two minutes while water is continuously circulated around them.

The processor is required by regulations (U.S.D.A., Consumer and Marketing Service, 1968)[4] to add a minimum of one quart per bird per minute of fresh water to the scalder. For a plant processing 9000 birds per hour this amounts to a minimum of 2250 gallons per hour or 37.5 gallons per minute. Overflow from the scalder is usually discharged into the feather flow-away drain. The actual point of entry of this scalder discharge into the feather flow-away is important when considering how useful it is in removing the feather volume. If the scalder discharge is at the point of origin of the feathers (defeathering machines) it is more useful than if it enters the flow-away after defeathering has been completed.

Using water from other parts of the plant (for example, the chiller water) in the scalder is one way to cut down the fresh water input. There is also the possibility of using a heat exchanger on the scalder outflow in order to conserve energy. This energy would be used to heat the input water to the scalder.

Wastes in the water discharged from the scalder consist of blood, grease, feathers, and dirt.

Defeathering

After leaving the scalder the birds enter the defeathering operations. There are several configurations available for accomplishing this job, but use of three or four defeathering machines, one positioned right after the other, is most common. Each machine has a special area of the bird or type of feather which it is intended to remove. The most common defeathering machine is a continuous one which employs rubber fingers attached to cylinders to remove feathers as the cylinder turns. Continuous water sprays are generally used in these machines to flush out feathers. The feathers fall out of the machine into a trough which serves as a flow-away removal system for feathers, dirt, etc.

The amount of fresh water used in the defeathering operations varies greatly from one plant to another and at different times in the same plant. This great variation can be traced to the need for hosing down feathers that pile up in or under the defeathering machines. If improvements were made on the nozzles in the defeathering machines and troughs more adapted to removal of feathers were used, the system would operate more smoothly. Recirculation of wastewater from other areas of the plant to supplement the feather flow-away volume would definitely help prevent clogging. The removal of feathers by auger may be more desirable than the present flow-away system.

Wastes from the defeathering operation mainly consist of a very large volume of feathers. Some heads are removed by the pickers and there is some dirt and blood. This waste flows to a screening area where the feathers are removed from the water.

Feather Recovery

The large volume of feathers represents a tremendous waste load, but, if removed from the water, the feathers can be sold to a renderer. In some cases a renderer may not be available and another method of disposal will be required. Removal of feathers from the wastewater can be accomplished by several different types of screens. The vibrating screen, the reel screen, and the traveling screen are three major types. The feathers, once removed from the water, are generally augered into a truck for shipment to a renderer. If the feathers are augered straight from the defeathering machines to trucks, the need for a feather screen is eliminated.

Screens require frequent repairs in order to prevent spills of wastes into the sewer and stoppages due to screen breakdowns, employment of a by-pass screen is necessary.

Whole Bird Wash

Once the birds have been defeathered, the few remaining pin feathers are removed by hand and the body hair is singed off by having the bird pass through a flame. The birds then go through the whole bird wash. Here water is sprayed on the birds as they pass through a washing chamber. Discharge from this operation goes into the feather flow-away system beyond the defeathering machines. This discharge water is fairly clean, thereby lending it to recirculation for a second use.

The whole bird wash water could be used in the scalder as a replacement for the fresh water input. If this is not feasible at a particular plant, redesigning the nozzles in the wash and using an automatic cut-off for the water when no birds are on the line will reduce the amount of fresh water used.

Evisceration

After leaving the whole bird wash the birds enter the evisceration room which is segregated from the defeathering area. The separation prevents wastes of the previous operations from coming in contact with the eviscerated birds. The first operation in the eviscerating room is removal of the feet. The feet can be collected in drums or allowed to fall into the wastewater flow from the evisceration trough. Use of fresh water at this point involves cleaning of the area onto which the birds fall after the feet have been removed. The birds are rehung on another overhead conveyor line which takes them to the eviscerating trough.

Evisceration of the birds consists of exposing the viscera for inspection by the U.S. Department of Agriculture; recovery, and cleaning of the heart, liver, and gizzard; and removal from the carcass of the head, inedible viscera, lungs, and any other remaining material. The neck may be removed now or after chilling operations. The heart, liver, gizzard, and neck are giblets and are wrapped and packed into the bird just before the weighing operation.

The gizzard has to be processed separately from the bird and special machines are available for this purpose. The gizzard must be split, emptied of its contents (sand and grit), peeled of its inner lining and washed. Water may be used to transport the giblets to the giblet wrap and pack area of the plant.

Evisceration of the birds occurs along an evisceration line. This line usually consists of a trough down the center of which a large volume of water is continuously flowing. This water originates from hand washing faucets and side washing nozzles that are located along both sides of the trough. Also contributing is the water from the final wash chamber, located at the end of the eviscerating line, and the gizzard machine.

Hand washing faucets are usually hook-necked pipes with no nozzles. By using nozzles it would be possible to reduce the volume of flow from these faucets and to improve the washing of the hands. It may be possible to install body operated valves on these faucets, thus reducing the water volume even further. Since the side pan wash water never comes in contact with the bird or the employees handling the bird, use of recycled water might be possible for the pan wash.

Wastes from the evisceration room consist of inedible viscera, crops and windpipes, heads, flesh trimmings, grit and sand from the gizzard cleaning, fat, blood, grease, etc. These wastes are generally termed offal and are carried from the evisceration room in the water that flows down the eviscerating trough. The water serves as a transportation system to remove wastes from the plant. If improvements to the eviscerating area cause the water volume in the trough to fall below that necessary to remove the offal, it is usually possible to reuse water from another area of the plant to increase the volume.

Final Wash

The birds receive a final wash after all evisceration operations have been completed. The final wash is performed in a chamber where spray nozzles cover the bird with a continuous stream of fresh water. The wash serves to cleanse the bird of remaining particles inside or outside of the carcass.

Water discharged from the final wash usually joins the water flow from the eviscerating trough since the final wash is generally a part of the eviscerating line. Final wash water is suitable for recirculation and if it is not needed to carry offal away, it may be better utilized in the defeathering area or along the eviscerating table as side pan wash water. Those improvements suggested for the whole bird wash may also be applicable to the final wash. These involve better nozzles and an automatic water cut-off when no birds are on the line.

Offal Recovery

Offal resulting from the evisceration operations is screened from the wastewater at the waste collection area. The offal can also be sold to a renderer. Offal screens are similar to feather screens, but the large amounts of grease present in this wastewater can cause trouble by clogging the screens. The offal, once removed from the wastewater, is augered to a waiting truck to be hauled away.

The frequency-of-repair of the offal screen, like the feather screen, is high. Employment of a spare screen could serve as an insurance against breakdown for both feather and offal screens. If this spare screen was designed as a fine mesh screen, it could be used as a final screening of the wastewater before it enters the settling basin. The screen would have to also be able to handle the entire feather or offal load in case of a breakdown. If a single-dual purpose screen is not practicable because of loaction, two different screens could be used.

Chilling

Chilling operations follow the final wash. Chilling is accomplished by large horizontal tanks containing an ice and water mixture which is stirred by a mechanical device. Two or three of these tanks are usually employed with a counter-current recirculation of the water and ice within each unit and between units. The Poultry Products Inspection Regulations[4] requires that there shall be not less than 1/2 gallon per frying chicken discharged from the first section of the chilling unit. In this tank type of chilling the birds are continuously moving through the system. Some smaller plants use a batch process. Temperature of the bird is reduced to approximately 34 degrees F at the end of the chilling process.

The birds are removed from the overhead conveyor and placed in the chilling tanks. They remain in the tanks for approximately 30 to 35 minutes. During chilling the birds pick up between 6 and 12% moisture by weight.

The partial counter-current recirculation between chilling tanks is a good water conservation measure presently being employed. Converting this to a complete counter-current system may be better. Making further use of the chiller water in other areas of the plant such as in the defeathering area will cut down on fresh water input to the plant. Using heat exchangers on the input-output of the chilling operations will reduce the energy requirements for this operation.

Water discharged from the chilling operation contains parts of flesh, grease and blood, but this material should not prevent reuse elsewhere in the plant.

Weighing and Packaging

Upon leaving the chilling operations the birds are replaced on overhead conveyors in order to allow the excess moisture to drain off and to carry the birds through the giblet packing and weighing operations. The giblets, that were removed during evisceration and other operations such as removing the neck, are wrapped and packed into the bird before the birds are sorted into various weight classes. After sorting the birds are put into boxes, weighed and packed with ice. They are then put into waiting trucks or are held in a cold storage room for shipment later.

During actual processing there is no fresh water used in the weighing or packaging area. There is an input of ice in this area but the amount of water resulting from melting ice is very small.

Final Wastewater Collection and Control

The wastewater, after having passed through the screening operations, may or may not have further treatment before being discharged. Plants discharging to a stream must have further treatment at the plant site but those discharging to a municipal sewer may or may not. In the past, few plants that discharge to a sewer have made serious attempts to further treat their wastes after screening, but the coming of surcharges may make this a profitable operation.

A settling basin with grease skimming would provide for removal of settleable solids and grease. Grease could possibly become another byproduct bringing in revenue.

WATER SUPPLY IN FEDERALLY INSPECTED POULTRY PLANTS

Turner (1973)[5] related the following official interpretation about water supply in poultry processing plants. The amount of water per bird used in poultry processing increased significantly during the middle and late 1950's, when most poultry plants remodeled for Government inspection and at the same time installed flowaway systems for moving organic waste and flumes or pumps for moving giblets. Since that time further mechanization, such as continuous chillers and gizzard machines, has added still more to the demand for clean water.

> Section 381.50 of the Poultry Products Inspection Regulations[6] outlines the general requirements for water. More detailed references may be found in the Poultry Inspector's Handbook and The Guidelines for Implementation of Sanitary Requirements in Poultry Establishments.[7] Some of the provisions of section 381.50 are as follows:
>
> 1. The water supply shall be ample, clean, and potable; the pressure and facilities for distribution must be adequate and protected against contamination and pollution.
>
> 2. A water potability report issued under the authority of the State health agency, certifying to the potability of the water, must be provided.
>
> 3. Nonpotable water must be restricted to parts of the plant where no poultry product is processed or otherwise handled and then only for limited purposes such as condensers not connected with potable water supply, vapor lines serving inedible-product rendering tanks, and in sewerlines moving heavy solids in sewage. Nonpotable water shall not be permitted for washing floors, areas, or equipment, nor in boilers, scalders, chill vats, or icemaking machines.
>
> 4. In all cases, nonpotable-water lines shall be clearly identified and shall not be cross-connected with potable water supply unless it is necessary for fire protection. Any such connections must have adequate breaks to assure against accidental contamination and must be approved by local authorities and the administrator.

5. Any untested water supply in an official establishment must be treated as a nonpotable supply.

In reviewing section 381.50, it can be seen that the use of nonpotable water is very restricted. Acceptible uses of nonpotable water are given on pages 4 and 5 of the Poultry Inspector's Handbook[7] outline areas and conditions under which water from chilling units, condensers, and compressors may be reused. It might also be added that, while it is not mentioned in any of these references, recirculated water from the refuse room is permitted in the drains to float feathers in the picking room. These drains are then considered the same as a sewer and any carcass that makes contact is condemned.

In permitting chilling water reuse, the Handbook[7] may appear to contradict section 381.50. The Handbook is taken by U.S. Department of Agriculture inspectors as the official, working intepretation of section 381.50, and administratively is much easier to update or amend.

The Handbook provides that water from poultry-chilling units may be reused:

1. To aid in the movement of heavy solids in the eviscerating trough, but not for flushing inner surfaces or side panels of the trough

2. After removal of visible solids by screening for:

    a. Scalding tanks
    b. Flushing feathers from the picking-machine aprons
    c. Feather flowaway
    d. Washing down the floor in the picking room
    e. Hardening the wax in pinning operations

Water from condensers or compressors may be used in any of the locations stated above provided the system is closed and there is a vacuum break in the line to prevent backsiphonage. It may also be used for any other purpose in the plant where artifically heated water is permitted, provided that it is covered by a potability certificate issued under authority of the State health agency.

If pumps or pipes are required to convey water intended for reuse from condensers, compressors, or chilling units, they must be of the same type that can be readily dismantled as required for sanitizing.

Specific amounts of overflow water in giblet and carcass-chilling units are required, and the Handbook[7] suggests a minimum amount of overflow from scalders. All other requirements regarding the amount of water required are on an "adequate amount" or what-is-necessary basis.

Sanitary processing requires enough running water on gooseneck washers to keep hands and hand tools rinsed, enough on bird washers to thoroughly wash each carcass, and enough on equipment to keep contact surfaces rinsed. In addition, some noncontact surfaces, such as the insides of troughs, must be rinsed continuously to prevent accumulation of waste. There is, however, a difference between an adequate amount of water and a wasteful amount. Many plants waste water--by running more than is required or necessary, or by failing to cut it off when no longer needed, or both. In many instances, water can be saved by paying more attention to plumbing.

Most plants now take advantage of melted ice to count toward the required overflow in the first chilling unit, but there appear to be few that have made any attempt to utilize the overflow water from chillers. Perhaps that is because it is not generally needed in the areas where permitted. Most plants do utilize some source of recirculated water to move feathers to the refuse room.

WASTEWATER TREATMENT IN POULTRY PROCESSING

Many communities are faced with having to provide advanced waste treatment to comply with Federal and State regulations. Individual industrial plants discharging directly to a water course are also coming under more stringent controls. All poultry processors will eventually come under direct or indirect pressure to reduce their wastewater flows and strengths. Either wastewater characteristics will be directly regulated or those processors using municipal facilities will experience substantial sewer surcharges. While a considerable number of plants are being charged minimal rates for their waste treatment, there is a rapidly growing trend among municipalities to make industry pay for its share of waste treatment. As regulations force municipal plants to improve their wastewater effluent qualities at greater treatment costs, the costs will be passed on to those industries discharging a significant amount of waste to the system. Normal sewer charges to industry are based on flow rate and allow up to 250 or 300 mg/l of BOD and suspended solids in the waste stream. Additional concentrations of BOD and suspended solids have been charged at rates of $20 to $80 per thousand pounds of each. Incentive for waste reduction is increasing.

A survey[8] in 1970 of federally inspected slaughtering operations indicated that 29 percent of the plants had some degree of private waste treatment, 65 percent of the plants had final municipal waste treatment and 6 percent had no waste treatment whatsoever. The reduction of water usage in the poultry processing operations and the water discharged will thus be a benefit to processors, municipal waste treatment facilities and the general public whose environment is affected.

Reduction of flows need not be completely at odds with the industry trend toward modernization and improved processing using flowaway systems. It will remain for the industry to assess the costs of process changes to either "dry" or recirculating systems and compare them against wastewater treatment charges. In the event of borderline decisions, one should be aware that wastewater quality restrictions imposed by states and municipalities are likely to become more stringent in the future and the most economical method to meet those restrictions is often by in-plant process modifications.

Based on a sewer charge of 25 cents per 1000 gallons, typical water use and waste discharges, and a wastewater flow of 18.4 billion gallons, the USDA predicted[8] a cost to poultry processors of municipal waste treatment at $4.6 million. The live weight slaughter at the plants surveyed by the USDA was 8.4 billion pounds with a calculated sewer charge of $0.55 per 1000 pounds of live poultry. Inefficient plants losing excessive solids to the wastewater streams stand to have increased sewer surcharges and concomitantly increased processing costs. Total treatment costs were estimated for anaerobic-aerobic lagoon systems and extended aeration systems. Private waste treatment by lagooning could cost the processor from $0.22 to $0.08 per 1000 pounds live weight for poorly to properly controlled plants; respectively.

Extended aeration plants, which provide a higher degree of treatment with less land area, would require investment, operating and maintenance costs of $1.10 to $0.40 per 1000 pounds live weight for hydraulically unmanaged and managed processing plants respectively. Careful and diligent in-plant water use reduction by the poultry processor may save him substantial quantities of money by realizing smaller waste treatment systems than those calculated here for "typical" poultry processing plants in 1970. At a normal sewer charge of $0.25 per 1000 gallons of waste, a water use charge of $0.25 per 1000 gallons of water supplied, and a sewer surcharge of $50 per 1000 lbs. of BOD discharged over 300 mg/l in concentration, a typical 100,000 broilers per day poultry processor with poor water and waste management may pay a monthly bill of $21,600. With proper water management this bill can be reduced to approximately $11,520.

LITERATURE REVIEW

The poultry processing industry and its water and waste load has been extensively studied by several agencies, FWPCA[1], Porges and Struzeski[2] and USDA[8]. The main efforts have been directed at establishing the gross water use and waste load for poultry processing although classification by area, size and technology were examined for differences.

Porges and Struzeski[2] made initial studies directed at understanding the water demands and waste discharges of the poultry processing industry. The authors prefaced their pamphlet in part with the following words, "Protecting our water resources is essential to health and economic growth. Stream pollution control provides benefits to the industry, the individual citizen, and the nation. Since the most economical operation is achieved when process water is at a minimum, it is particularly advantageous for industry to understand its waste problem." Obviously this study was attacking the same goals as the present research and demonstration grant.

They found the average poultry processing plant of the early sixties to be a "modern, highly automatic" establishment. The average kill for the plants surveyed was 50,000 BPD while the larger plants handled 60-90,000 BPD. The largest plants processed in excess of 150,000 BPD.

The blood from the killing station was found by Porges and Struzeski[2] to be waste of the greatest pollutional significance. They indicated that blood was usually collected in a "bleeding tunnel" and removed several times a day as a semi-solid in the better managed plants. A study by Porges[9] found that 8 percent of the body weight of the chicken may be blood, of which 70 percent is drainable. BOD_5 analysis indicated that the mean BOD_5 was 92,000 mg/l. Thus the drainable blood was shown to have a pollutional load of 17.4 lbs/1000 chickens processed. Bolton[10] found that the BOD and suspended solids loads can be reduced by 15 lbs/1000 birds and 6 lbs/1000 birds if the blood is recovered.

Federal Water Pollution Control Administration[1] identified those processes which have substantial impact upon wasteloads. Those processes are: (1) Blood recovery, (2) screening of feathers, and (3) cleanup. Blood recovery can reduce wasteloads by approximately thirty-eight percent. With only fifty-six percent of all plants reportedly recovering blood in 1966, this process is potentially an area where substantial pollution reduction could occur. 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. Dry cleanup of manure and feathers preceding the wet cleanup can reduce both the solids and BOD concentration of the wastewater.

Technology was defined[1] in terms of the subprocess mix. The three levels of technology: "Old," "Typical," and "Advanced" were 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 submersion 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 dur 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 submersion into mechanical chilling tanks containing refrigerated water
5. Shipment of processed poultry frozen
6. Wet cleanup of plant (partial dry cleanup)

It was reported that technology is directly related to wasteload reduction. The major reduction occurred as technology changed from "old" to "typical". The waste reduction in this change was caused by the introduction of blood recovery into the subprocess mix. The "flow-away" system comes into existence with a consequent increase in wastewater per unit of product.

The change from "typical" to "advanced" technology saw 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 was caused by increased reuse of wastewater. The effects of technology upon wasteload and wastewater volume are summarized in Table 3.

The most common method of waste treatment used by the poultry processor is municipal treatment. The plants of the typical and advanced technology levels which employ the flow-away system of feather and offal removal use a screening process to remove feathers and solids from the plant effluent. In the majority of processing plants (eighty percent) this is the only type of treatment employed. All further treatment is done by the municipality.

Camp[11] previewed a new poultry processing plant with an elaborate waste treatment system. He reported in-plant changes were instituted to reduce water use and wastes from the plant. Water use was put at 7.6 GPB and BOD_5 waste load at 39 lbs/1000 B. The by-products collector was removing 35-45% of the BOD (mean = 40%), 54-70% of the suspended solids (mean = 60%) and 56-71% of the grease (mean = 60%). Final effluent after extended aeration and polishing ponds showed 99% BOD removal or better.

Camp and Willoughby[12] predicted strict water conserving practices in a poultry processing plant could reduce the wastewater flow to 6 GPB. Table 4 details the waste from one poultry processing plant.

Porges and Struzeski[2] studied the wastes from poultry processing plants. They recommended municipal plants receiving poultry wastewaters should be designed with liberal allowances for plant loads.

Table 3. 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

Table 4. EFFLUENT OF CANTON, GEORGIA POULTRY PLANT

		Range	Average
		(mg/l)	
BOD		370-620	473
Solids	Total	-	650
	Suspended	120-296	196
	Settleable	15-20	17.5
Grease		170-230	201

Peak and average loadings were urged for use in the initial design. Reserve treatment capacity was a need in design considerations and flow could be designed using a 16-hour discharge period.

Various treatment methods were explored for reducing the load from the poultry processing plant. They noted that grease could be collected in primary sedimentation basins with appropriate skimming and collecting devices. Grease traps were mentioned as working but often giving problems due to lack of operator attention. They expanded on the findings of Teletzke[13] to conclude that air flotation systems are practicable for the removal of suspended solids, grease and particles of flesh where the floating material may be rendered into by-products. Studies were noted that primary settling basins could be expected to remove 17-28% of the BOD and 30-64% of the suspended solids.

Treatment methods practiced on poultry wastes were compiled by Porges and Struzeski[2]. Treatment and disposal by land irrigation was pointed out as attractive and efficient. Large acreage required was a deterrent, but the low initial and operational costs were the major benefits. At the time, trickling filters and activated sludge processes had not been widely used in the poultry plants because of the costs and operational demands. An extended aeration system was reported to be removing 90 percent of the BOD_5 and 79 percent of the suspended solids. Stabilization ponds were reported being used for poultry wastes and domestic poultry wastes at loadings up to 50 pounds BOD per acre per day with reductions of 70 to 90 percent.

Twigg[14] discussed water conservation in a poultry processing plant in broad terms. He presents a list of areas where he suggests particular attention should be devoted. His suggestions mainly deal with good housekeeping principles, such as using nozzles on clean-up hoses avoiding unnecessary water overflows from equipment, and using nozzles in washing operations which employ low-volume high-pressure principles. Bower[15], in discussing the food processing industry in general, indicates a need to incorportate wastewater handling into plant design. He is mainly concerned with treatment of wastes with little mention of in-plant modifications.

Kaplovsky[16], Bolton[10], Porges[9], Barnard[17], Miller[18], Henkeledian, Orford and Cherry[19], and Wolf and Woodring[20] deal explicitly with poultry processing waste characteristics. Porges and Struzeski[2] presented a table (Table 5) which illustrates the range of results that are derived from these studies. Hamm[21] reported on the analysis of individual process effluents of 10 poultry processing plants. As no wastewater flows are detailed, waste load calculations are impossible without assumptions on flow rate which is a very risky assumption. A summarization is contained in Table 6.

Table 5. COMPOSITION OF COMBINED POULTRY PLANT WASTES, PORGES AND STRUZESKI (1962)

	Range
Five-day BOD, mg/l	150-2,400
COD, mg/l	200-3,200
Suspended solids, mg/l	100-1,500
Dissolved solids, mg/l	200-2,000
Volatile solids, mg/l	250-2,700
Total solids, mg/l	350-3,200
Suspended solids, % of total solids	20-50
Volatile solids, % of total solids	65-85
Settleable solids, ml/l	1-20
Total alkalinity, mg/l	40-350
Total nitrogen, mg/l	5-300
pH	6.5-9.0

Table 6. WASTEWATER CHARACTERIZATION, HAMM (1972)

Process	COD	Fat
	(median mg/l)	
Scalder	2268	30
Feather flume	1919	135
Chiller	903	165
Giblet Chiller	988	54
Eviscerating Trough	687	149
Final Bird Washer	379	85
Viscera Flume	1005	185

Most of these articles basically report of surveys comparing the methods of waste treatment used by poultry plants. Camp[11] presented a detailed analysis of a poultry plant's waste treatment facilities.

Two of the United States Government publications, Federal Water Pollution Control Administration[1] and Porges and Struzeski[2], present general descriptions of the poultry processing operation and informative reviews of the problems. The solutions presented are of a general nature. The ranges shown in Table 5 indicate that specific solutions can only be made after a specific plant is analyzed.

SECTION IV

METHODOLOGY AND BENCHMARK

INTRODUCTION - GOLD KIST STUDY

Gold Kist, Inc.

The Gold Kist Poultry Processing Division is the third largest poultry processing organization in the United States with six (6) plants in North Carolina, Georgia and Florida. The Durham plant processes an average of 70,000 birds each operating day using two processing lines and can be classified as a medium-to-large size plant. The plant employs 275 people. All products are inspected by the United States Department of Agriculture with the direct supervision of veterinarians. Mechanical Services and plant maintenance are provided by a team of seven mechanics.

The Durham plant used typical technological methods as defined in the Cost of Clean Water[1] in its processing operations. Total water intake was 192 million gallons in 1969 and required approximately 10 percent of the total water supply of the City of Durham. Product composition at the initiation of the project in July, 1969 consisted of whole birds (95 percent) and parts (5 percent). The product composition in May 1972 was 70 percent whole birds and 30 percent parts.

Purpose and Objectives

The research, development and demonstration project in water and waste management in poultry processing was conducted at the Gold Kist plant in Durham, North Carolina. The purpose of this project was to use the whole operating plant for the development and modification of process and equipment changes and for an evaluation of the technical and economic feasibility of these changes. Specific objectives were to:

A. Develop and demonstrate process and equipment changes for water and waste management.

B. Evaluate the impact of production methods, technical changes in equipment, conditioning of water and by-product recovery on water use and reuse and waste loads.

C. Determine the economic implications for water and waste reduction methods demonstrated in the project.

D. Make recommendations for the management of water and water-borne waste in poultry processing.

Technical and research requirements in support of the project were provided by North Carolina State University. The University had responsibility for:

1. Training key personnel to carry out measurement and control work within the plant.

2. Sampling and testing of all process wastewater to determine both quantities and characteristics.

3. Guidance and coordination in the development, fabrication and installation of specialized equipment.

4. Development and implementation of technical changes in plant processes.

5. Systems evaluation and partial budget analyses for the technical alternatives demonstrated.

6. Publishing results and related information developed in all phases of the project including recommendations for the management of water and waste in poultry processing.

Special Features

This project has a number of features which are of special interest which follow:

1. The project was jointly developed and conducted by a federal agency, Environmental Protection Agency; by industry, Gold Kist; and by an educational institution, North Carolina State University.

2. An interdisciplinary research team worked cooperatively. Members had training in microbiology, food science, engineering and economics.

3. The project encompassed both water use and waste abatement throughout the plant, from water intake through final waste water collection and control. Systems analysis was applied.

4. A full-time staff in the plant worked on the project without assigned production-related responsibilities.

5. The University provided supporting microbiological evaluation in all phases of the project.

6. A cooperative working relationship with the USDA-CMS product inspection staff was achieved which enhanced the effectiveness of the project.

Plan-of-Work

The plan-of-work was organized into three phases: collecting benchmark information (6 months), technical development (30 months) and evaluation and preparation of the final report (9 months).

The Gold Kist Poultry Division provided its plant and processing facilities at Durham, North Carolina, and made available the required personnel for conducting this project. A wastewater testing laboratory was installed and equipped at the plant for monitoring water and waste systems. A subcontract, negotiated with North Carolina State University at Raleigh, provided technical and research requirements in support of the project.

Approach

The plant was divided into thirteen separate operating areas, Figure 3. (Appendix A provides a complete description of poultry processing details about the Gold Kist plant.) Preliminary studies and laboratory analyses were made to establish benchmark quantities and characteristics of water and waste in eleven areas. Sampling points are numerically identified on the flow chart. Laboratory tests are detailed in Appendix C, Table 1. Information from benchmark studies was used in the development of plans and specifications for new or modified process equipment.

Mechanical services for modification and installation of process equipment were provided from the maintenance and repair labor force of

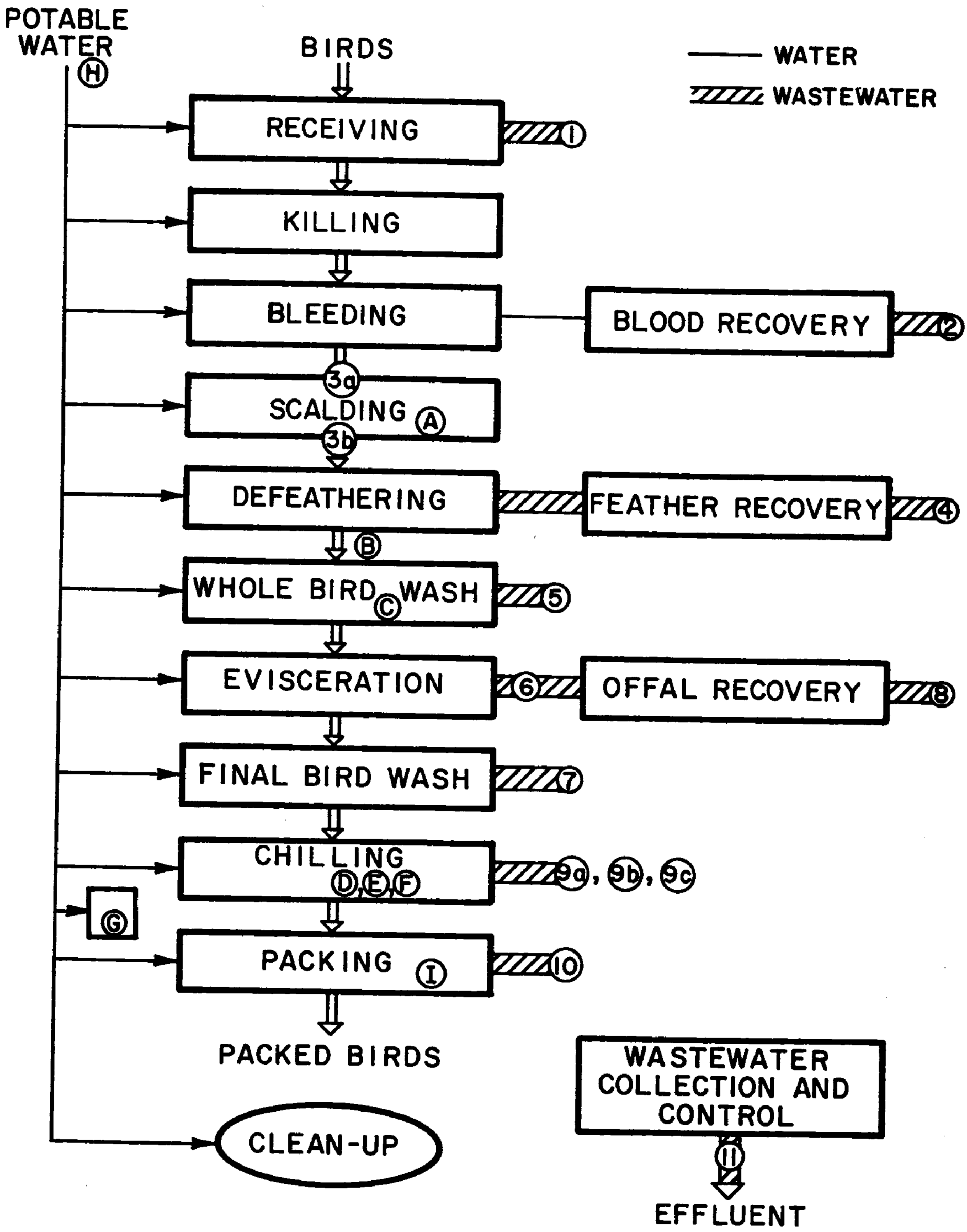


Figure 3. Water and broiler flow in Gold Kist plant with wastewater (numbers) and microbiological sampling points (letters) identified

the plant. Special equipment and assistance was obtained from outside firms as such requirements arose.

OBJECTIVE A: DEVELOP AND DEMONSTRATE PROCESS AND EQUIPMENT CHANGES FOR WATER AND WASTE MANAGEMENT.

Specific process changes for accomplishing OBJECTIVE A in each of the operating areas are listed as follows:

1. Receiving Area

   a. Dry sweep of pad and docks prior to washing
   b. Air system to clean coops

2. Blood Collection and Recovery

   a. Blood collection trough
   b. Tank collection on by-product truck
   c. Installation of stunners

3. Scalding

   a. Use of prechiller overflow for scalder make-up water
   b. Directed discharge to feather flow-away flumes under pickers

4. Picking

   a. Installed nozzles for uniform feather removal within pickers
   b. Designed and install flumes under pickers to further facilitate uniform feather removal
   c. Eliminated use of potable water in feather flow away flume

5. Feather Recovery

   a. Installed new screen media

6. Whole Bird Washers

   a. Nozzles installed
   b. Flow regulation devices installed
   c. Discharge redirection to feather flow-away flume

7. Evisceration

   a. Nozzles installed for rehang belts
   b. Installed pressure regulating equipment for trough supply

c. Installed regulated nozzles for handwash stations and put body operated valves at selected locations
d. Isolated the water supply for the side pan wash and installed time delay valve
e. Giblet flumes were eliminated where possible
f. Nozzle use and pressure regulation practiced for flow control in final bird washer

8. Offal Recovery

a. Screen media changed
b. Screen addition to prevent solids overflow

9. Chilling

a. Nozzles installed for rehang belt
b. Collection box and pump added to distribute water to scalder

10. Grading, Weighing and Packing

a. Use of CO_2 in packing reduced ice requirements

11. Clean Up

a. High pressure system utilized
b. Monitoring equipment installed

12. Final Wastewater Collection and Control

a. Primary separation chamber built
b. Air flotation cell with associated equipment installed

13. Water and Wastewater Measurement and Control

a. Installed meters
b. Pressure regulation devices were utilized
c. Placed flumes (Parshall)
d. Recorders-continuous and automatic were mounted
e. Sampler positioned in final effluent stream
f. Other flow measuring devices and techniques were utilized

14. Waste Characterization

a. Laboratory(s) installed
b. Sampling practiced
c. Records kept
d. Laboratory testing continued
e. Microbiological sampling and testing performed
f. Training executed

OBJECTIVE B: EVALUATE THE IMPACT OF PRODUCTION METHODS, TECHNICAL CHANGES IN EQUIPMENT CONDITIONING OF WATER AND BY-PRODUCT RECOVERY ON WATER USE AND REUSE AND WASTE LOADS.

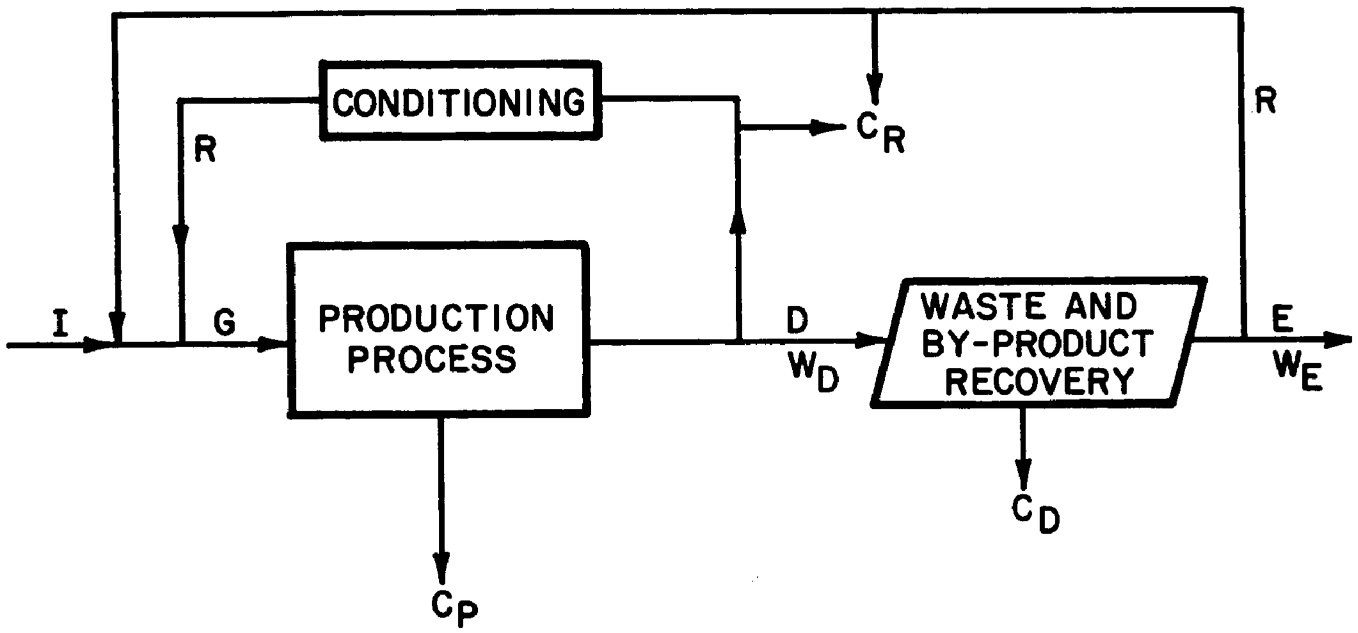
The analysis of water use and waste load was made for process and equipment changes. Conceptually this is shown in Figure 4. Within this framework, the plant was considered a production process in making an analysis of total water used and the final wastewater going from the plant. Also, as in-plant changes were made for the control of water and/or treatment of the wastewater, the effluent was monitored to establish the effect of the changes on the wastewater characteristics.

OBJECTIVE C: DETERMINE THE ECONOMIC IMPLICATION FOR WATER AND WASTE REDUCTION METHODS DEMONSTRATED IN THE PROJECT.

Budgeting procedures were used to determine changes in net revenue. Economic factors inherent in the reduction of water and waste were the associated reduction in the cost of fresh water supplies and waste treatment. Additional benefits were derived from by-product recovery and labor savings resulting from the mechanization of manual operations.

OBJECTIVE D: MAKE RECOMMENDATIONS FOR THE MANAGEMENT OF WATER AND WATER-BORNE WASTE IN POULTRY PROCESSING.

Project results were used to develop recommendations for the management of water and waste in poultry processing plants.



I = Intake Water

P = Production Process

R = Recirculated Water

G = Gross Water Applied for <u>All</u> In-plant Uses

C = Consumptive Use or Net Depletion of Water = $C_P + C_D + C_R$

D = Wastewater Discharge from Production Process

E = Final Effluent from Production Process (Available for Reuse)

W_D = Waste Load in D (lb of BOD)

W_E = Waste Load in E (lb of BOD)

Degree of Recirculation = $\frac{R}{G} \times 100\%$

Figure 4. Water and waste schematic for any industrial process

METHODS

Water Measurement

Gold Kist purchases its supply of water from the city of Durham, N. C. The city's water meters were already in operation for the purpose of measuring the amount of water used by the plant. These main water meters were checked monthly by the city's personnel for consequent monthly water-sewer billing by the city for such services.

Meters

The main water meters were monitored throughout the project to establish the volume of in-coming fresh water being used during any given period of time. Smaller size water meters (5/8 in. to 3 in.) were used to develop the amount of water used within units of equipment, water hoses, and any system where the uses were defined. All water use was supplied from the main water supply lines within the plant. All meters are cumulative use type units and could be checked at any frequency desired for the volume during the chosen period. They were also used for flow rate measurements when timed with a stop watch.

Stop watch and Calibrated Containers. In many instances it was impractical to apply water meters to all uses of potable water. An example would be a hand wash nozzle along the eviscerating trough where the flow would be supplied from a common supply line and could be regulated at the worker's station. For our project the flow rate at each nozzle was checked several times and combined with the average rates for other nozzles along the entire eviscerating line to get the total flow of water for this system. The flow was determined with a calibrated container and a stop watch.

Wastewater Measurement, Sampling and Testing

Volume

The measurement of unit process wastewaters is usually much different than the fresh water entering a plant or the water supply to a unit of operating equipment. Several factors contribute to the problems of such volumetric determinations, some of the most important are as follows.

1. Undefined discharge points,

2. Nonuniform distribution of water flow patterns within and from the equipment,

3. Contaminants that are entrained in waters that are used as carriers of waste or by-products from specific processes,

4. Intermittant use and variable flow operations,

5. Absorption or fluid release by the product in process, and

6. The mixing of waste waters from several unit operations in a central or complex drain system.

However, when these factors could be neglected, the volume of water used in a unit of process equipment or a system within the plant was measured by a meter in the water supply line to the unit or system.

Where a defined source and a uniform rate of wastewater were discharged, the flow rate and volume were determined with devices such as:

1. A container which will hold a known volume of liquid and a stop watch,

2. Area measurement of a drain pipe or channel with depth and velocity recordings,

3. Flow indicating devices that can be installed in a defined discharge stream such as weirs, parshall flumes, and other calibrated units of comparative design.

Solids or fluids introduced in a unit process will increase the wastewater volume and should be accounted for by physical or chemical determinations if differentiation is desirable. An example is a chiller where ice and potable water combine to form a chiller overflow.

For irregular and intermittant discharge of wastewater from a defined discharge point, source flow indicating devices such as weirs and flumes can be used with the addition of a flow recorder. Both should be capable of indicating variations in flow rates representative of the volume being discharged during the entire processing and other water use periods. Also, they must be installed so that solids and/or other materials in the wastewaters will not interfere with the proper indications of flow.

The most difficult wastewater sources to measure were the undefined or blended effluents. A typical example of such flows are described by the combination of effluents along an eviscerating line. Wastewater from the final bird washer, side pan wash, giblet splitters and washer, hand wash stations, etc., all enter the eviscerating trough in widely dispersed areas, along long lengths of trough and from many variable flow rate nozzles. The solution to these volumetric measurements is a sequential series of measurements by use of a flow measuring device to be used where each unit process is shut off and the difference in wastewater flow is determined at the end of the system or in the above case the eviscerating trough. Through the process of elimination the volume discharged from each unit process can be established during its operating period.

Measuring Waste Materials in Process Wastewaters

The sampling of process wastewaters can be categorized in two groups. (1) Those sources where automatic proportional samples could be obtained during a complete cycle of the specific process operation, (2) Hand sampling by a collection of a series of repeat proportional samples on a regular timed interval during a specified unit process cycle or period. In both cases the total sample must be both representative and preserved during collection to prevent deterioration or change in characteristics.

In this study determinations of the wastewater characteristics were made according to Standard Methods,[22] (see Appendix C for reference to specific tests). Both volume of wastewater and the quantitative amounts of chemical and/or organic materials were determined to establish the waste loads being discharged from point sources or combined flows being discharged into the major drains of the plant. By comparing the individual sources with the total plant effluent both a hydraulic and waste material balance were made for the complete wastewater system.

Microbiological Sampling and Testing

Introduction

With current technology, there is no better method for determining the actual (consumer) safety of a product, particularly a product such as poultry, than by the use of microbiological evaluation. For this reason, microbiological testing for total count, coliform count and presence of salmonella was conducted in conjunction with water use and wastewater evaluations. The initial phase of the microbiological evaluation was to establish the benchmark for the microbiological content of broilers and broiler contact waters throughout the processing line. Also, a determination was needed of the "normal" microbiological load to be found on carcasses at the processing plant under investigation. Literature figures were not sufficient nor were they felt to be representative of the plant under investigation. Anticipated problems included factors such as the lack of standard test procedures for poultry parts and carcasses, lack of day-to-day consistency of samples due to variations such as weather and age of birds, seasonality effects and correlation of microbiological and wastewater data. The overall thrust of the microbiological investigations was to assure that no significant adverse changes or trends in the microbiological content were evidenced during or because of changes in water use patterns or process equipment modification.

An indicator of microbiological fitness is the total numbers of the microorganisms present both in rinse water in various points throughout the plant as well as on the final carcass. The total number of bacteria present is one of the overall measurements that can be used to determine the sanitary quality of any given food. The fewer microorganisms that are present, the more likelihood that good sanitation has been used in producing the food and, furthermore, the better likelihood that the product is going to have adequate and desirable shelf life during its storage before the consumer receives it.

In the poultry operations, there are a number of sources that can add to microorganisms, particularly of the bird itself. First of all, the feathers will harbor a tremendous number of microorganisms so that the total outside portion of the carcass is going to be a source of great numbers of microorganisms. Many of these could be very undesirable. The next largest source of microorganisms is the intestinal tract and also the respiratory tract. It is from these sources that most of the carcass microorganisms originate.

The next group of organisms that were monitored were the coliform bacteria. The coliform bacteria are residents primarily of the intestinal tract and low numbers of coliforms indicate the extent of contamination from this source. Finally, the final carcasses for the occurrence of salmonella were monitored.

Methods for the Microbiological Examination of Water and Carcass Samples

Total counts and coliform counts were performed on samples collected at various points on the processing line. Total counts were determined on Difco Plate Count Agar (PCA) after 48 hr incubation at 32°C. Coliform counts were made on Violet Red Bile (VRB) Agar (Difco). Plates were incubated at 35°C for 24 hr.

Essentially four types of samples were collected:

1. Water samples were diluted and plated. Counts were recorded on a per ml basis.

2. Cotton swab samples of carcass surfaces. Approximately 1 sq in. of surface was swabbed and the swab placed in a test tube containing 6.45 ml of 10^{-3}M phosphate buffer (1 in.^{2} = 6.45 cm^2). Contents from the swab containing tube were diluted and plated. Counts recorded on per cm^2 basis.

3. Giblet samples were divided into three types: (a) liver, (b) hearts and gizzards, and (c) necks. These samples were collected in plastic bags. The samples were weighed and a volume of phosphate buffer equal to the weight of the giblets was added to the bags. The contents were shaken and the rinse water diluted and plated. Counts were recorded on a per gram basis.

4. Total carcass counts were determined by adding 1500 ml of sterile water to a bag containing the carcass. The bag was shaken for 1 min. Care was taken to ensure that water went inside the body cavity. The rinse water was diluted and plated. Counts per ml of rinse water were multiplied by 1500 to obtain counts per carcass.

Sample Points and Methods of Sampling

The following procedures were used in obtaining samples (see Table 7):

Point A. Scald water. Samples of water were collected in sterile bottles at the point where excess water overflows the tank. Freshly killed or stunned birds (with feathers) are fed into this tank. The water is maintained at approximately 125°F (52°C).

Point B. Whole Bird Washer. At this point the feathers have been removed but the carcasses are non-eviscerated. The carcasses

Table 7. MICROBIOLOGICAL SAMPLING POINTS

Sampling Point	To Sample
A	Scald Water
B	Whole Bird Washer
C	Final Bird Washer
D	First Chiller
E	Second Chiller
F	Giblet Chiller
G	Ice
H	Input Water
I	Finished Carcass

have passed through a flame intended to singe pin feathers and body hair. The carcasses were rinsed by passage between a row of sprays. Samples taken at this point were:

(a) Swabs before rinse. One side of two tagged birds was swabbed before the carcasses entered the rinse.

(b) Swabs after rinse. The opposite side of the birds swabbed in (a) were swabbed for this sample.

(c) H_2O from birds or carcasses. Water dripping from birds as they exited from the rinse was collected. Each sample represented the drippings from several carcasses.

(d) H_2O from trough. This H_2O was collected where water exited from the rinse chamber.

Point C. Final Bird Washer. This rinse occurs after evisceration. The samples taken at Point B were also taken at this point. In addition, whole carcasses, two before rinse and two after rinse, were collected.

Point D. First chiller. At this point the carcasses were submerged in a large tank of water maintained at approximately 52°F (10°C). Two types of samples were collected: (a) H_2O as it exited from the chiller and (b) two whole carcasses as they exited from the chiller.

Point E. Second chiller. Similar to Point D except that water temperature is about 33°F (0°C). The samples taken at this point were the same as Point D.

Point F. Giblet chiller. Livers, hearts, and gizzards are transported from the eviscerating line to the giblet chiller by a combination of flumes and belts. The chiller is a revolving drum. Ice is added periodically to maintain a temperature of _ca_. 32°F (0°C).

Point G. Ice. The ice was collected in plastic bags from an ice machine used to fill packing boxes. This ice is also fed into the various chillers.

Point H. Input H_2O. This sample was taken from a water tap in the loading area.

Point I. Finished carcasses. These samples, stuffed with giblets, were collected at the weighing bins before final packaging. The samples were selected to represent the most common weight of carcass at the time of sampling.

The finished carcasses were tested for the presence of salmonella. One hundred ml of rinse water was pre-enriched in 400 ml of lactose broth (Difco). One ml of the incubated lactose broth culture was transferred into selenite cystine broth (BBL) and one ml was inoculated into selinite cystine made from the individual ingredients with dulcitol substituted for lactose. Streak plates on Brilliant Green Agar, Bismuth Sulfite Agar, and Salmonella-Shigella Agar, all Difco products, were prepared from the above selenite cystine tubes showing growth. Suspect colonies from the selective media were transferred to triple sugar iron (TSI) agar slants. The time-temperature for incubation was the same for the above tests, 24 hr at 35°C. Isolates showing salmonellae-like reactions on TSI slants were tested for the presence of urease and lysine decarboxylase and their ability to ferment lactose and dulcitol to acid and gas. Finally, suspect isolates were tested for agglutination in poly-o-antiserum.

Economic Evaluation

Introduction

The Gold Kist plant is considered to be representative of plants processing approximately 70,000 birds per day. Conclusions should be generalized with caution because of the limited operating experience during the project. However, most changes were not complex and are generally applicable in poultry processing.

Research and development activities consisted of two parts: (1) a detailed analysis of major process and equipment changes; and (2) an overall plant evaluation. The overall reduction in potable water use and waste costs were expected to be greater than the sum of the costs of the process major changes. Increased worker awareness of water and waste problems were expected to improve housekeeping procedures through closer attention to minor water uses such as turning off hoses and other details that affect water use and waste. A reduced hydraulic load was expected to improve the efficiency of pretreatment methods such as screens and the air flotation cell.

Initial Costs

Budgets were developed for major process and equipment changes made to reduce fresh water use and waste levels in the final plant effluent.

Existing processes were modified to improve waste recovery, lower water requirements, and/or reuse process water where feasible. A combination of commercially available and project developed equipment were used for most changes.

Investment or initial costs included the materials cost, installation and tax associated with equipment and process modifications. Equipment and operating costs of the equipment already in place and not affected by process and equipment modifications were not included. Neither were research and development costs included. Details on the computations of initial costs are tabulated in Table 8.

Annual Budget

Annual cost includes depreciation, maintenance, interest on investment, and operating expenses. Straight line depreciation schedules were based on the expected useful life of the equipment. Annual maintenance was charged at a rate of ten percent of materials costs except for the laboratory. An interest rate of 7 percent on one-half of the initial costs of materials and installation was included in annual costs. Notes detailing annual budgets are included in Table 8.

Benefits included (1) reduced costs from savings in water, sewer services, labor, and cleaning chemicals, and (2) revenues from by-product sales of feathers, offal, and blood. The Gold Kist plant purchased municipal water and sewer services from the City of Durham, North Carolina. Water and sewer rate for the largest water use increment was 44 cents per 1000 gallons of water which included 21 cents per 1000 gallons of water and an add-on of 110 percent, 23 cents, for sewer services. In addition, there was a sewer surcharge of \$80 per 1000 pounds of BOD_5 discharged in the plant effluent for BOD_5 greater than 250 mg/l.

The wage rates for estimating the value of labor costs and savings were \$2.05 and \$2.15, depending upon the wage rate of the worker. The price of cleaning chemicals was \$3.20 per gallon. By-products of feathers offal and blood averaged \$19.48 per ton during the study period.

Total Plant Analysis

An overall analysis was made to determine the net effect of all process and equipment changes made in the plant on fresh water use, waste load, costs and income. A comparative analysis was made of annual benefits and costs associated with the changes made during the three year period from July, 1969 to July 1972. Water flow

Table 8. NOTES ON INITIAL COSTS AND ANNUAL BUDGETS[a]

1. All installation labor charged at $10/hour.

2. Interest on one-half of initial costs at a rate of 7%.

3. Maintenance is 10% of material cost unless otherwise noted.

4. Depreciation

Item	Useful Life
Nozzles	2 years
Piping	10 years
Valves, gauges	2 years
Sampler, regulators, meters	5 years
Troughs, pan (SS)	10 years
AFC	20 years
Pumps	1 year

5. Tax at 2% of materials cost.

6. Recurring labor @$2.15/hr for daily operation (cleaning and adjustment) and including labor not otherwise allocated

7. Water and sewer rate of 0.44/1000 gal - although average water and sewer rate is $0.51/1000 gal because of a higher rate for first increments of water. Reductions occured at lowest cost increment.

8. All daily savings and costs are computed for annual budgets using a 240 work day year with a 540 minute work day.

9. Surcharge costs and savings computed at $80/1000 lbs BOD_5.

[a] Research and development costs are not included in budgets for changes made during this project.

regulation and control, water and waste monitoring, laboratory operation and maintenance, and supervision of water and waste operations were important portions of the total plant costs which were not included in budgets for individual changes.

BENCHMARK INFORMATION

Benchmark information was obtained on water and waste quantities, wastewater characteristics and microbiological characteristics of both the product and process water at selected points throughout the plant. A flow chart was developed for identifying processes, water sources, sampling points, by-product recovery sources, product flows and wastewater flows, Figure 5.

Water Use

Several problems were encountered in obtaining water measurements. Methods for measuring the amount of water uses in major processes varied widely. In general, the process equipment was neither designed nor installed for consistent water use or ease of water measurements. Worse yet was the intermittent uses of water particularly in the use of clean-up hoses. Two workers would use different amounts of water to wash an area of the plant or piece of equipment under similar conditions.

The nonuniformity of use made obtaining water use information difficult. Every effort was made to determine the use at a given application point and then to observe several times later to confirm earlier measurements. Flow regulation and control was noted as being necessary for water management. The amount to use had to be dictated by management through water pressure control or valve regulation or employees made their own decision about the amount of water needed.

Average water use for the three month benchmark period amounted to 850,000 GPD with average daily broiler receipts of 69,200 birds. Live weight (LW) of broilers for this period was 3.65 lb. with a processed weight (KW) of 2.70 lb. The use rate was 12.28 GPB received or on a weight basis was 3,365 gal/1000 lb. LW or 4,549 gal/1000 lb. KW.

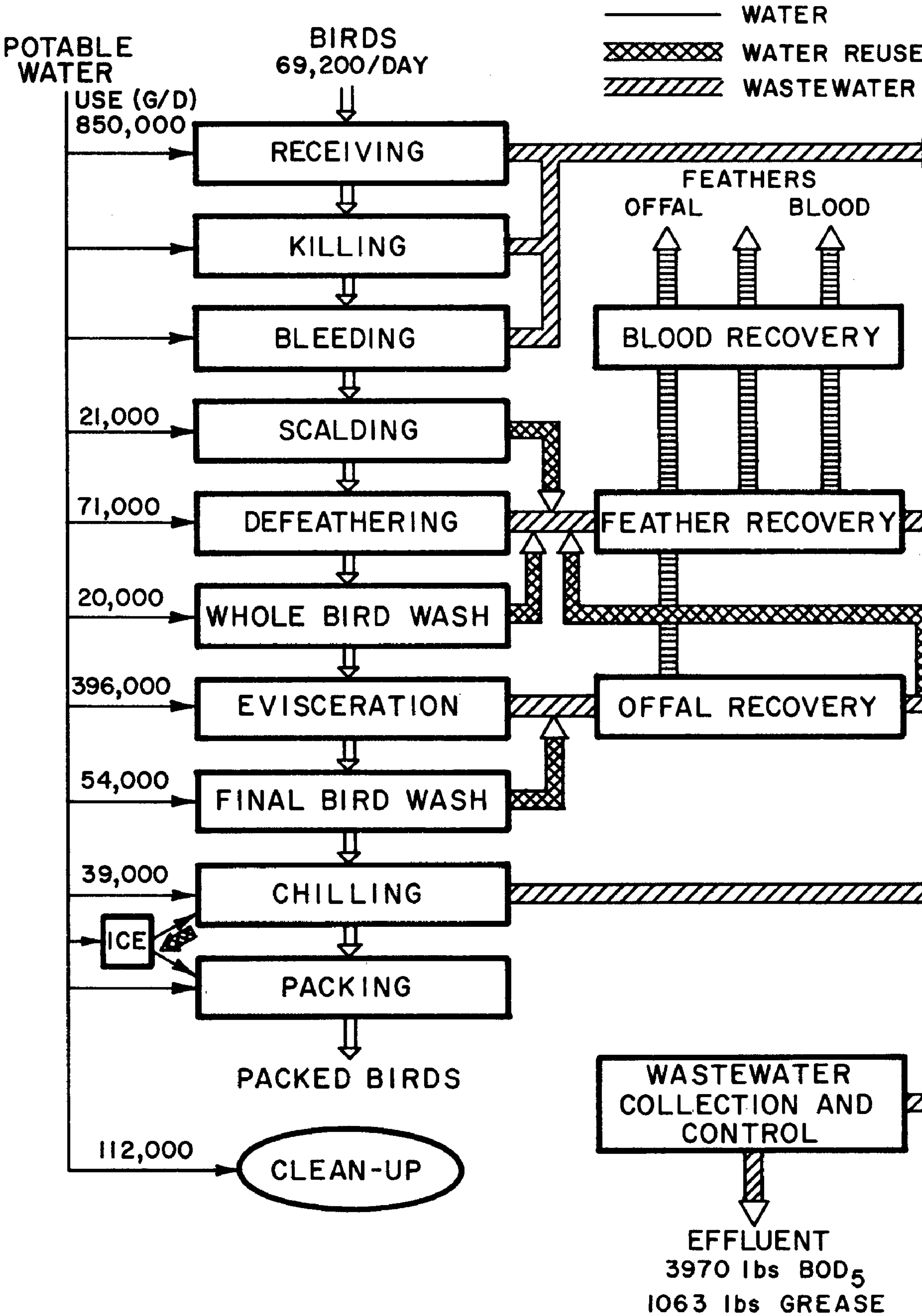


Figure 5. Water and broiler flow in Gold Kist plant with selected water use and waste benchmark results

Details of water use can be observed in Table 9. One should note 24% of the water use was in the evisceration trough for hand wash facilities and for side pan washing. Hand wash goosenecks were observed to use approximately 3 GPM each. Also, 23% of the total potable water use was for the gizzard machine and giblet flumes. These two areas accounted for almost 50% of the total water use. The feather flume utilized 51,000 GPD (6%) of the potable water use which was recognized as being unneeded in initial observations.

Hoses used for washing and cleaning equipment averaged 34 GPM each. Most employees did not turn off the hoses when not in use but laid them on the floor until needed again.

The wasting of water is probably the number one criticism of all wet industries. Since our society has had a plentiful supply of water, in general little concern has been given in the past to its conservation. Poor work habits and uninformed supervision has resulted in most of the unused and misused water. Here are some examples of misuses observed in the poultry processing plant:

1. A worker would drop a hose and let it run rather than walk back to the valve and shut the water off between needs.

2. The supply valve on a washer would be turned wide open regardless of how much water was needed.

3. Process waters would be left running during lunch periods when no birds were being processed.

4. The scalder would be filled a second time to flush solids rather than wash them away with a hose.

5. A full-flowing hose has been used to prevent blood accumulation at the kill station rather than catch this blood in a collection chamber.

6. Excess water has been used by some cleanup personnel to create overtime.

Wastewater Characteristics

The amount of waste produced per bird is dependent upon the technology within the plant. The Gold Kist plant in 1969 was using a "typical technology" which included recovery of some of the blood from the killing room, a wet flow-away system and a wet cleanup of the plant.

Table 9. BENCHMARK WATER USE FOR GOLD KIST POULTRY PROCESSING PLANT, DURHAM, N. C., 1969.

Process	Source	Flow Rate (GPM)	Volume (GPD)
Scalder	Potable	38.7	20,898
Pickers	Potable	38.0	20,520
Feather Flume	Potable	94.3	50,922
Whole Bird Washers	Potable	37.3	20,142
"Hand-Back" Belt	Potable	9.1	4,914
Eviscerating Trough			
a. Hand Wash Outlets	Potable	285.0	153,900
b. Side Pan Wash	Potable	90.0	48,600
Final Bird Washers	Potable	100.0	54,000
Lung Vacuum Pump Effl.	Potable	14.2	7,668
Gizzard Machine and Giblet Flumes	Potable	360.0	194,400
Giblet Chiller	Potable & Ice	4.5	2,430
Neck Cutter	Potable	4.0	2,160
Chillers	Potable	72.1	38,934
Packing Ice	Ice	15 lbs/box	6,111
Bird Pickup	Potable	--	8,640
Cleanup Hose Stations	Potable	--	9,760
Total use in processing		--	643,990
Clean-up		--	112,000
Undetermined use		--	94,010
Average use per day			850,000

The flow-away system uses a water stream to transport dirt, blood, feathers and parts. The larger solid particles are separated from the waste flow by screens. Cleanup, chilling and packing waters are also passed through screens before discharge to the municipal system.

Process water samples were collected at 11 points, Appendix C, Table 2. Samples were taken from the scalder vat at both the points where birds enter and exit because water overflows at each point. The giblet chiller was sampled where the water overflowed. Chiller I represents the prechiller overflow and Chiller II the final chiller effluent. Feather and eviscerating flume samples were taken following the vibrating screens following by-product separation. The first seven sampling points involve wastewater from selected processes in the plant. The feather flume and eviscerating flume wastewater are the two major flows of wastewater from the plant and are combined in the final plant effluent. The feather flume wastewaters consist of fresh water (94 GPM), chiller effluent (54 GPM), and recirculated eviscerating flume wastewater (112 GPM), final bird wash water (100 GPM), and scalder wastewater (39 GPM). The eviscerating flume wastewaters consist of wastewater from the eviscerating trough including handwash outlets (285 GPM) side pan wash (90 GPM), gizzard splitters and giblet flume (360 GPM) and wash down from packing room. Characteristics of these and other wastewater flows are detailed in Tables 10 and 11.

Microbiological

The range, median and mean total counts and coliform counts for the different samples taken at various processing points are shown in Figures 6, 7, 8 and 9. These tables also show the number of times samples were collected and the number of replicates obtained at each sampling. The range and median counts for the different type samples are shown graphically; water samples (Figure 6), carcasses (Figure 7), swab samples (Figure 8), and giblet samples (Figure 9). Vertical lines on these graphs represent the range of counts. Lines connecting the median counts were drawn.

The median total count in water decreased from a high of $2x10^6$/ml of scald water (Point A) to $3.3x10^3$ and $3.4x10^3$/ml of chill water at Points E and F (Figure 6). The high count in the scald water might be expected due to the high levels of microorganisms in soil, fecal material and other debris in the feathers and feet of the freshly killed birds. Water contacting the carcasses at Point B generally had less than 1% of the total count in the scald water. Note, however, that the coliform count was slightly higher in water at Point B than at Point D. The coliform count in the scald water was only 0.02% of the total count. This may simply reflect the relative percentage of

Table 10. BENCHMARK WASTEWATER CHARACTERISTICS, GOLD KIST PLANT, DURHAM, N. C., 1969

Sampling point	BOD_5	COD	Solids: Total	Solids: Dissolved	Solids: Suspended	Grease
			(mg/l)			
Process						
Scalder Vat Entry	1,180	2,080	1,870	1,190	687	350
Scalder Vat Exit	490	986	1,050	580	473	200
Whole Bird Wash	108	243	266	185	81	150
Final Bird Wash	442	662	667	386	281	580
Giblet Chiller	2,360	3,959	2,880	1,900	976	1,320
Chiller I	442	692	776	523	253	800
Chiller II	320	435	514	331	183	250
Major Flows						
Feather Flume	590	1,080	894	382	512	120
Eviscerating Flume	233	514	534	232	302	430
Plant Effluent	560	722	697	322	375	150
			(lb/day)			
Waste Load						
Plant	3,970	5,118	4,941	2,283	2,658	1,063

Table 11. SELECTED WASTEWATER CHARACTERISTICS

Sample	BOD_5 (mg/1)	COD (mg/1)	Settleable Solids (% volume)	NH_3-N (mg/1)	NO_3-N (mg/1)	NO_2N (mg/1)	PO_4P (mg/1)	Alky. (mg/1)	Cl. (mg/1)
Feather Flume	--	--	0.2	12.5	5	0.02	9.5	160	49.63
" "	450	1100	0.2	14	3.5	0.06	11	88	55.6
" "	440	1440	0.25	12.8	1	0.03	15	120	50.2
" "	560	--	0.2	--	--	--	11	138	52.0
" "	580	2000	0.18	14.5	--	--	10	--	--
" "	400	980	0.2	15	4	--	--	--	--
" "	450	1160	--	--	--	--	--	--	--
Evisc. Flume	100	350	--	3.2	1	--	1	--	--
" "	160	200	0.05	4	--	--	2	--	--
" "	120	200	0.08	3	--	--	9	--	--
Feather Flume	--	1400	0.25	--	--	--	24	--	--
Evisc. Flume	100	--	--	2	--	--	4	45.2	27.9
" "	150	390	--	1	--	--	1.2	--	--
" "	170	440	--	--	--	--	1.8	40	29.7

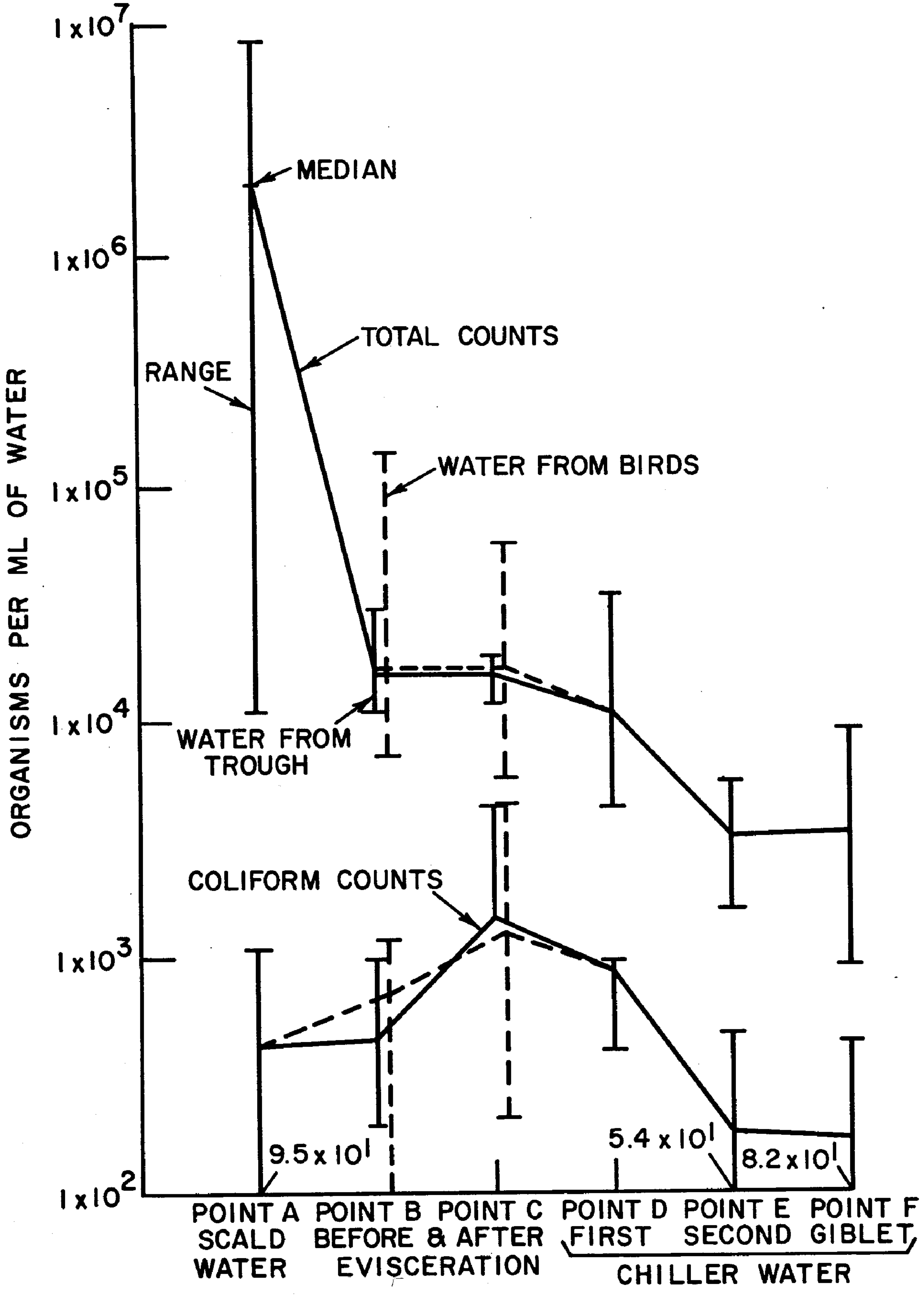


Figure 6. Total and coliform counts in water at various processing points

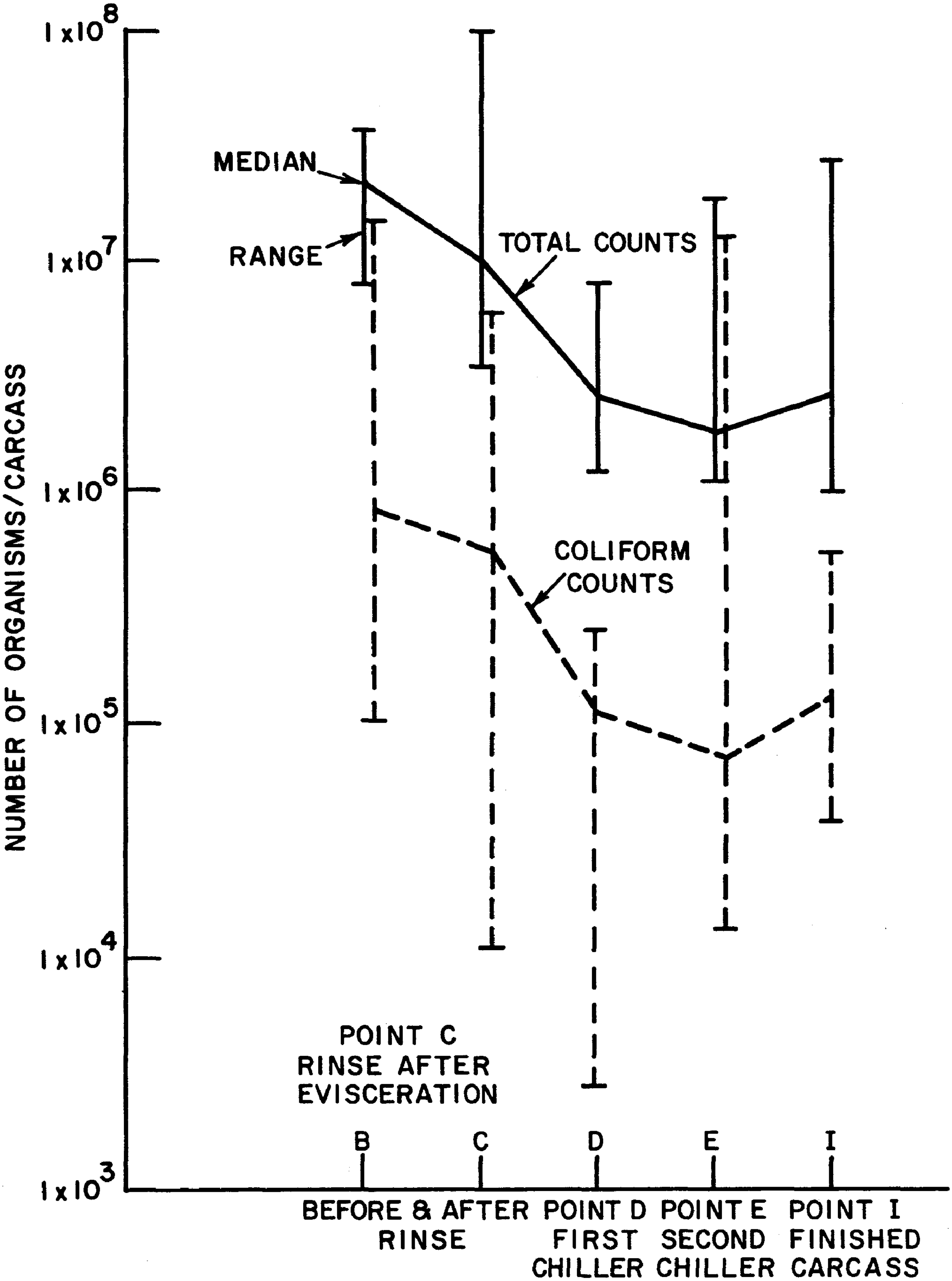


Figure 7. Total and coliform counts on carcasses at various processing points

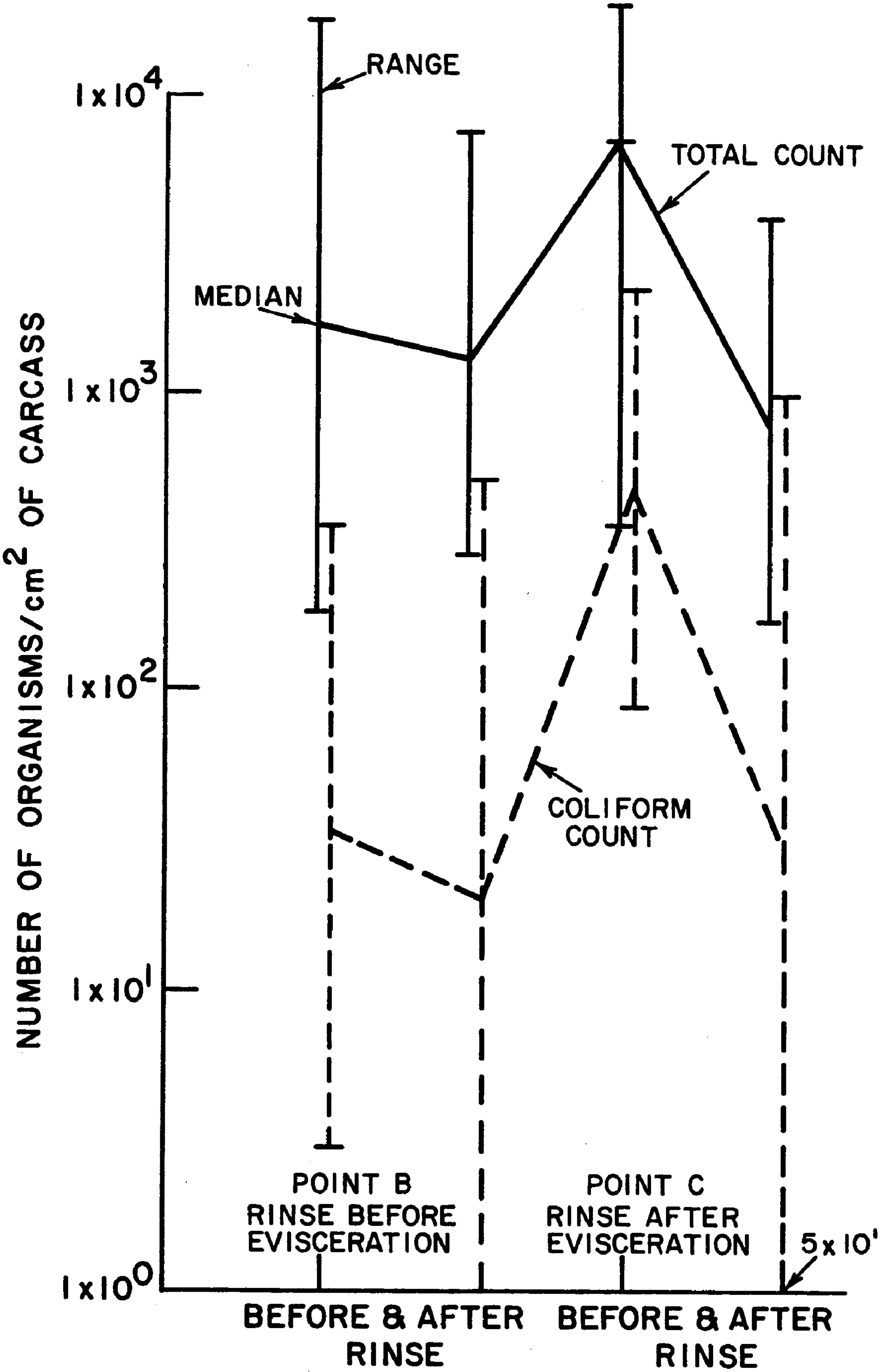


Figure 8. Total and coliform counts as determined by swab technique

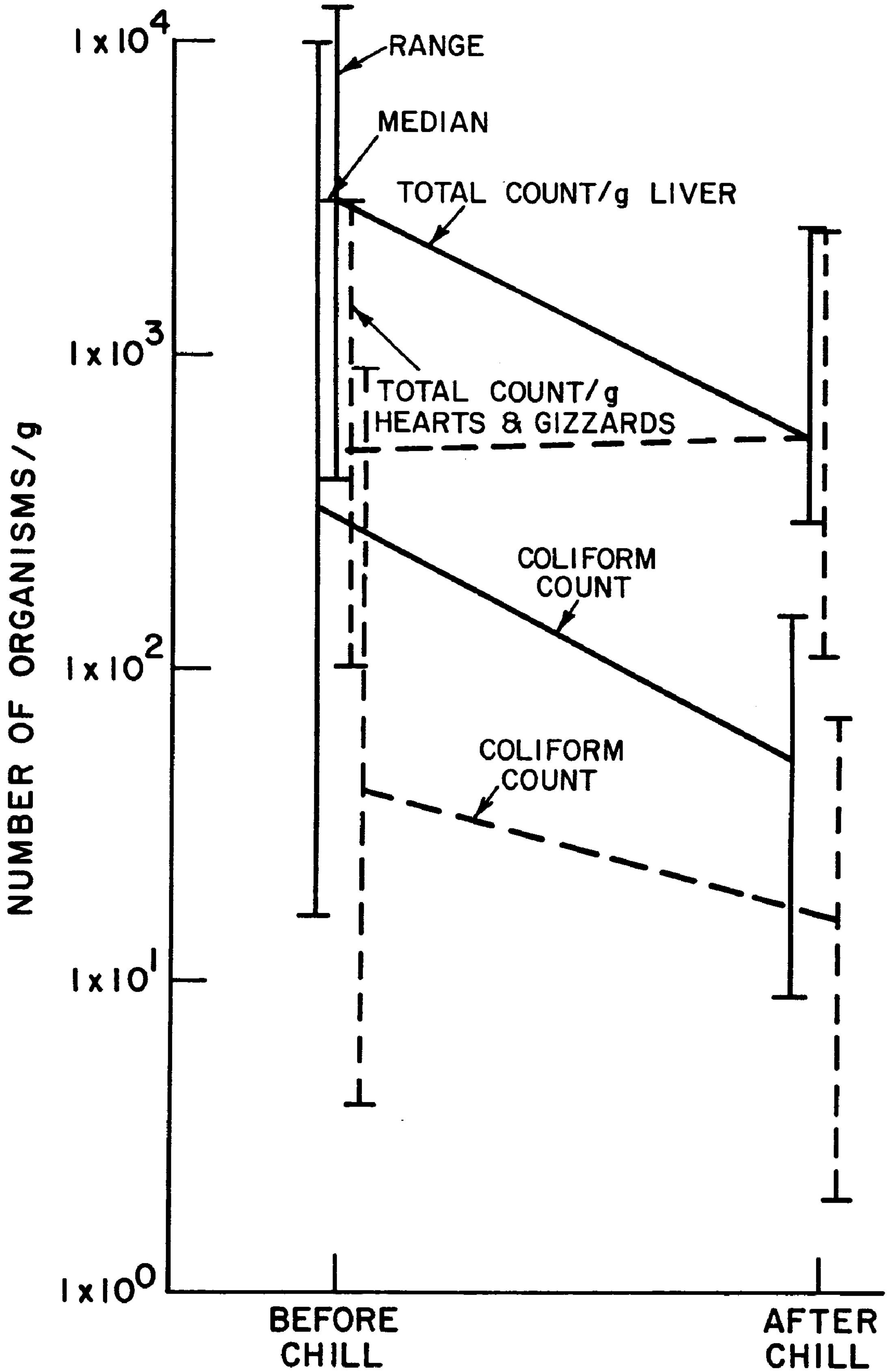


Figure 9. Total and coliform counts on giblets before and after chill

coliforms to other organisms which enter the scald tank on the carcasses. Also, it may mean that the coliform count was initially higher than what was measured in water collected at the exit point and that some coliforms were killed by the temperature (ca. 125°F) of the scald water. There was little difference in total counts in water at Points B and C. However, the coliform counts at Point C were nearly twice as high as at Point B. This increase in coliform counts is no doubt related to the evisceration process. Two types of water samples were collected at Points B and C (Water from Birds and Water from Trough). Only three Water from Trough samples have been collected and more samples are needed to establish more meaningful microbial levels. However, the levels in the two types of samples appear to be nearly the same.

Total and coliform counts per carcass decreased as the carcasses advanced through the various processing stages (from before rinse at Point C to after chill at Point E) (Figure 7). Based on the median counts, total and coliform counts per carcass were reduced by more than 90% between these two processing points. The counts for the finished carcass (Point I) were higher than at Point E. The finished carcasses contained giblets, thus, organisms added with the giblets plus those added by handling of the carcasses between Points E and I could account for the increased counts.

Total and coliform counts/cm^2 of carcass, as measured by the cotton swab technique, decreased slightly from before rinse to after rinse at Point B (Figure 8). Both sets of counts increased, probably as a result of contamination during evisceration, between Point B (after rinse) and Point C (before rinse). After rinse at Point C, however, both the total and coliform counts/cm^2 were reduced to levels comparable to those at Point B.

Total and coliform counts of livers were less after chill than before chill (Figure 9). Coliform counts of hearts and gizzards also were lower after chill, although total counts were essentially the same on these samples before and after chill.

Salmonella was detected on 9 of 23 finished carcasses examined.

Waste Load

The total average daily BOD_5 load during the benchmark observations was 3,970 lbs/day. The COD discharged equalled 5,118 lbs/day while the grease discharge level was 1,063 lbs/day. Attempts to equate the respective unit processes with their waste load were not satisfactory due to the daily variation, the location of discharges, difficulties in sampling and the combined sewers. However, Table 12 provides some

Table 12. SELECTED DAILY PROCESS WASTE LOADS

Process	Waste Load (lbs BOD_5/day)
Scalder	145
Whole Bird Washer	18
Final Bird Washer	199
Giblet Chiller	48
Chillers	143

average relative unit process loads that should be used with caution because of the uncertainty associated with the individual unit processes. Over 51% of the total BOD_5 load was determined to originate either in the blood collection tunnel, in clean-up operations, or in other miscellaneous activities. A large contributor observed but not detailed was the truck drains on the offal trucks. Especially when the lung tanks were emptied was highly concentrated wastewater containing blood and other solubles released.

Operating Characteristics

A summarization of water use, waste load and production data is compiled in Table 13. Production, water use and wastes are averaged for results obtained during an approximately 90 day period beginning in July of 1969. An average of 12.28 gallons of potable water was used for each broiler received and the average BOD_5 load was 15.72 lbs/1000 lb LW.

The production is indicated by mean broiler receipts of 69,200 per day. Live weight of these broilers was 3.65 lb. The mean hours of payroll time worked was 9.48 hours/day.

Water use and wastes varied widely from day to day. However, the means established indicate an approximate benchmark for comparison with operating characteristics after changes. The Durham plant was known to be very similar to other poultry processing plants.

Water and sewer costs averaged $4.92/1000 birds received as shown in Table 13. If the city of Durham had their surcharge in effect the water, sewer and surcharge would have totaled $9.56/1000 birds received. One must note that all water use, waste and costs are detailed on birds received and not on birds sold. This was due to company recordkeeping procedures. By-product sales averaged $7.38/1000 broilers received.

Table 13. BENCHMARK OPERATING CHARACTERISTICS

Production		69,200 broilers/day (Received) -- broilers/day (Packed)		
		LW 3.65 lb KW 2.70 lb 9.48 hours/day (Mean)		
Water Use		3,365 gallons/1000 lb LW 4,549 gallons/1000 lb KW 12.28 gallons/broiler		
Wastes		lbs/1000 lb		Total Load
		(KW)	(LW)	(lb/day)
BOD		21.24	15.72	3970
COD		27.39	20.26	5118
Solids	Total	26.44	19.56	4941
	Dissolved	12.22	9.04	2283
	Suspended	14.23	10.52	2658
Grease		5.69	4.21	1063
Monthly Costs/Revenues				
Water and Sewer Costs		$ 6,954.	$4.92/1000 birds	
By-product sales*		$10,950.	$7.38/1000 birds	

* August, September

SECTION V

PROCESS CHANGES AND EVALUATION

INTRODUCTION

A necessary consideration in the development of water conserving and waste reducing practices was that the quality of the finished product must not be lowered. During the benchmark study, many of the unit processes were found to be inefficient in the use of water and the recovery of waste. Water use and waste reduction aspects of each operation were evaluated separately because of the variation in circumstances and factors affecting use and waste recovery.

Research and development efforts focused on the modification of in-plant processes and equipments. The "Gold Kist" plant was used as a "laboratory in action." Each process was examined to determine the way in which water was used and waste was generated. Modifications were made to increase the efficiency of water use or to reduce the waste load from the process. Additional benefits were expected in the form of reduced labor requirements, increased efficiencies of pretreatment and conditioning processes such as screening, settling and flotation, lowered chemical use in the form of cleaners and sanitizers and reduced down time.

The amount of water used and waste produced in processing a given number of birds can be generalized as follows:

$$WU = f\ (LS, PP, PM, SR, WP)$$

$$WL = f\ (WU, PP, PM)$$

WHERE: WU = Quantity of water LS = Line speed

PP = Production processes PM = Product mix

SR = Sanitation requirements WL = Quantity of waste

WP = Water pressure

The number of birds processed in a given time period is determined by the speed of the line and the efficiency of the line. An upper limit of the line speed is provided by the design capacity of the plant and the number of inspectors on duty. (USDA-APHIS regulations limit the number of inspections per inspector per time period).

Production processes were found to vary in water requirements per unit of time and in the waste load discharged into the plant wastewater system. Opportunities explored for water and waste management included new and modified in-plant equipment and processes, pretreatment of wastewaters and wastewater treatment. Most traditional production techniques were known not to be compatible with economic water and waste management. These management techniques were also modified to achieve water use reductions and waste load reductions.

Optimum water use is influenced by sanitation requirements in processing, packaging and shipping the poultry product. Regulations enforced by the USDA limit the reuse or continued use of water in most poultry processes.

The product mix of most poultry processing plants is changing rapidly. There has been a continued expansion of cut-up, pre-cooking and prepackaging operations which concentrate more operations at the processing plant.

This section contains a discussion of the problems of water and waste management for the several operating areas in the plant. Specific changes are outlined and described in detail. Specific changes may not be applicable to every plant but each should attempt to attack each problem area. Water use will be curtailed and waste loads decreased if the changes are followed.

A most critical aspect of any in-plant process changes is the understanding of the line foreman and employees of the necessity for the change. The water-waste supervisor is the key to this understanding and to the continued success of any changes.

The discussion of costs and benefits are specific for the research and development activities performed in the Gold Kist plant. Budgets were developed for process and equipment changes made to reduce potable water use and waste loads in the plant effluent. Some processes in the plant were modified to improve waste recovery, lower water requirements and/or reuse process water where feasible and allowed by USDA regulations. In some instances, new equipment was added using commercial equipment. Development of equipment and equipment modifications were required in some processes.

Partial budgets include acquisition, installation and operating costs. Budgets for equipment modifications do not include equipment and operating costs of the equipment already in place, but only those costs affected by the modifications. The cost of equipment developed for the project does not include development costs but only the required materials, installation and operating expenses.

Annual costs include depreciation, maintenance, interest on investment and operating expenses. Straight line depreciation schedules were based on the expected useful life of the equipment. Annual maintenance unless otherwise noted was charged at a rate of ten percent of the materials cost. An interest rate of 7 percent on one-half of the initial costs - materials and installation - was used. Benefits included (1) reduced costs for savings in water, sewer and sewer surcharges, (2) revenues gained from by-product sales of feathers, offal and blood, (3) reduced costs of labor. An overall analysis was made of a summation of the individual process changes to determine the net effect of process and equipment changes on potable water use, waste load and income. A comparative analysis was made of benefits and costs associated with each process change.

PROCESS CHANGES

Solids Removed from Receiving Area and Coops

Problem

Two major problems were found in the receiving area. Large water hoses were used to "sweep" manure, feathers and other trash to drains in the receiving area. As a result of these employees actions, water was being used for a purpose for which it should not have been used and the solids washed to the wastewater system created a major wasteload. The second problem existed with the feathers and manure left in the coops. Citizens around the plant complained of the aesthetic problems associated with feathers leaving the coops during the backhaul to the farms and being deposited in their yards.

Description of Change

The first problem associated with the misuse of water for sweeping was simply one of management inaction. Plans were made and implemented to use stiff bristle brooms and flat shovels to remove the solids from the docks and receiving pads. The solids were shoveled into empty 55 gallon drums and hauled to the sanitary landfill.

Impact

No accurate measurements of water use reductions or waste load reductions were possible due to the frequency of the cleaning cycle and the lack of uniformity of the deposition of the solids. Budgets were not prepared as reasonable estimates of costs and benefits were not feasible.

Description of Change

Feather and manure removal from coops after the birds have been removed was accomplished by passing empty coops through a short wind tunnel as shown in Figure 10. Air is blown directly into the bottom of the coops at a rate equivalent to a sixty mile per hour wind. The heavy solids are set in motion, caught in the lower chamber of the unit, and removed dry at the end of a working period. Light materials such as fine feathers are pulled by suction up to a water spray chamber located on the roof of the building. Within the spray chamber, the feathers are wetted by a baffled arrangment with 5 gallons of water per minute. This small amount of water and solids are then discharged by gravity into the feather flow-away system. The feathers and large solids are passed over the feather screen for removal with the feather from the pickers. Figure 10 highlights design elements of the unit.

Impact

The measurement of the before and after water use and waste load was not possible. Therefore no comparison can be presented. However, it was obvious by observation that the system performed a large part of its task. Further developments are needed to improve the cleaning of the coops.

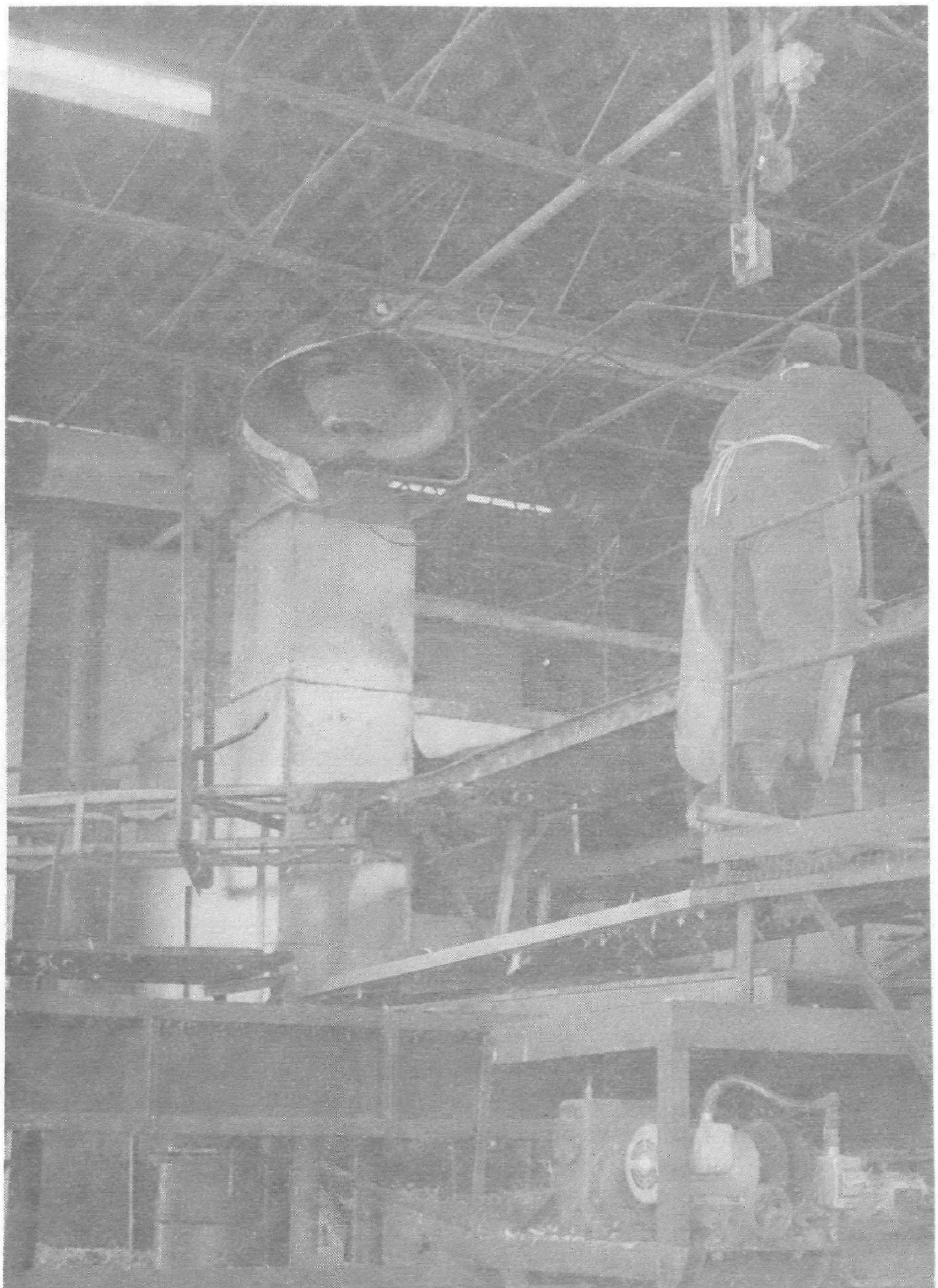


Figure 10. Coop cleaner

Blood Collection

Problem

Blood is the major contributor of BOD from a poultry processing plant. It was pointed out that 40 percent of the BOD will originate in the blood tunnel[8]. This plant as most poultry plants did not have an efficient blood recovery system. Recovered blood can be processed with the offal into poultry feed.

A tile walled, cement floored blood collection room existed. Blood spattered freely on the walls and floor as shown in Figure 11. Clean-up of blood was accomplished at the end of the day by shoveling the blood out a discharge chute to waiting by-products trucks. The blood was dumped on the feathers. Considerable serum and blood solids leaked directly to the floor drains from the truck drains.

Blood before congealing continuously flowed into the floor drains in the blood collection tunnel. The liquid portion (serum) of the blood went down the drain and became a major part of the plant waste load.

Blood was spattered on the birds and adjacent birds after their jugular veins were severed. This is evidenced in Figures 11 and 12. Blood was washed off in the scalder or carried over with the feathers to the feather pickers.

The blood was shoveled and scraped to the discharge chute and floor drains whichever was more conventient. After gross cleaning, hoses and detergents with brushes were used with the resulting blood solids going "down the drain".

The mechanical, automatic killing operation as shown in Figure 13 was often inefficient as problems were presented in the diameter and length of chicken necks, amount of feathers along the neck and the relative position of the main artery to the mechanical automatic, killing machine. Poor adjustment of the cutting blades would allow improperly cut birds so that good bleeding would not be obtained. Feathers caused even the sharpest of blades to do a poor job by preventing accurate cutting on some birds.

Description of Change

The curtailment of the loss of blood into the wastewater system was a major goal of this project. The ineffective cutting and killing machines were modified for more efficient killing. Stunners were installed to quiet the body movement of the cut birds

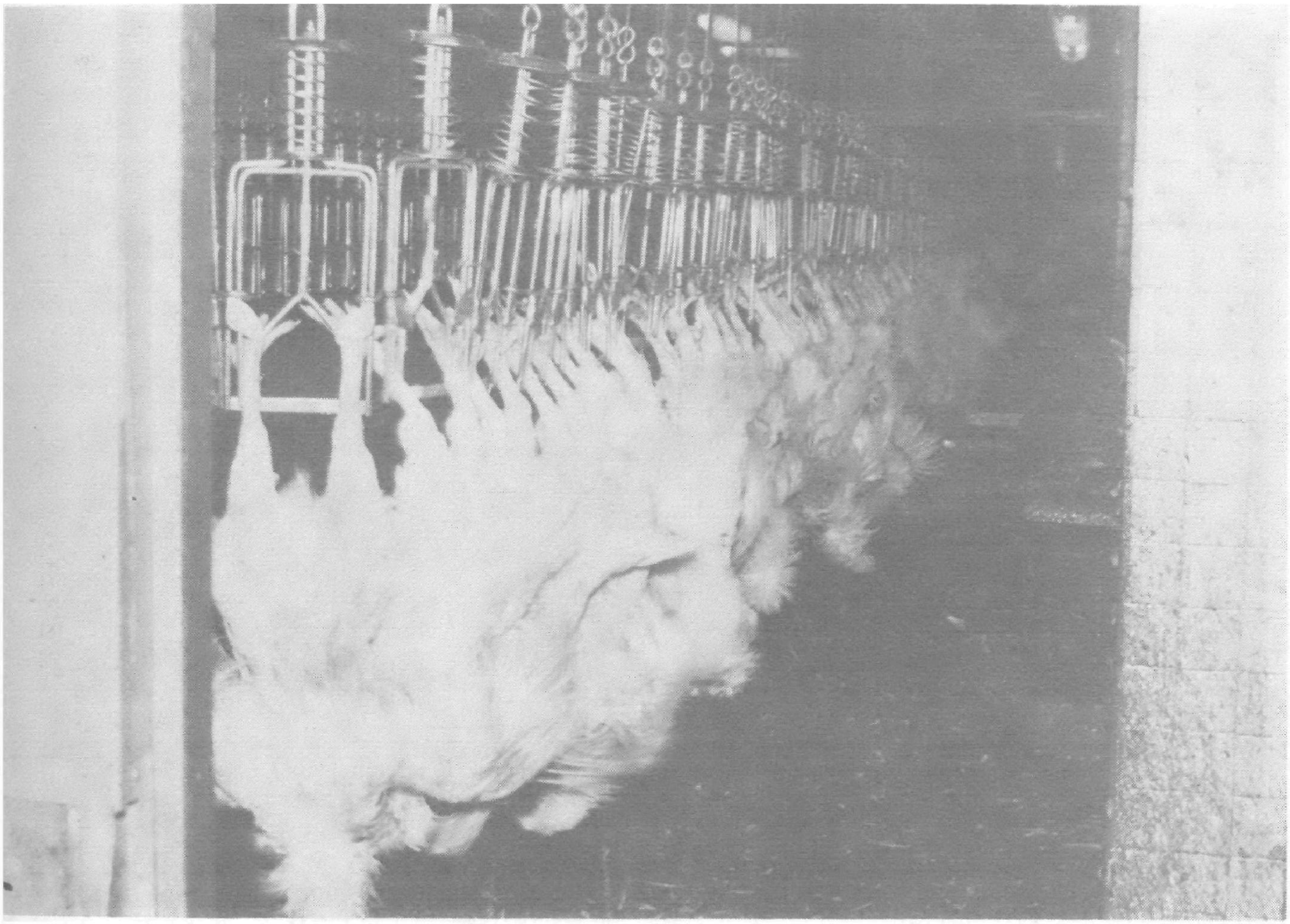


Figure 11. Blood tunnel before changes

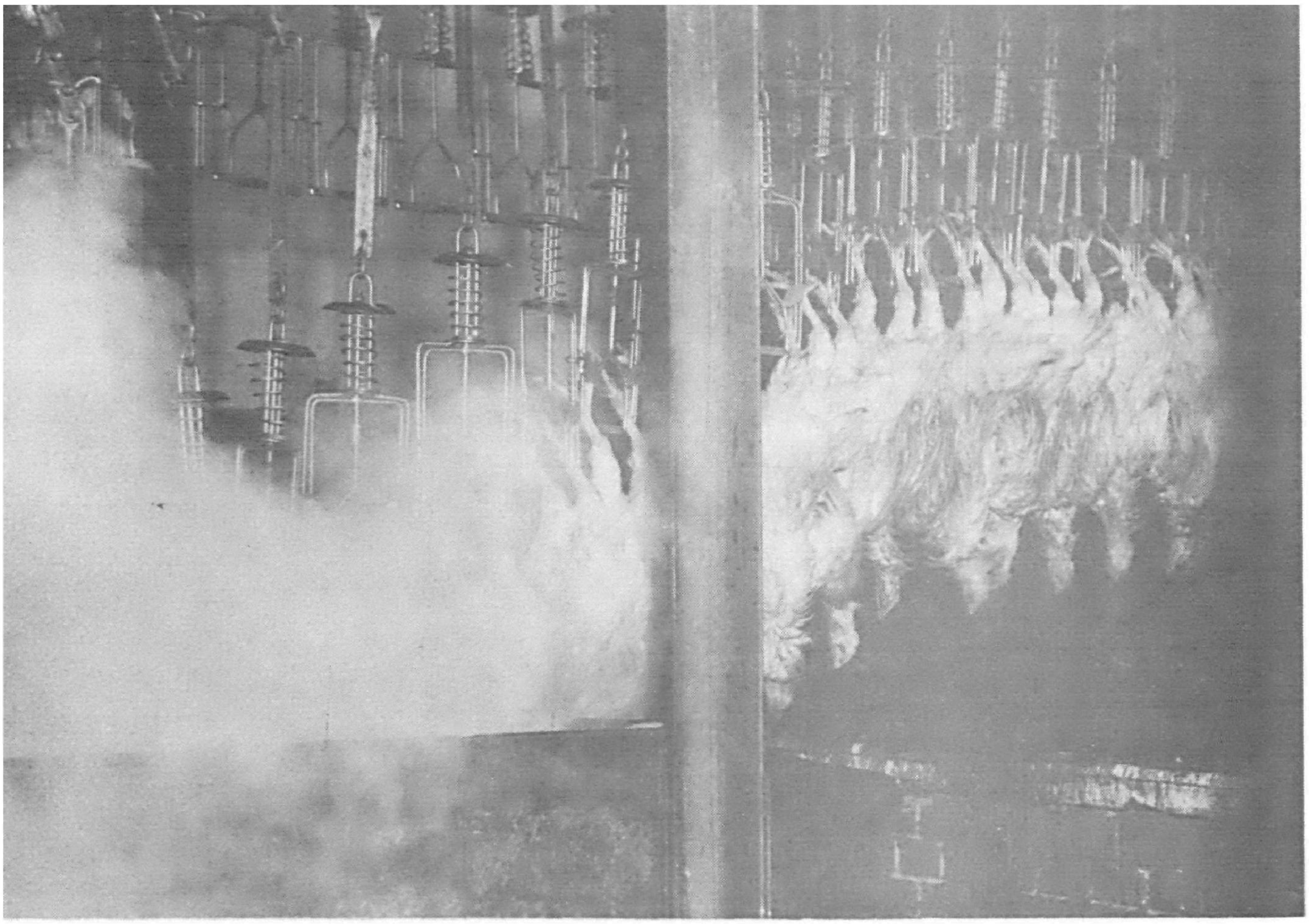


Figure 12. Non-stunned birds entering scalder

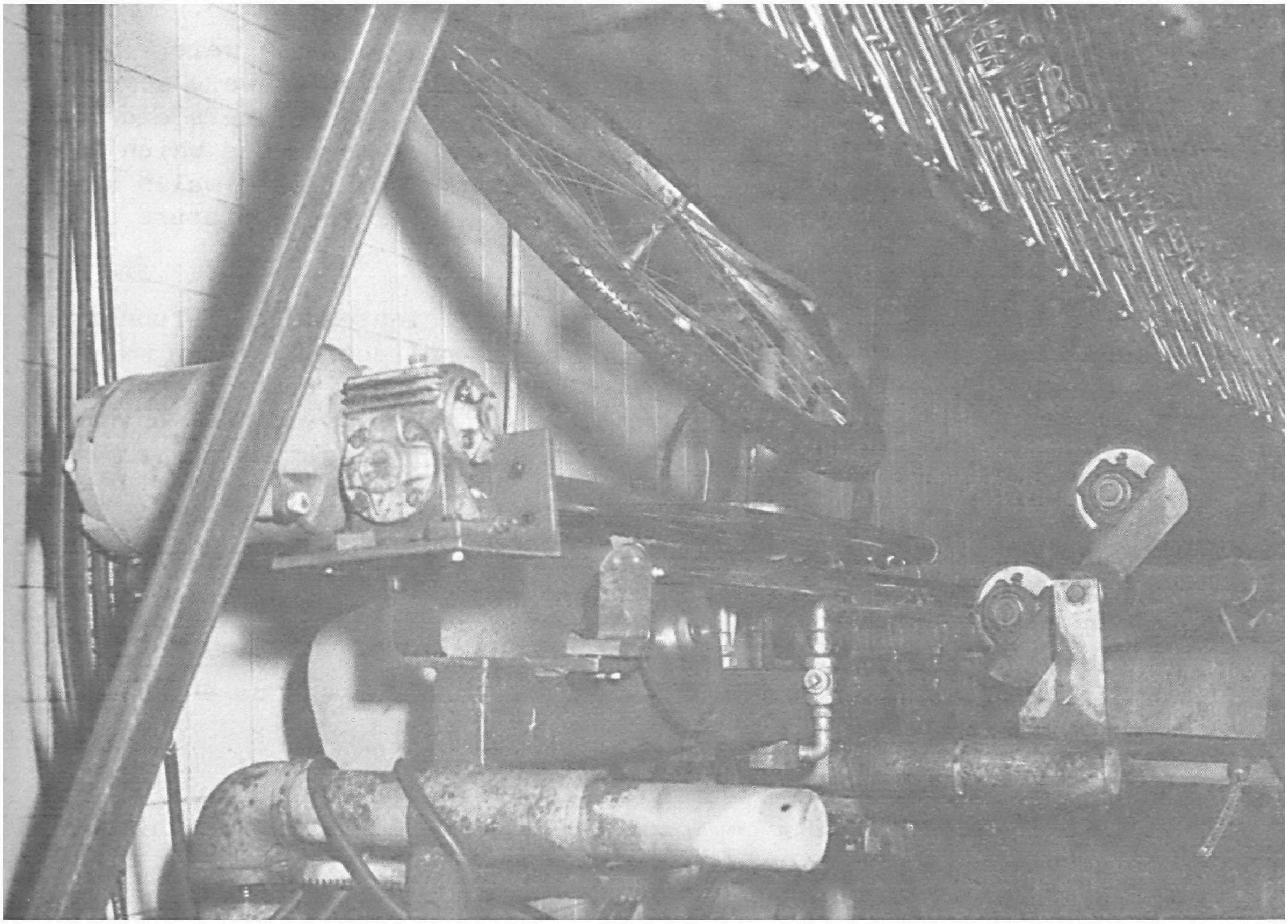


Figure 13. Killing station showing killing machine

scattering blood all over the killing area. A stainless steel trough was fabricated to contain and collect the blood. The trough was connected by direct piping into the by-products truck. Details of each of these changes follow.

The dry feather interference to the efficient use of the automatic cutters was eliminated by applying 2 GPM of water to each of the cutting and killing machines. The water wet the feathers and lubricated the blades for more efficient cutting.

Electrical stunners (General Research Co., Model-Special) were installed to still the birds immediately after the veins were severed in the automatic killing and cutting machine. These stunners did still the birds and thus controlled the wild body movements which had previously spattered blood all over the room on the floor, walls and ceiling. Compare Figure 14 with Figures 11 and 12 for a picture of the dramatic results.

After the killing machines were made more efficient and the stunners installed to control the blood spattering, a collection system was installed to achieve the maximum recovery of blood. This consisted of a blood collecting trough and a piping system to a collection tank on the by-products truck. A stainless steel, sheet metal trough was fabricated as shown in Figure 15 and installed in the blood tunnel. See Figures 14 and 16 to observe the containment of blood in the trough. The trough was connected directly to a collection tank through a gravity 4 inch flexible hose with a quick connect coupling to the collection tank. The collection tank installed on the by-products truck was sufficiently large to contain both the blood from the blood collection tunnel plus the blood and lung tissue from the lung vacuum chamber.

<u>Impact on Water Use</u>

Water use reductions could be accurately estimated for the changes made in the killing and blood tunnel area. Observation of the clean-up of these areas presented the view that much less water was used for only the trough needed extensive cleaning where before the floor, walls and ceiling required extensive cleaning. Water meter readings indicated a reduction in clean-up water of 1,050 gal per day or some 252,000 GPY. The water added to the killers to aid in efficient cutting increased the water consumption by some 4 GPM or a yearly increase of 518,400 gallons.

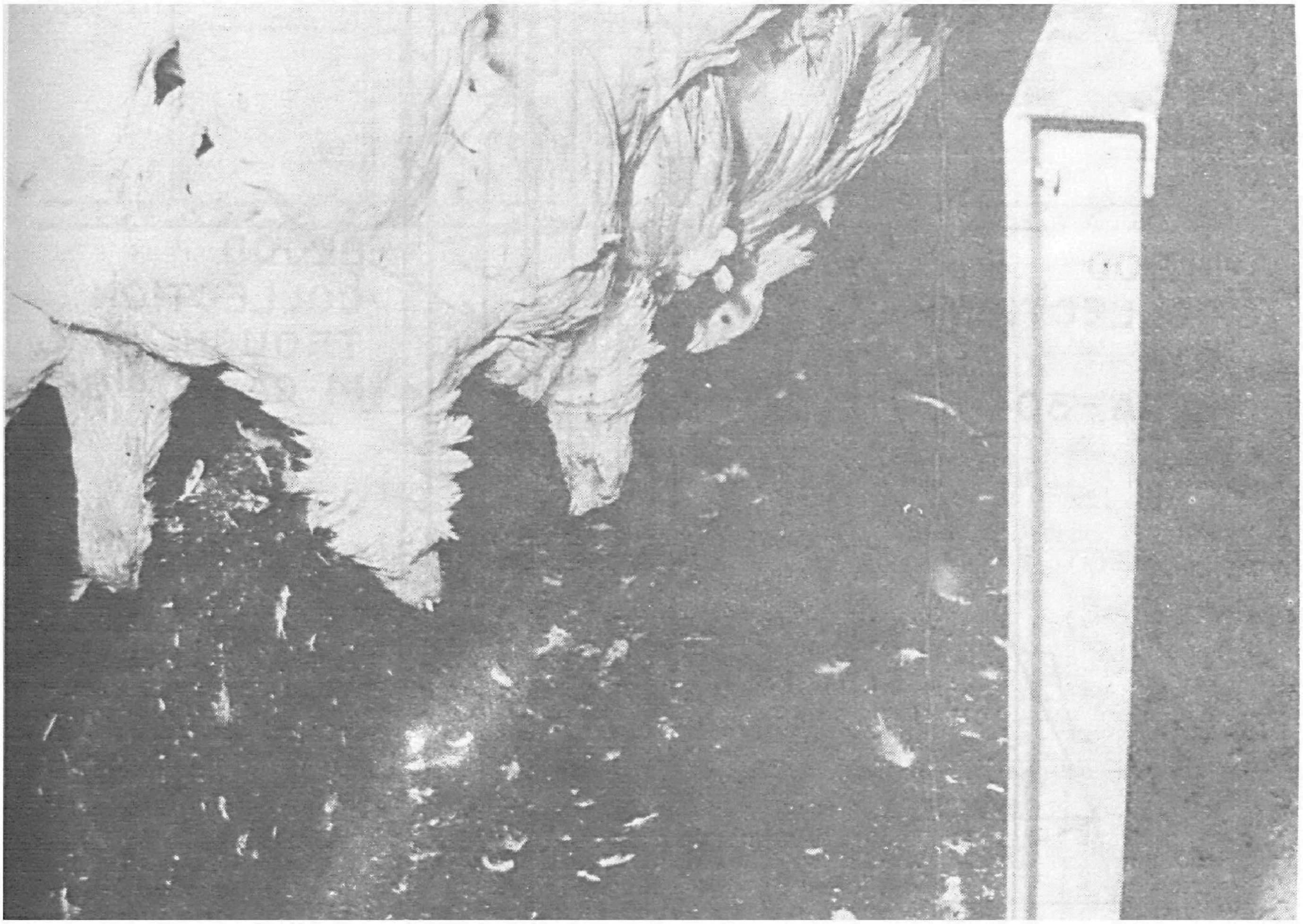
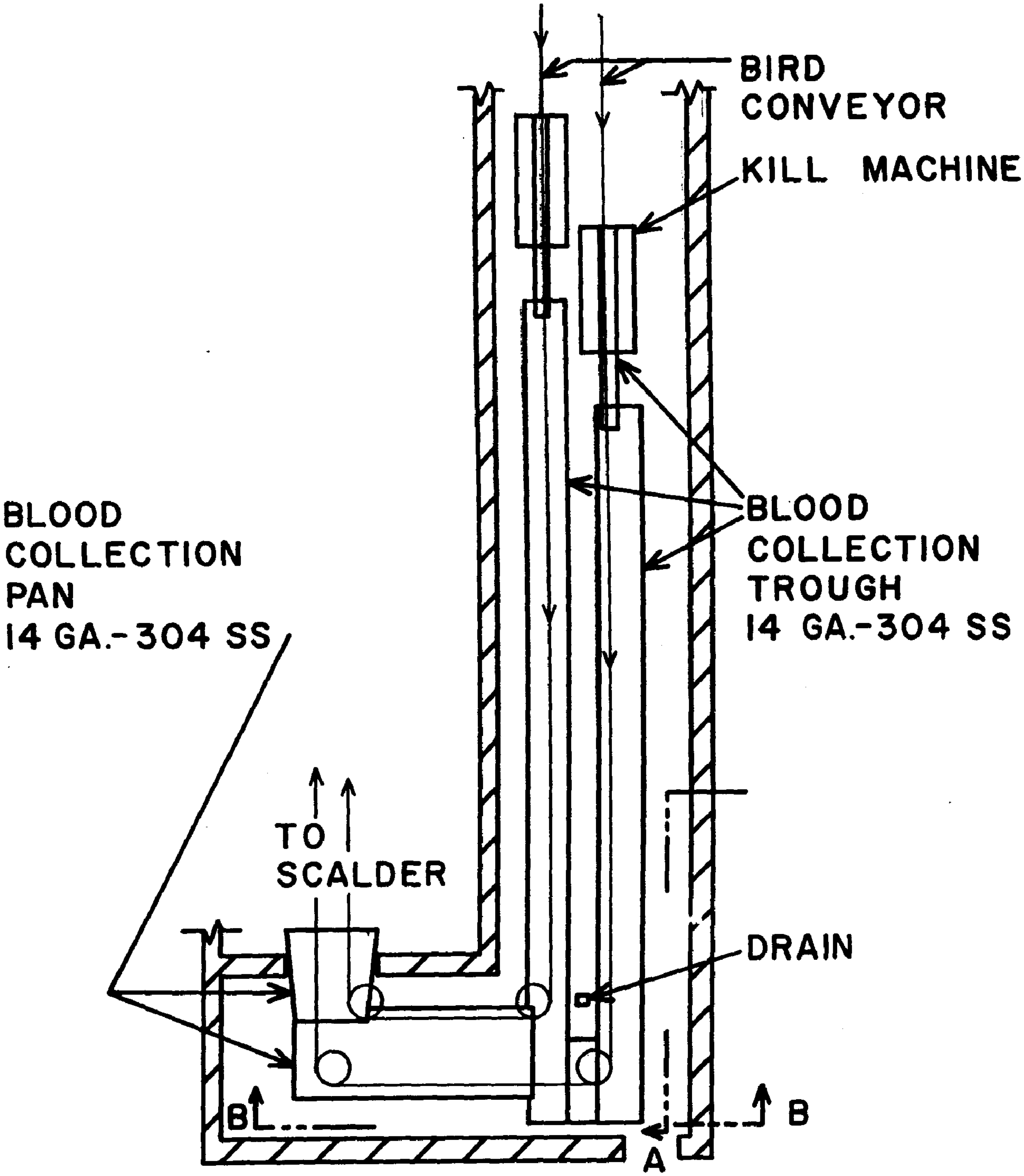
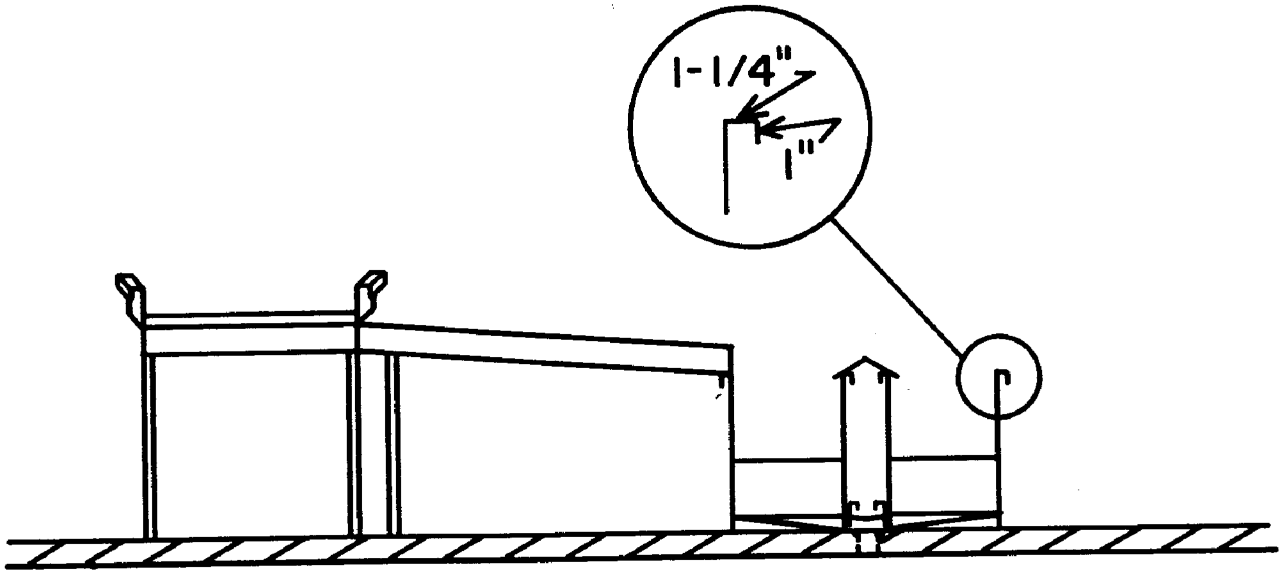


Figure 14. Stunned birds and bleeding trough

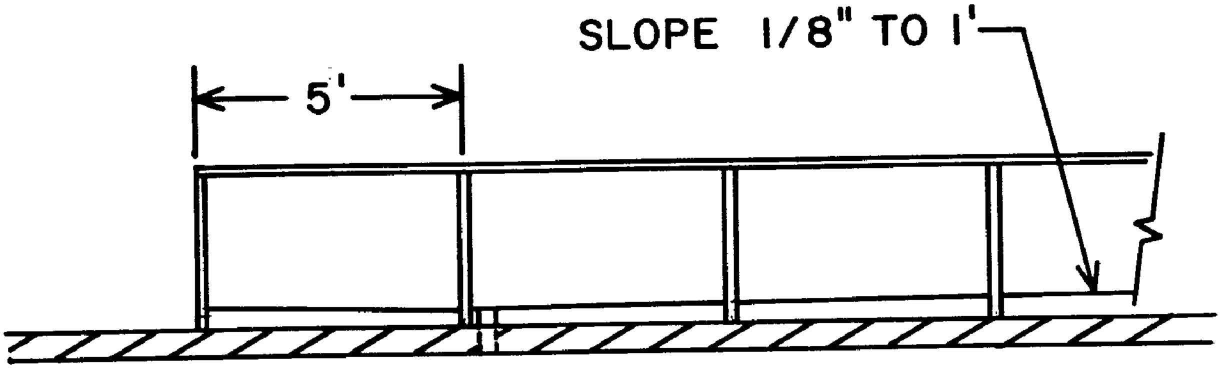


BLOOD COLLECTION SYSTEM

Figure 15. Blood collection system



SECTION B-B



SECTION A-A

Figure 15. Continued

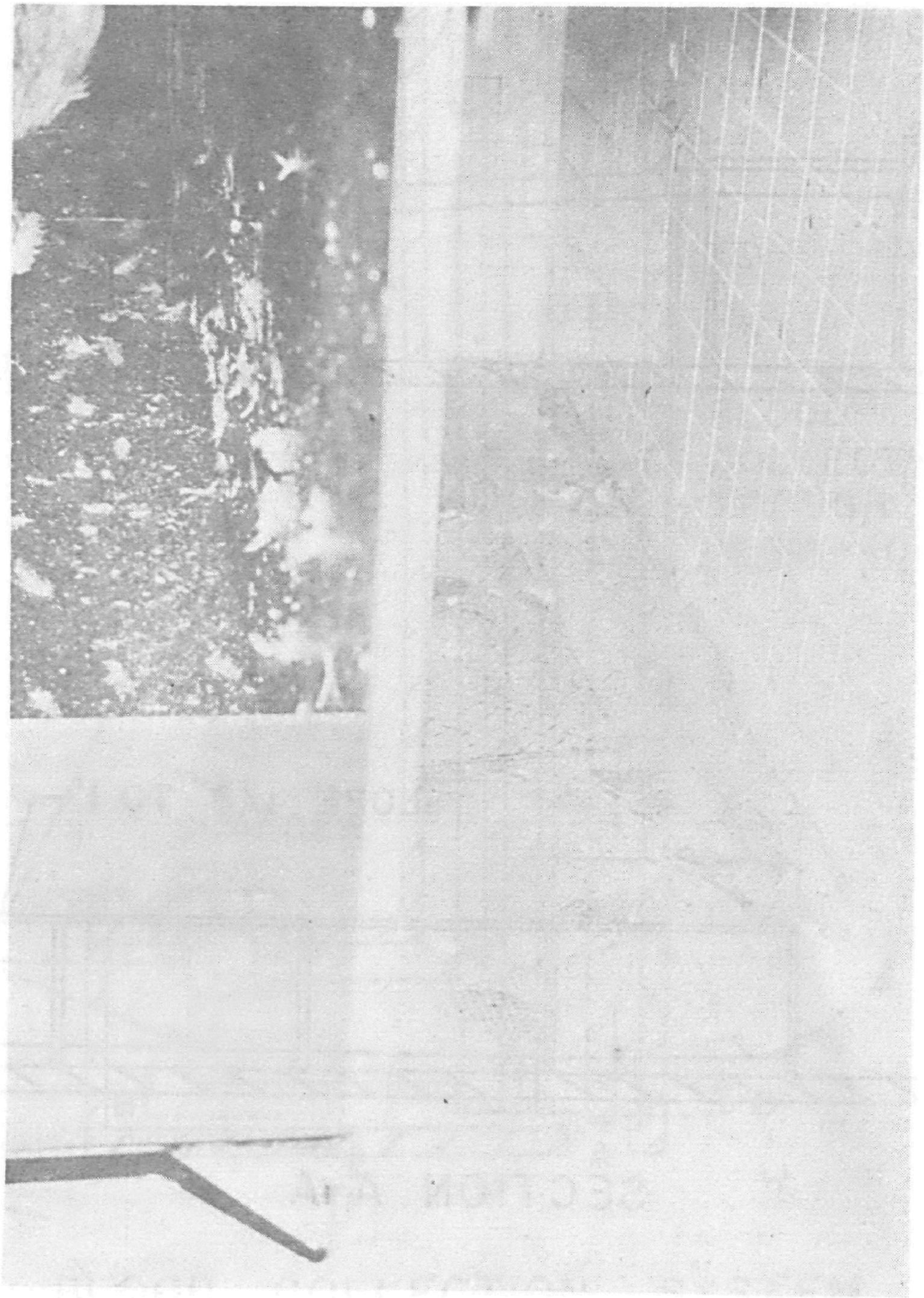


Figure 16. Floor and walls under blood collection trough

Impact on Waste Load

The water flowing to the killing machines discharges into the blood collection system. The blood is diluted but is contained in the blood collection tank. These dilutions of the blood makes the by-product processing of the blood more expensive. The tank installed on the by-products truck to receive the discharge of the blood and lung collection tank prevents much of the loss of blood to the wastewater system. Poultry blood has a BOD_5 of approximately 100,000 mg/l and even small amounts put an increase in the waste load of a poultry processing plant. The advantage of the collection tank is that blood and pieces of solids are not discharged from the by-product truck drains. These drains are left open to let the fluids leave the offal and traditional practice has the collected blood and lungs discharged on the feathers or offal with subsequent draining and eventual discharge. Total collection of blood probably accounts for 18 pounds of BOD_5 per 1000 broilers per day.

Initial Costs and Annual Budget

Costs for improvements in the blood collection area are detailed in Table 14. Major initial cost items included the trough at $5,069. and the stunners at $1,250. each. A net savings per year of $15,742. was earned on an initial investment of only $7,674 (Tables 14, 15). Reduced costs were sewer surcharge and labor savings in the clean-up of the tunnel.

Scalder

Problem

The use of prechiller overflow in the scalder was permitted[23] but was not practiced in this plant. This resulted in the use of some 40 GPM of potable water for the scalder make-up to provide for USDA requirements of a minimum of 1 quart/broiler overflow from the scalder.

Description of Change

A collection chamber of stainless steel with a sanitary pump, valves and tubing allowed a portion of the prechiller overflow to be used for scalder make-up. The collection system was fabricated as shown in Figure 17. The chamber allowed the grease and feathers to float from the surface and the underflow was piped to the scalder. The prechiller overflow was screened before it entered the collection chamber.

Table 14. INITIAL COSTS OF THE BLOOD COLLECTION SYSTEM

Item	Quantity and/or rate	Amount
Material:		$ 5,269.
Stainless steel sheets 2,215 lbs.[a]	$ 2,769.	
Stunners - 2 @ $1,250 each	2,500	
Tax - 2% of material cost		105.
Labor - Approximately 230 hours @ $10/hr.[b]		2,300.
Total Costs		$ 7,674.

[a] The material for the troughs were charged by the pound (@1.25/lb) to Gold Kist.

[b] The cost of labor for making and installing the blood troughs was comprehensively charged to Gold Kist.

Table 15. ANNUAL BUDGET FOR BLOOD COLLECTION SYSTEM

Item	Quantity and/or rate		Amount
Reduced costs:			$ 9,623.
Labor	- 1,560 hrs. @$2.15/hr.[a]	$3,354.	
Chemicals	- 72 gals. @$3.20/gal.[b]	230.	
Surcharge	- $503.22 per month[c]	6,039.	
Increased revenue:			7,791.
Blood	- 400 tons @$19.48/ton		
Total savings per year			$17,414.
Increased costs:			$ 1,672.
Water	- 266,400 gals. @.44/1000 gals.[d]	$117.	
Electricity	- 194.4 KWH @$.009076/KWH[e]	2.	
Maintenance		527.	
Depreciation:			
Stainless steel sheets		277.	
Stunners 100% in 10 years		250.	
Recurring Labor Cost		230.	
Interest on investment 1/2 of initial cost @7%		269.	
Net saving per year			$15,742.

[a] There was a reduction from 10 to 3.5 hours per day for clean-up labor. This savings totals 1,560 hours of labor per year.

[b] An estimate of 10 percent reduction in chemicals used due to the modification. The use of chemicals before the change was 3 gallons per day. This saving of 0.3 gallons per day is multiplied by 240 days per year to obtain 72 gallons per year.

[c] The average monthly surcharge to Gold Kist from July 1970 through November 1970 was $1,188.98. A saving of $503.22 is multiplied by 12 months per year to obtain $6,039 per year.

[d] An increase in water use of some 4 GPM was necessary to aid cutting while water use for clean-up was reduced by 1,050 GPD.

[e] The average rate charged to Gold Kist from October 1969 through March 1970 was $.009076 per kilowatt-hour. Each stunner uses 45 watts per hour.

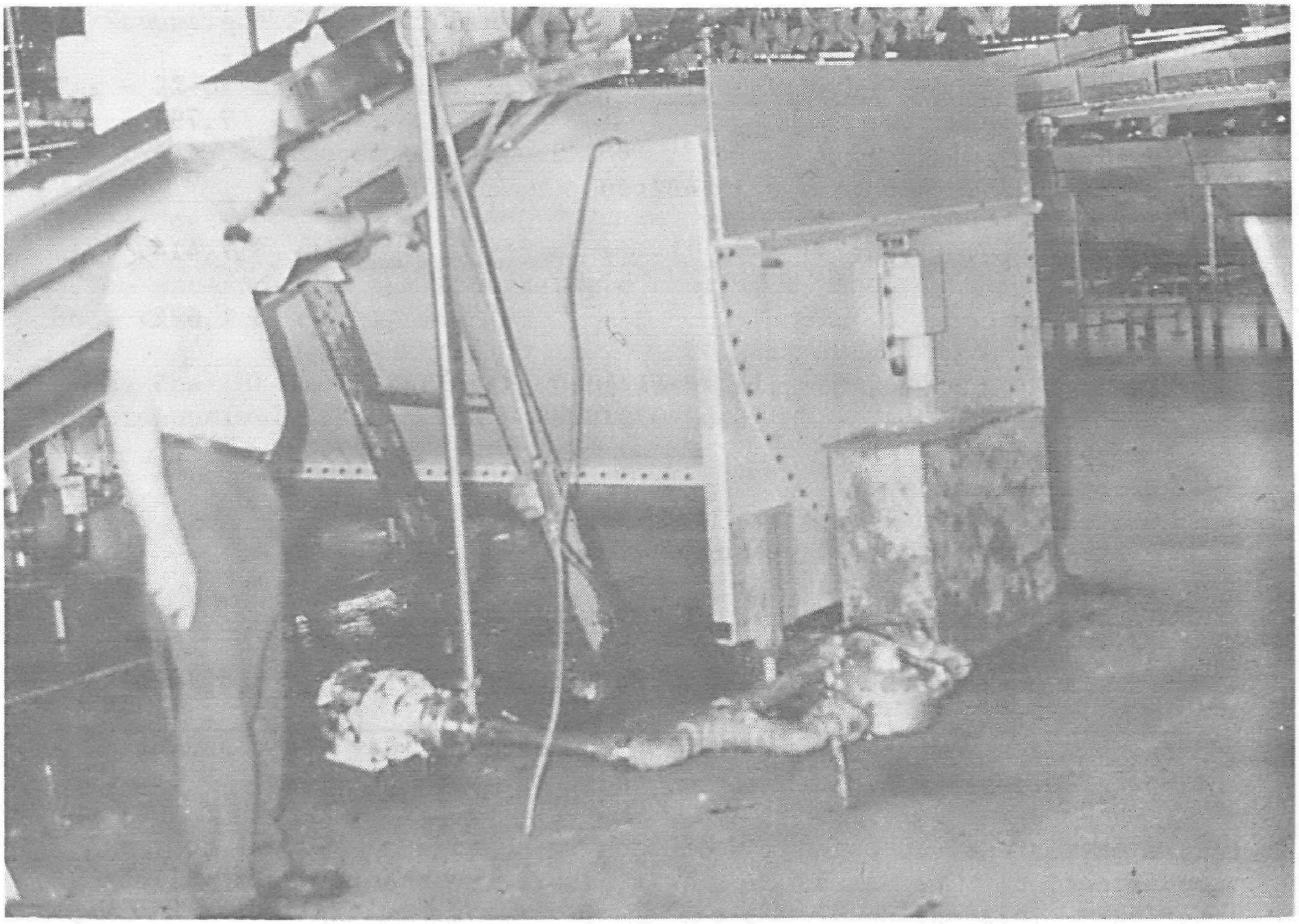


Figure 17. System for utilizing chiller overflow in scalder

Impact on Water Use

Water use was reduced by some 32 GPM (some potable water was added to the tank to keep up the overflow) for 8 hours every day. The reduction in water on an annual basis would be some 3,686,400 gallons.

Also, the scalder overflow was redirected to the feather flowaway system allowing a decrease in potable water use. This is a good example of the continued use of water as the water entered the chiller first; passed through the prechiller, the collection chamber, and the scalder; and was last used to flush feathers down the feather flume.

Initial Costs and Annual Budget

Annual benefits were $445 from the reduction in water of 3,686,400 gallons (Table 17). Reduced purchases of water amounted to $1,622 from an initial investment of $1500 and a yearly cost of $1177. (Tables 16, 17). Better care of the pump to extend its useful life from 1 to 3 years would increase the yearly savings by $319. This may be possible as plant maintenance and clean-up crews become knowledgeable in the care of sanitary pumps.

Defeathering

Problem

After the conditioning of the feathers in the scalding operation, the feathers are removed from the broilers in a series of pickers. The pickers are machines with various arrangements of rotary drums to which are attached rubber fingers (See Figure 18). Problems existed in that the feathers clumped in the pickers, fell to the floor drains, matted and caused the floor drains to overflow on the floor which required the plant to cease operation until the situation was corrected (See Figure 19). These fingers flailed the feathers from the birds. Water was used to lubricate the fingers, wash the feathers from the machines and to prevent clusters in the picker interiors. The irregular flow of feathers from the pickers let feathers accumulate on the floor and the ever present clumping problem in the floor drains required that 4 potable water hoses be used continuously to help assist in feather flushing. A full time man was assigned to police these areas and prevent work stoppages.

Description of Change

Potable water application in the pickers had been done utilizing holes in pipes. The first two pickers on each line were modified by re-piping and the addition of nozzles to reduce the water use and permit a more uniform application. Figure 20 depicts the changes made.

Table 16. INITIAL COSTS OF USING CHILLER WATER OVERFLOW IN THE SCALDER

Item	Quantity and/or rate	Amount
Materials:		$ 1,284.
5 HP stainless steel pump	$478.	
Piping and valves	731.	
Chamber	75.	
Tax:		26.
Labor: 19 hr @ $10/hour		190.
Total Costs		$ 1,500.

Table 17. ANNUAL BUDGET FOR USING CHILLER WATER OVERFLOW IN THE SCALDER

Item	Quantity and/or rate	Amount
Reduced Costs:		$ 1,622.
Water 3,686,400 gal @ $.44/1000 gal[a]		
Increased Costs:		1,177.
Maintenance	$ 76.	
Depreciation		
Valves	140.	
Pump	478.	
Piping	45.	
Chamber	8.	
Interest on investment	52.	
Utilities[b]	78.	
Recurring labor	300.	
Net savings per year		$ 445.

[a] Reduction of 32 GPM for 8 hours each day.

[b] Assumes that the overflow water from the chiller requires no more heat than the incoming city water.

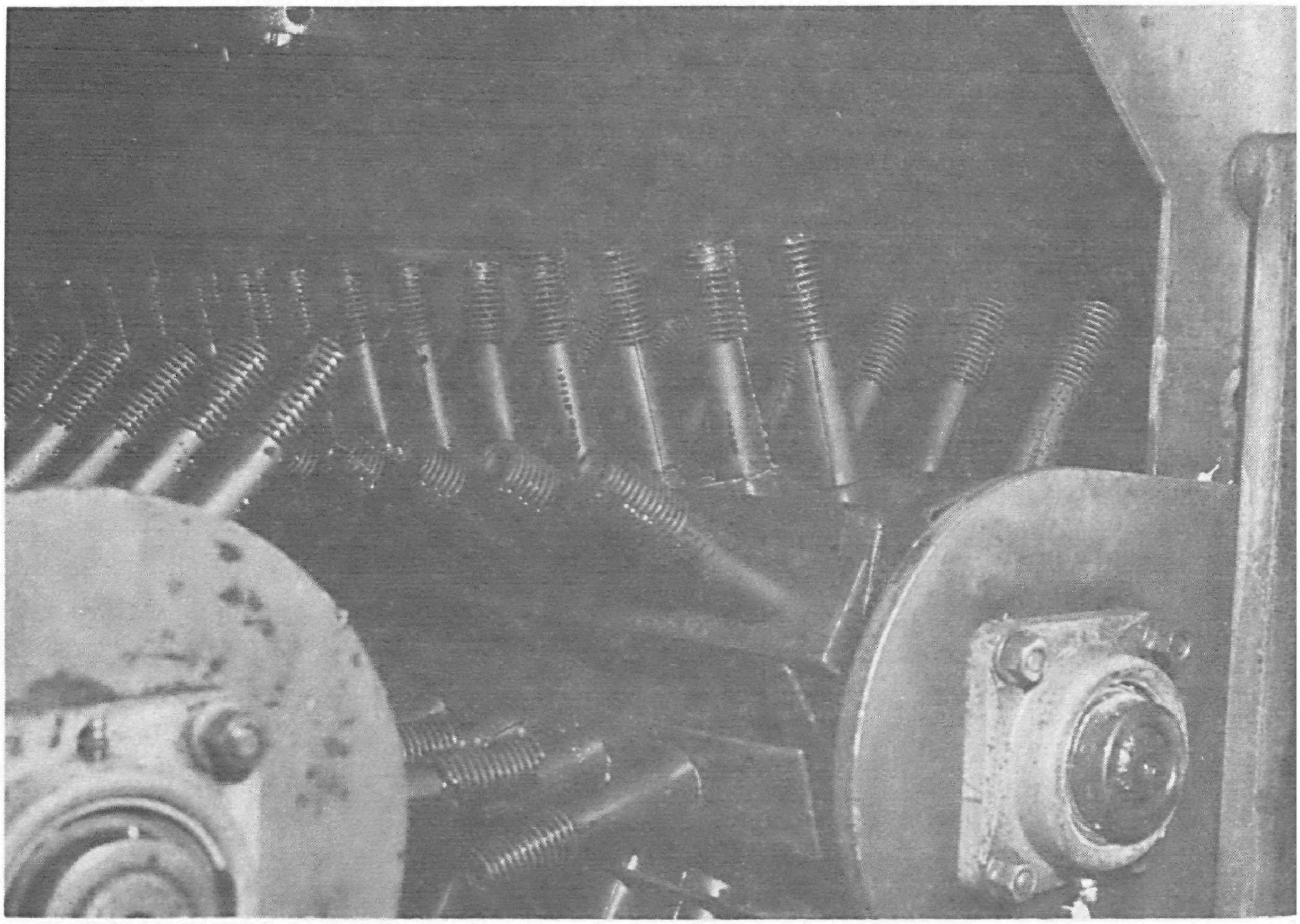


Figure 18. Picker fingers

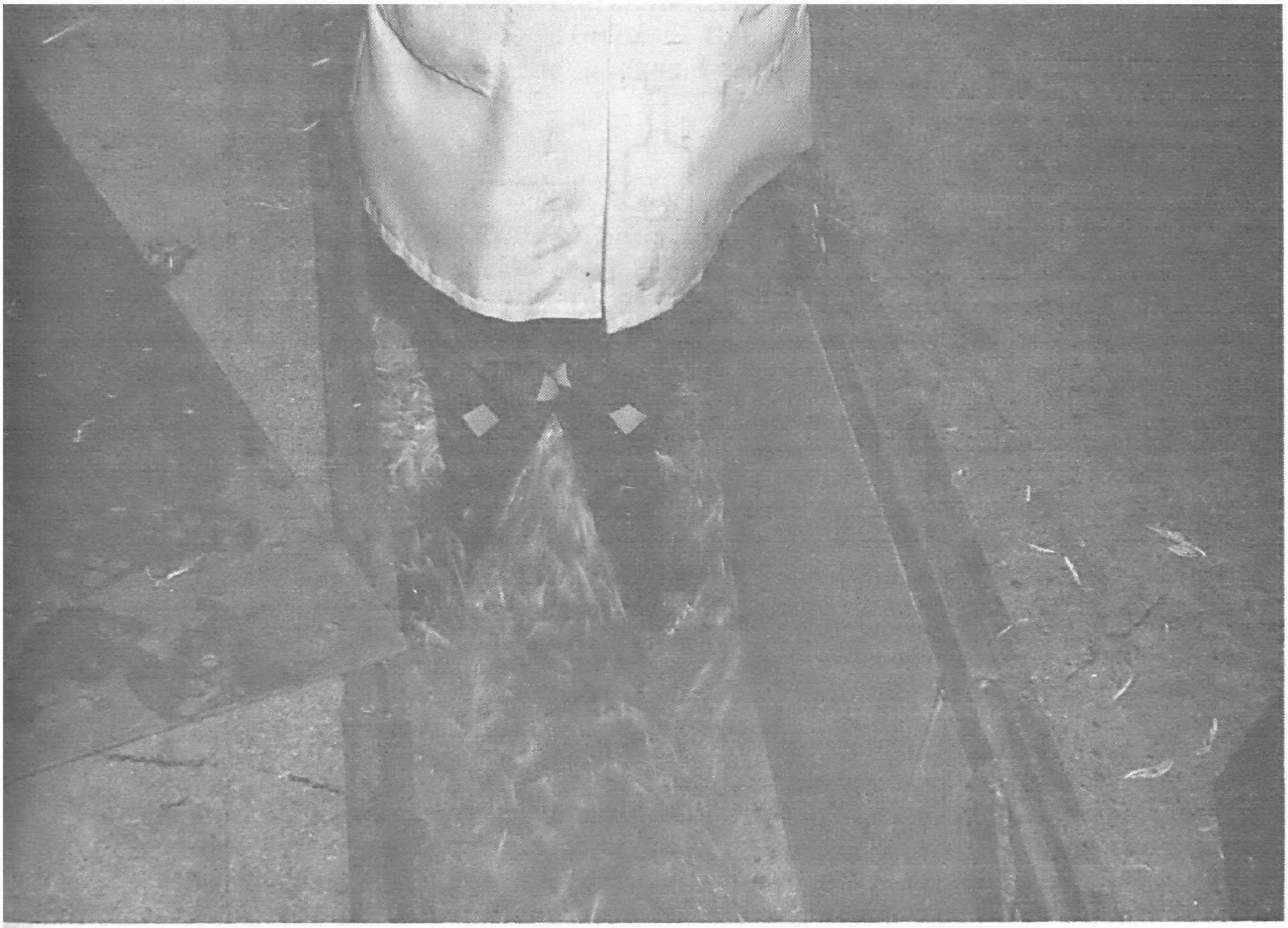


Figure 19. Feather flow-away flume

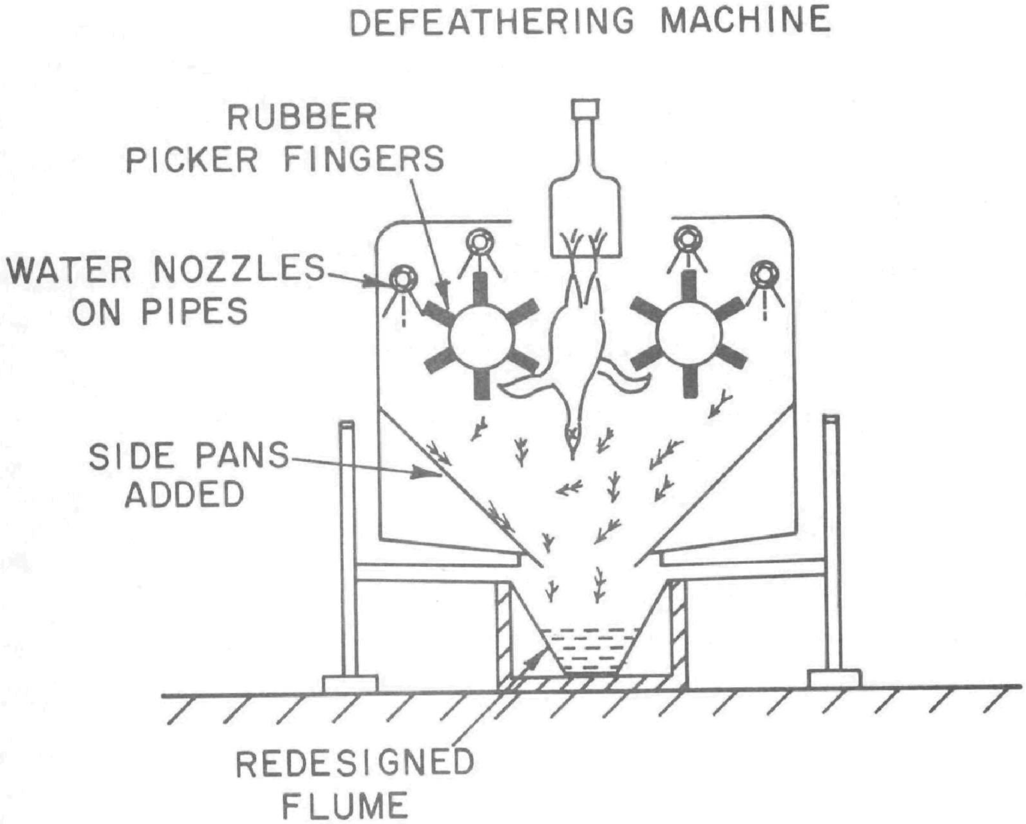


Figure 20. Picker modifications

The Main Picker (head, shoulder and breast) and the body picker (lower body) each had 22 nozzles installed with the water jet oriented horizontal to the picker side wall. Nozzles used were 57° spray angle at 20 psi (Spraying Systems, Inc., Model Vee Jet, Type U - No. 1/8 U 6510) which deliver 0.5 GPM (10 psi) and 0.61 GPM (15 psi) with an equivilent orifice diameter of 5/64". Pressures were regulated to 10-12 psi for operation with a valve - pressure gauge assembly.

The design of the under picker stainless steel flume was modified as shown in Figure 21 to reduce the need for water which was being recirculated from the offal screens. The modification also better directed the feathers from the picker bottoms to the floor flow away drains.

Impact on Water Use

The 4 hoses that had previously been used to assist in feather movement were stopped. The resulting decrease in potable water use was 94 GPM or a yearly savings of 12,221,000 gallons. A considerable labor expense was eliminated as the feathers flowed freely. Work stoppages due to feather clumping almost ceased and had previously been a frequent daily occurance.

Initial costs and Annual Budget

The annual budget for the changes presents an annual savings of some $7,013, Table 19. The initial costs were only $2,123, Table 18. Reduced costs included water savings but labor savings were also a major factor.

Feather Recovery

Problem

Clumped feathers from the feather flow-away drain were discharged on the feather recovery screen (Figure 22). The clumped feathers bulked together caused a flooding over the screens and a subsequent flooding of the offal room. Feathers after screening were discharged into a by-products truck (Figure 23), later to be hauled to the rendering plant. Unfortunately, many feathers got past the screens. Since feathers are long range BOD solids, it is essential that complete removal be made. Feathers were known to be very troublesome to municipal treatment systems[24]. Feathers often clog pumps and since they decompose very slowly, tend to fill up digesters with a subsequent detrimental effect.

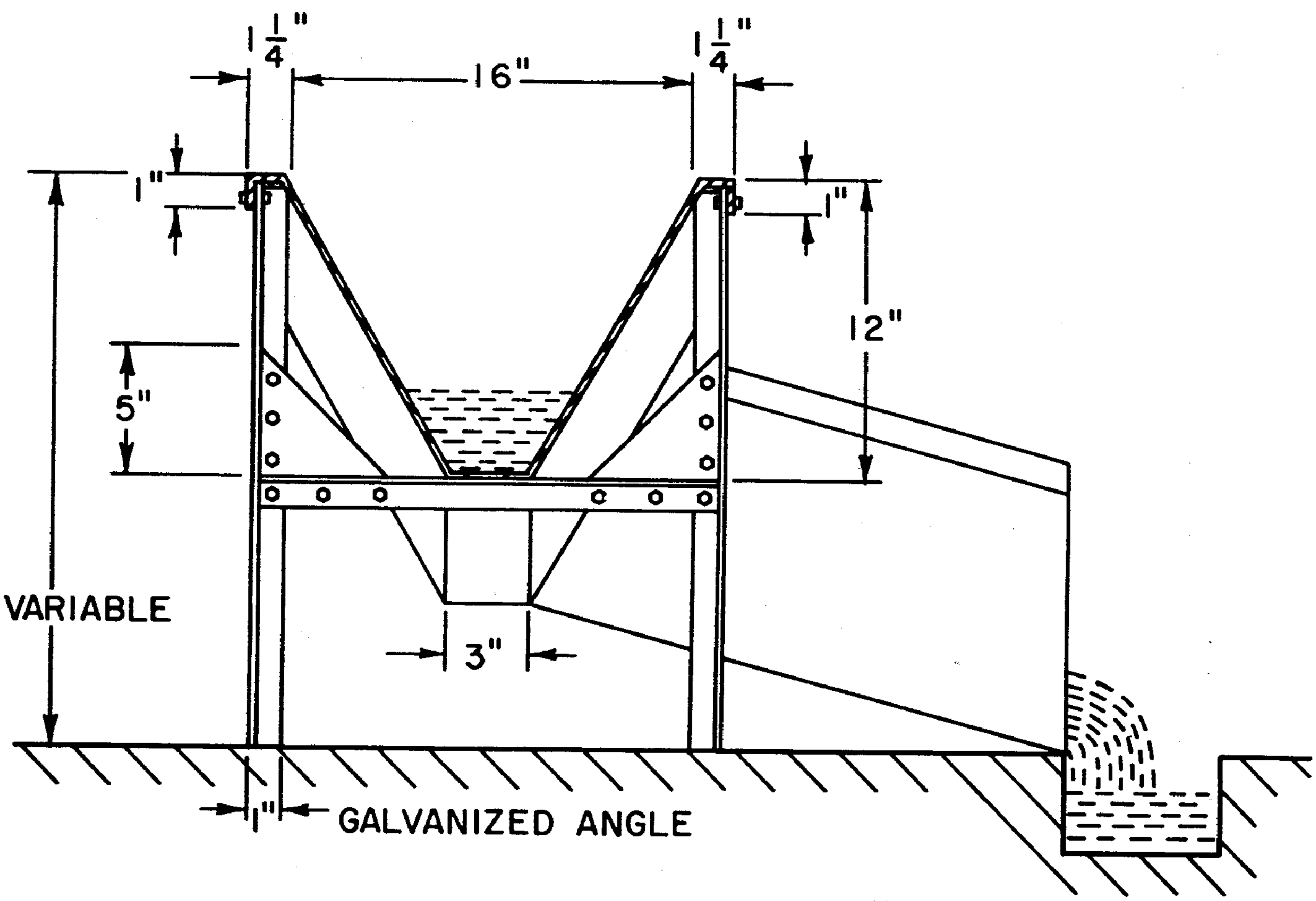
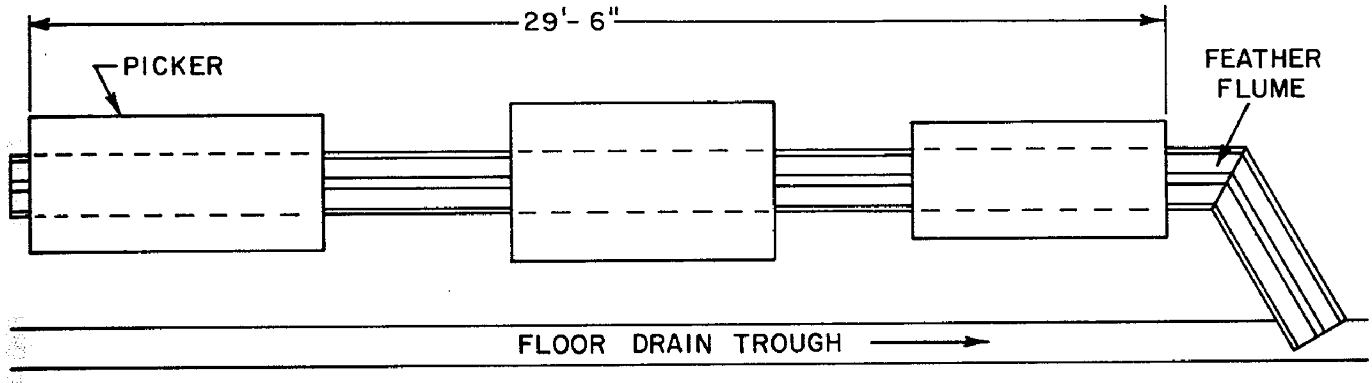
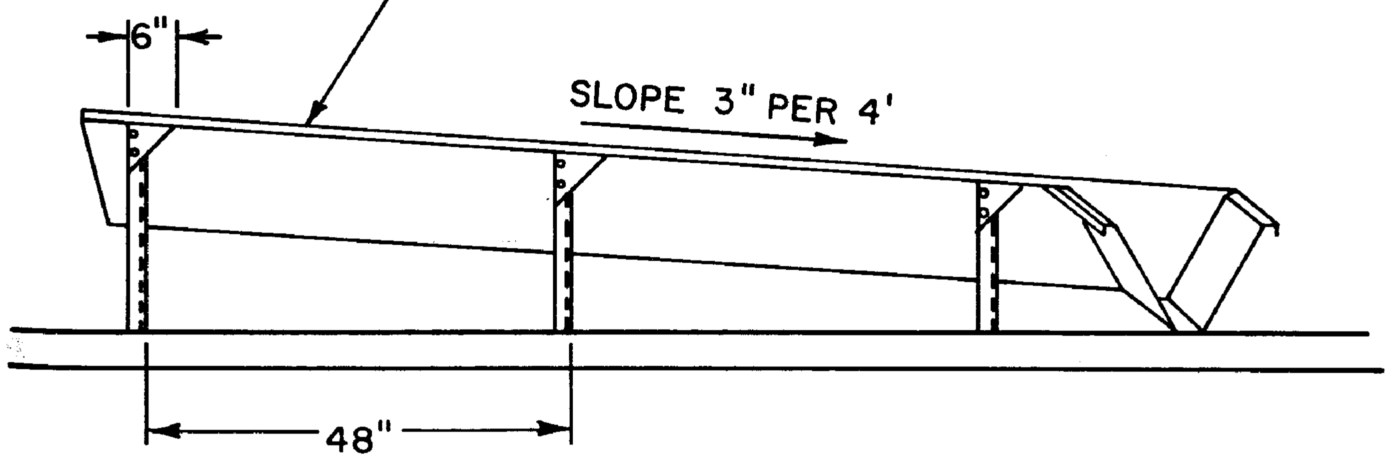


Figure 21. Picker feather flumes



TOP VIEW



SIDE VIEW

Figure 21. Continued

Table 18. INITIAL COSTS OF THE DEFEATHERING SYSTEM MODIFICATIONS.

Item	Quantity and/or cost	Amount
Material:		$ 1,179.
88 Brass nozzles	$160.	
60 ft. stainless steel sheet	741.	
2 stainless steel pans	267.	
12 ft. 3/4" galvanized pipe	3.	
2 3/4" gate valves	8.	
Tax:		24.
Labor: 92 hrs. @ $10/hour[a]		920.
Total costs		$ 2,123.

[a] See Table 19.

Table 19. ANNUAL BUDGET FOR DEFEATHERING SYSTEM

Item	Quantity and/or cost		Amount
Reduced Costs:			$ 7,591.
Water	12,221,280 gals. @$.44/1000[a]	$5,377.	
Labor	1080 hours @ $2.05/hour[b]	2,214.	
Increased Costs:			578.
Maintenance	1% of material cost	12.	
Depreciation			
Nozzles		80.	
Valves		4.	
Stainless Steel		101.	
Galvanized Pipe	100% in 10 years	0.	
Interest on Investment	1/2 of initial cost at 7%	74.	
Recurring Labor Cost		307.	
Net saving per year			$ 7,013.

[a] Due to the modification the need for fresh water was eliminated here. The use of fresh water before the modification was 94.3 gallons per minute.

[b] Labor cost for clean-up has been reduced. The change is from a full-time employee at $2.05 per hour to a half-time employee at $2.05 per hour. There is a reduction of labor time by 4.5 hours per day. This savings is multiplied by 240 days per year to obtain a savings of 1080 hours per year.

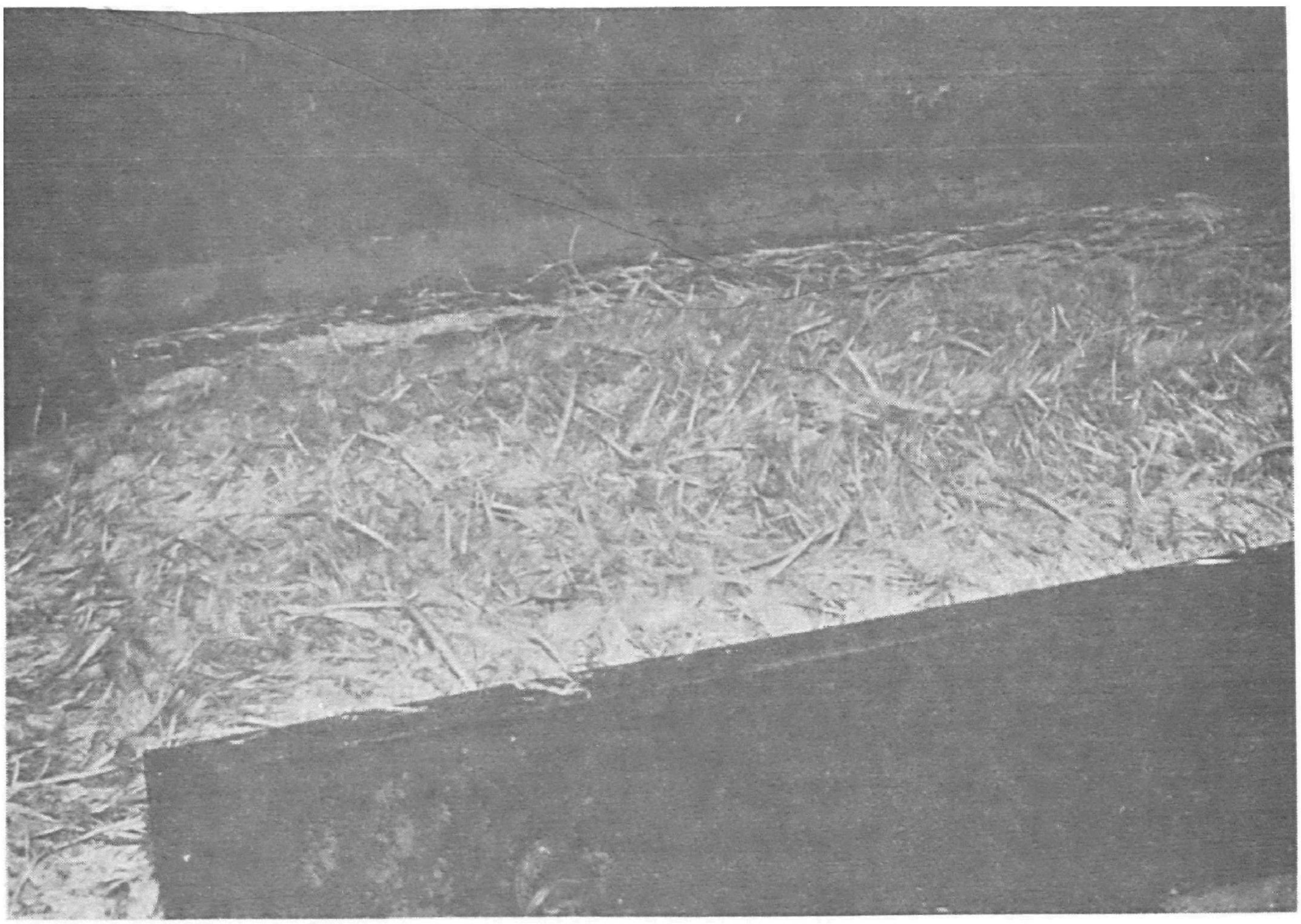


Figure 22. Feathers on screen

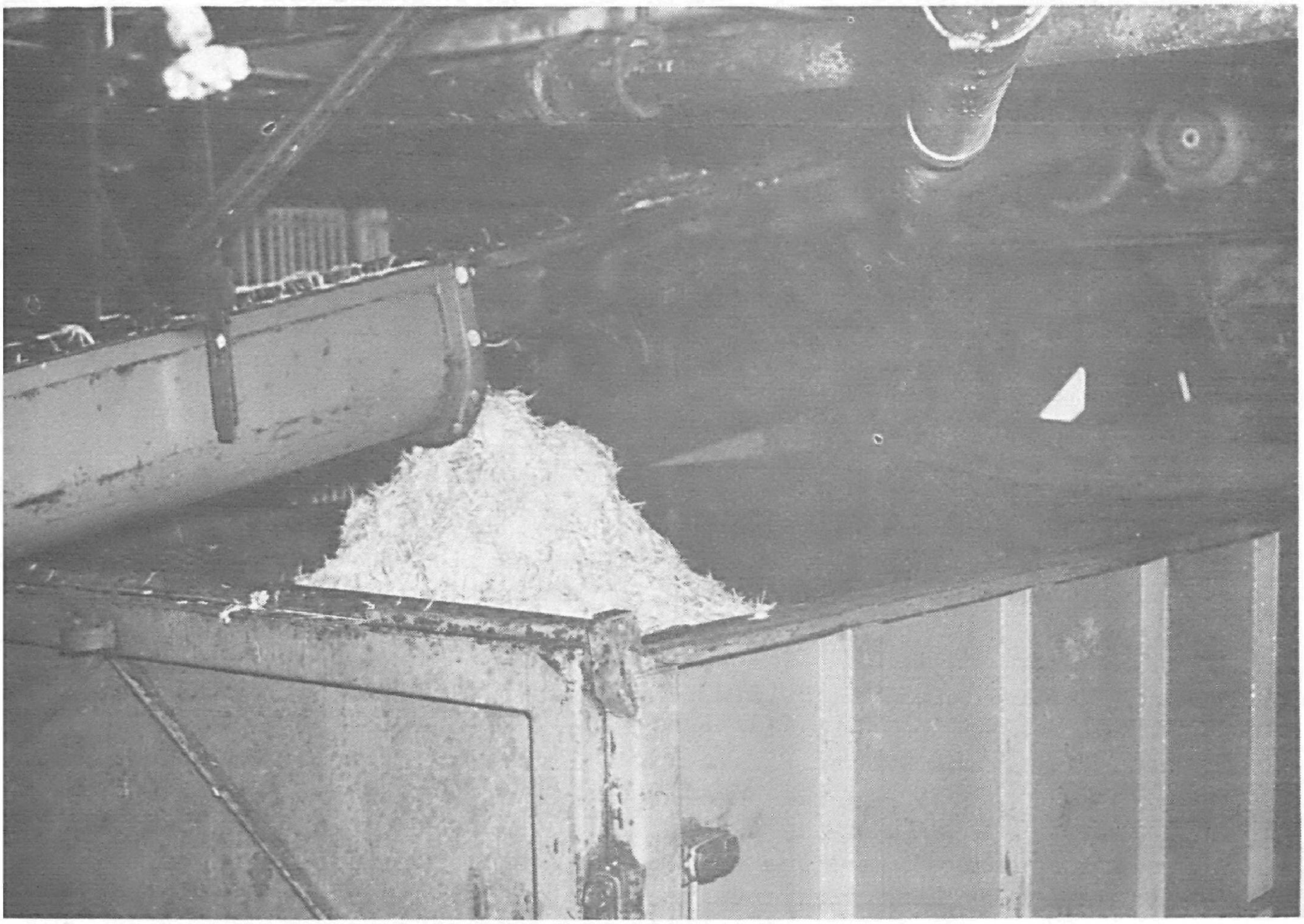


Figure 23. Feather discharge into offal truck

Description of Change

The mesh of the recovery screen was increased to help better recover the feathers. The vibratory screen media were changed from a 10 mesh to 20 mesh at the time of normal screen replacement.

Impact on Waste Load

The total impact on waste load of this change could not be identified. However, visual observation of the effluent and discussions with municipal officials indicated a significant change did take place.

Whole Bird Washer

Problem

An early conclusion was that the holes-in-pipe potable water applicators as found in the whole bird washer were not efficient water spray applicators. Excessive water was used in areas that did not wash the birds. Also the effluent fell to the floor and was not utilized.

Description of Change

The whole bird washer was modified by replacing the pipe hole nozzles with commercial nozzles. A variety of nozzles were tested including shower heads of several designs, square pattern heads of several designs, square pattern nozzles (Full Jet, Spraying Systems, Inc.), off center projection (Vee Jet, Type U-OC; Spraying Systems, Inc.) and the Vee Jet, Type U (Spraying Systems, Inc.). Each whole bird washer was equiped with 16 nozzles located on pipes horizontally arranged in the washer (Figure 24). The nozzles selected were the No. 1/4 - U 6510 and the No. 1/4 - U 6515. At 10 psi, the U-6510 delivers 0.5 GPM and the U-6515, 0.75 GPM. At 15 psi, the U-6510 delivers 0.61 GPM and the U-6515, 0.92 GPM. The pressure was controlled by hand with a valve-gauge assembly at 12 psi. A quick shut-off ball valve was installed on each washer to permit quick and easy shut off of water during breaks and periods of inactivity.

Impact on Water Use

The shower nozzles tried increased the water consumption from 37 to 45 GPM in the two whole bird washers (Figure 24). The selected nozzles reduced the flow to 25 GPM or a reduction of some 12 GPM. The net yearly water savings would be over 1,500,000 gallons.

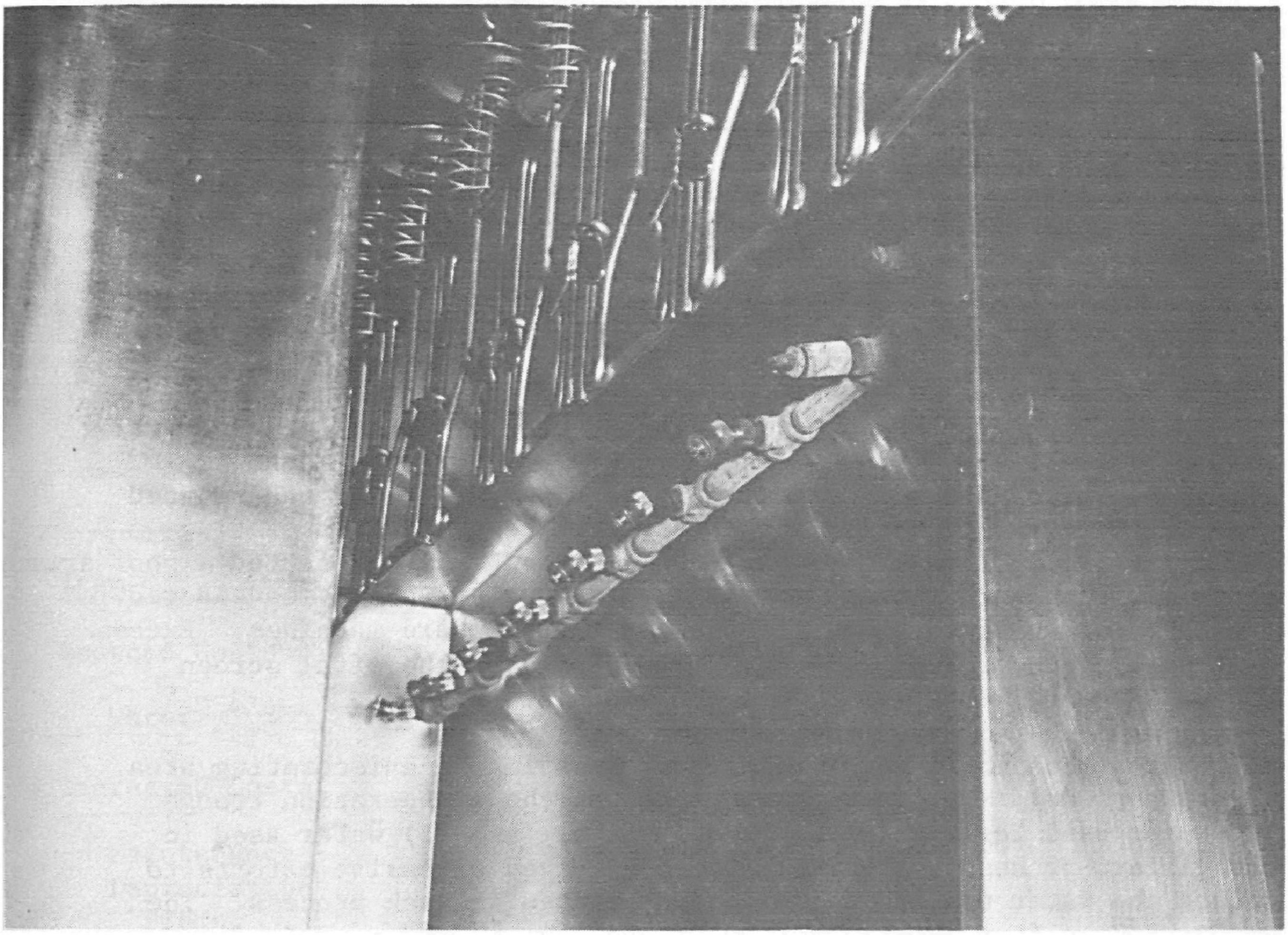


Figure 24. Whole bird washer with shower type discharge nozzles

Initial Costs and Annual Budget

The budgets are presented in Tables 20 and 21. Total net savings amounted to more than $501. per year from a reduced cost of water alone. Initial costs indicate a cost for one washer of $256 or a cost for two washers of $512, Table 20. Thus, yearly savings almost equal initial costs.

Evisceration

Problem

The evisceration area is the major water using section in the plant. Total water consumption indicated in the benchmark studies that the eviscerating area used some 458,400 GPD, 6.6 GPB or 63 percent of the total water used for processing.

Excessive water use was the rule rather than the exception in this water use area. The excess water use in handwash goosenecks was especially obvious to the critical observer. The scene shown in Figure 25 was taken 30 minutes before scheduled production. No control of water use was practiced during breaks, lunch or down time periods (see Figure 26). The water supply pressure was found to fluctuate between 10 and 85 psi. Excess water demands often reduced the pressure in the gizzard machines below the critical operating point (20 psig). The giblet handling area generally presented a poor arrangement of washing and fluming operations when water use was considered. Figure 27 shows water hoses feeding a set of gizzard machines. Excess water use often created flood over conditions on the offal screen and solids were washed over into the floor drains.

There are three major water using processes in the eviscerating area. The three were: (1) flushing the sides of the evisceration trough; (2) water used for rinsing hands and knives; and (3) water used in the gizzard processing system. These received extensive efforts to reduce the water use and waste load generated in each process. The water use was found to be continuous even though the need for water was often intermittent. Other processes receiving attention in the evisceration area included the final bird wash and the rehang belt washers. Also, water pressure regulation was recognized as needed to prevent excessive water use and to control the rate of water use.

Table 20. INITIAL COSTS OF ONE WHOLE BIRD WASHER MODIFICATION

Item	Quantity and/or rate	Amount
Materials:		$ 163.
16 brass nozzles	$29.	
Piping	76.	
Gauges	7.	
Union and valves	51.	
Labor: 9 hrs @ $10/hr.		90.
Tax:		3.
Total Costs		$ 256.

Table 21. ANNUAL BUDGET FOR MODIFICATION OF TWO WHOLE BIRD WASHERS

Item	Quantity and/or rate	Amount
Reduced Costs:		$ 684.
Water 1,555,200 gal[a]		
Increased Costs:		183.
Maintenance	$ 32.	
Depreciation		
Piping	16.	
Gauges	7.	
Nozzles, Union and valves	80.	
Interest on Investment	18.	
Recurring Labor Cost	30.	
Net Savings Per Year		$ 501.

[a] Reduction from 37 GPM to 25 GPM.

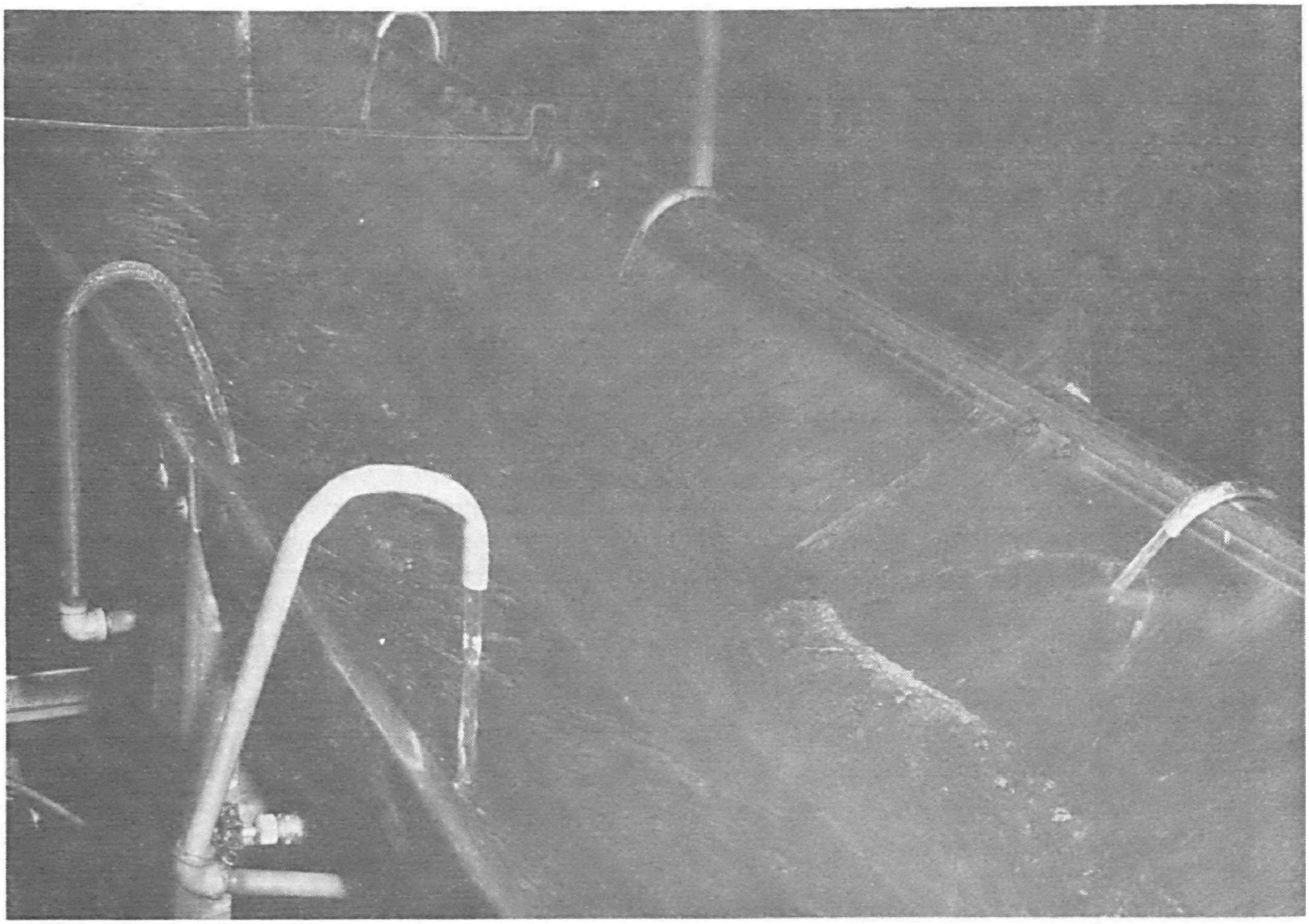


Figure 25. Eviscerating trough showing handwash goosenecks

Figure 26. Evisceration area during lunch break

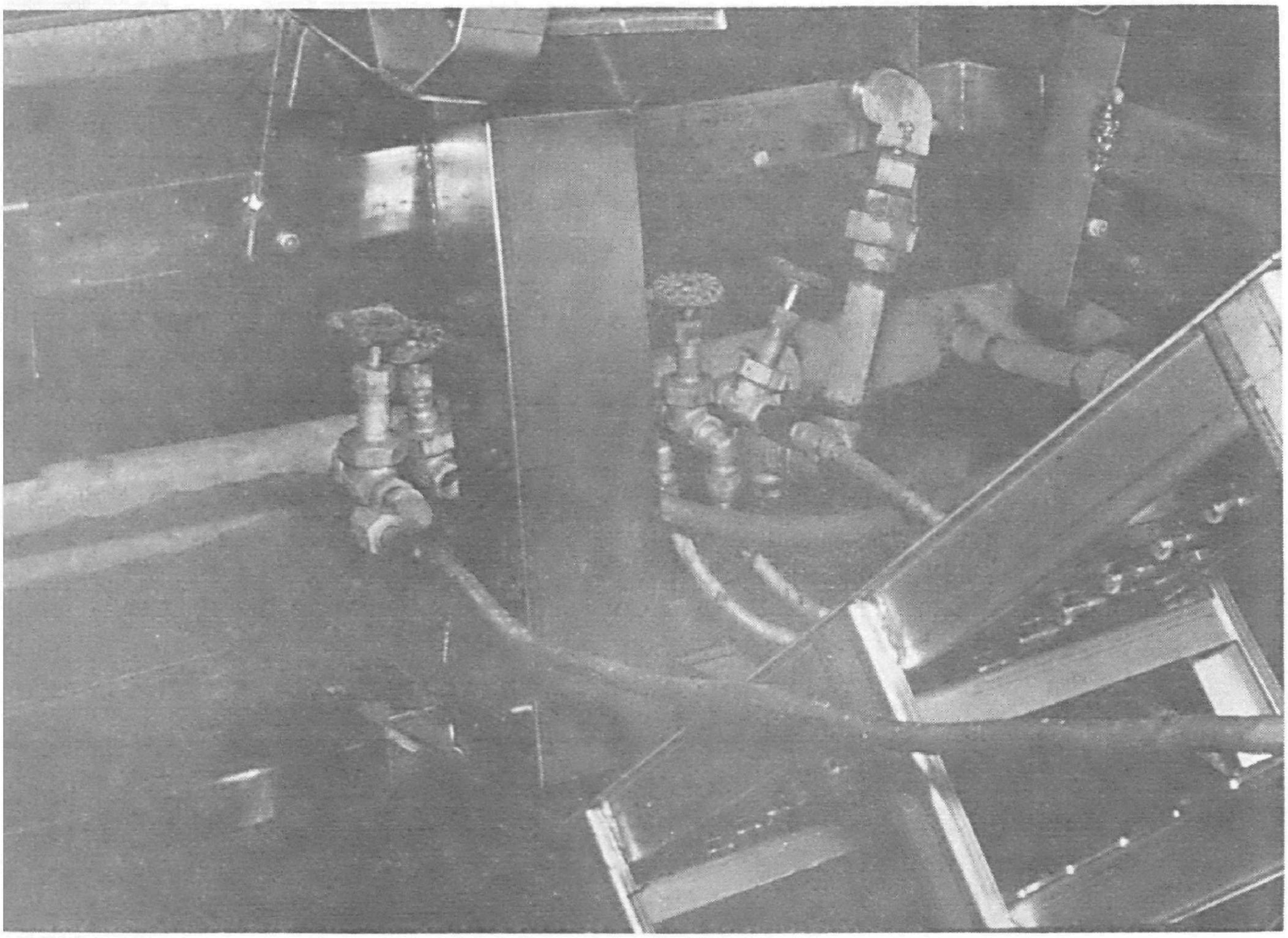


Figure 27. Water hoses to gizzard machines

Description of Changes

Several techniques and changes in the design were applied in the eviscerating area to increase water use efficiency and to eliminate excessive wastes from entering the wastewater stream. These changes were as follows: (1) Installed nozzles on handwash goosenecks and body operated valves where feasible and permitted by USDA-CMS, (2) Installed spray nozzles in the final bird washer to replace the hole-in-pipe nozzles, (3) Installed pressure regulator to main supply for eviscerating trough excluding the side pan wash, (4) Isolated the water supply for the side pan wash and installed a time delay valve. The details of these changes follow.

The second largest volume use of water in the poultry processing plant was from the hand wash goosenecks. Benchmark results showed each of the goosenecks was using some 2.85 GPM. Water pressure was found very important in the flow rate from these goosenecks. Pressures in excess of 80 psi were encountered which would allow the shower nozzles to fog and wet everything in the plant. A pressure regulator was installed on the supply line to help prevent this problem (see Figure 28).

The nozzles selected for installation on the goosenecks were the FullJet, No. 1/4 - HH6.5 with a 3/32" orifice diameter (Spraying Systems Co., North Avenue at Schmale Rd., Wheaton, Ill. 60187). These nozzles had approximately a 45 degree spray angle. The flow from these nozzles is 0.55 GPM (7 psi) and 0.65 GPM (10 psi). The pressure found best for handwashing was 8 psi and this is where regulation of pressure was set. Figure 29 shows a gooseneck with nozzle attached.

Other nozzles tried included the VeeJet, Flood Jet, Whirl Jet and Hollow Jet with the cone and hollow cone spray pattern all from the Spraying Systems Co. Also, home shower heads and automotive washing hose nozzles (tickler nozzles with hand activated bar - see Figure 30) were tried. The automotive washing hose nozzles were not entirely satisfactory to the USDA-CMS inspection staff. The nozzles selected performed the best in the judgment of the plant management and employees.

A valve was installed at each station to regulate pressure and water flow. The flow was set using a bucket and stop watch and the valve adjusted for minimum desired flow which was 0.6 GPM.

Eight stations on each line had body operated valves installed. These valves were the Quick Acting On-Off Valve (Spraying System Co., Type AA 36) and quarter inch valves. These valves were placed on the head

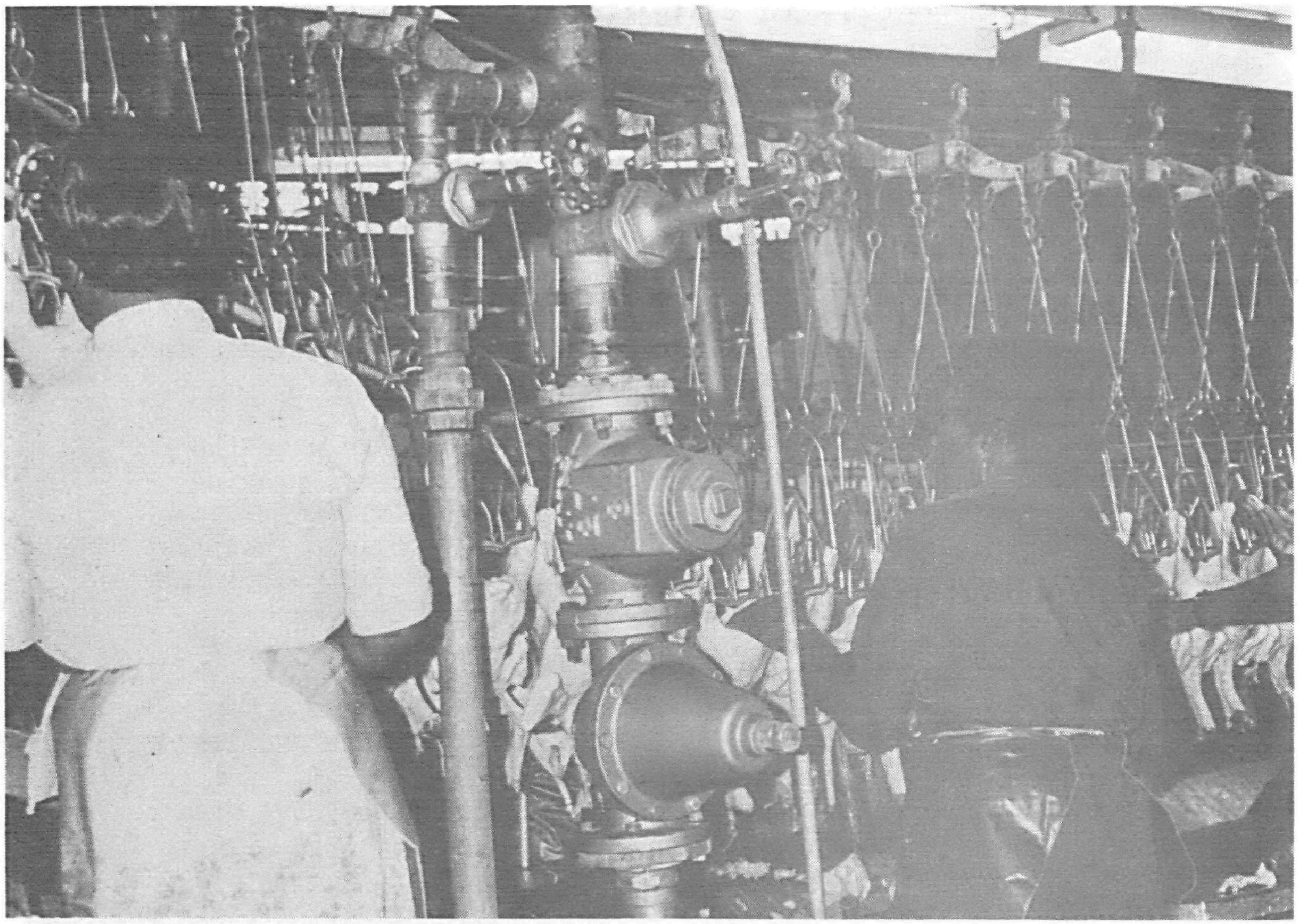


Figure 28. Pressure regulator on eviscerating supply

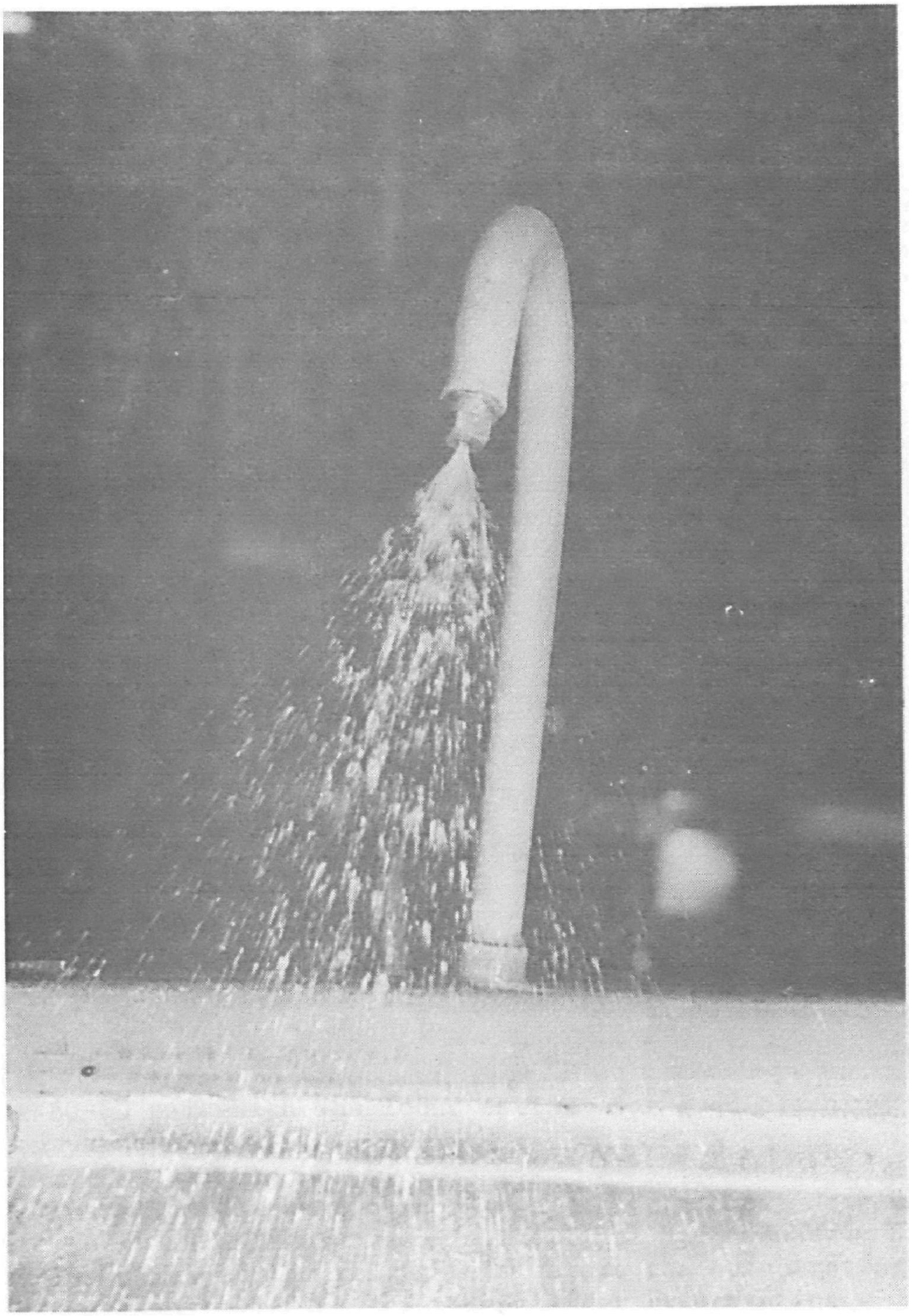


Figure 29. Nozzle Installed on goosenecks for hand washing

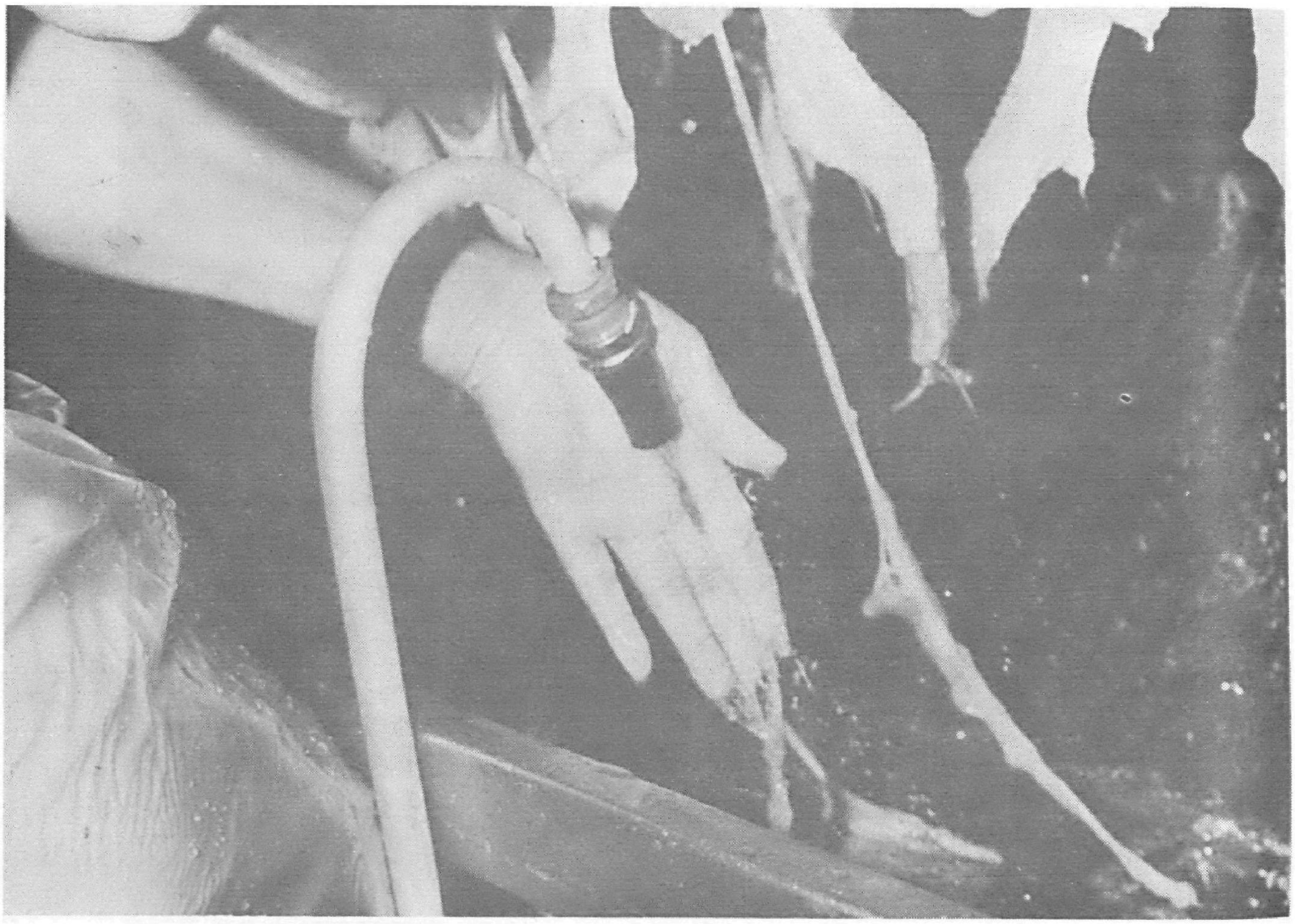


Figure 30. Tickler nozzle activated

of each line where the birds enter the process area. The valves were positioned such that the employee could activate flow using either his hip or leg between the knee and hip (see Figure 31).

Higher efficiency commercial nozzles were installed in the final bird washer to replace the hole-in-pipe nozzles. A variety of nozzles as tested in the whole bird washer were tried but finally the VeeJet (Spraying Systems Co.), Type U, No. 1/4 - U 6550 or U 6560 were selected for maximum coverage of birds for washing and minimum water use.

The flow was regulated by a valve-pressure gauge assembly to approximately 8 psi. The nozzles selected delivered 2.1 and 2.5 GPM (7 psi) and 2.5 and 3.0 GPM (10 psi). A quick shut off valve (ball) was installed to enable workers to cut off the flow during breaks, lunch and downtime periods. Figure 32 shows a ball valve, the flow regulating valve and the pressure gauge used for setting the regulating valve to desired flow rate. Thirty two nozzles were installed in each washer on 4 rectangular pipe sections mounted vertically, parallel to the washer wall. Nozzles were oriented at various angles to give maximum coverage by best utilizing the spray pattern of the nozzle (Figure 33).

The final wash water was noted to be "clean" in the benchmark results. A chamber was installed under the washer to collect the water and condition it by the removal of settling and floating solids (Figure 34).

The side of the eviscerating trough was washed with water to flush the solids into the trough bottom for flushing to the sewers. An electric on-off switch with a time delay was installed on the side pan wash. The most effective combination of time delay was 20% on and 80% off by time. The actual on time was 0.4 min and the off time 1.6 min. A problem existed in that the reduced pressures in the regulated eviscerating supply line would not flush the sides of the pan. Therefore, the side pan wash supply was isolated and the pressure regulated at 60-80 psi which was found optimum for good cleaning during the on periods.

Nozzles were installed on the two rehang belts locations. Nozzles selected were the same as those used in the final bird washer. Six nozzles were installed at the rehang belt before the eviscerating area and 4 nozzles were installed on the rehang after eviscerating.

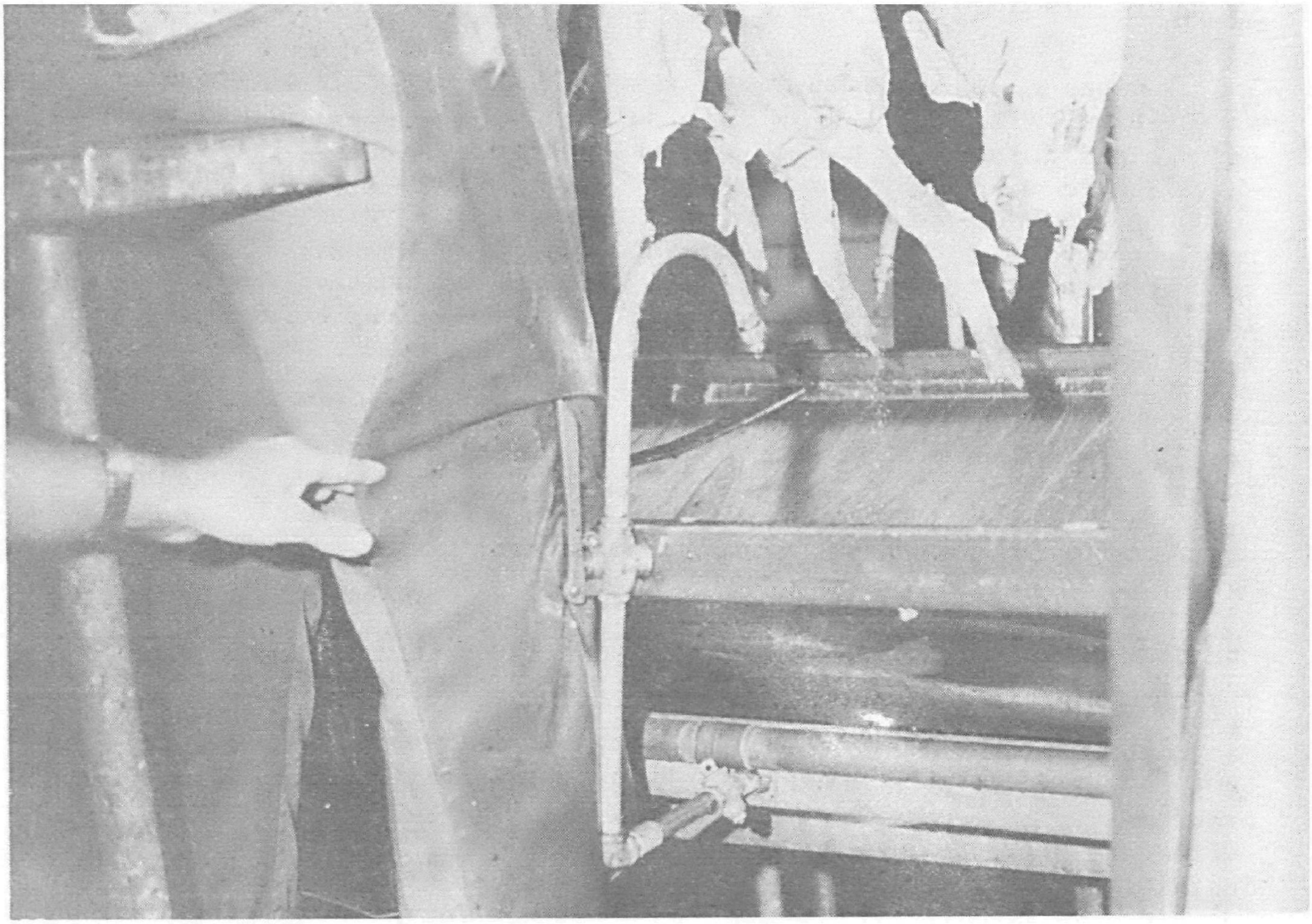


Figure 31. Quick acting on-off valve, body operated

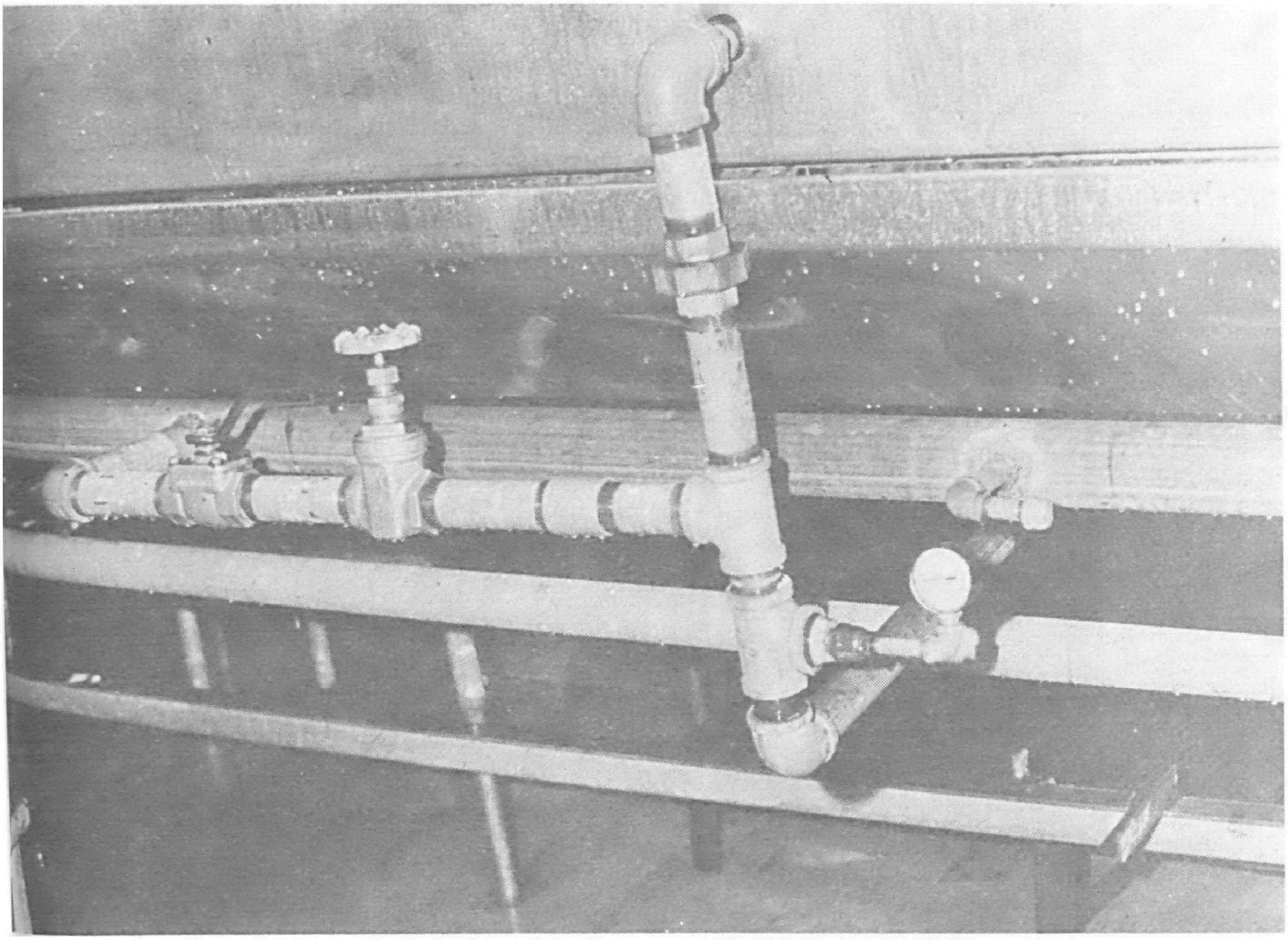


Figure 32. Final bird washer supply manifold

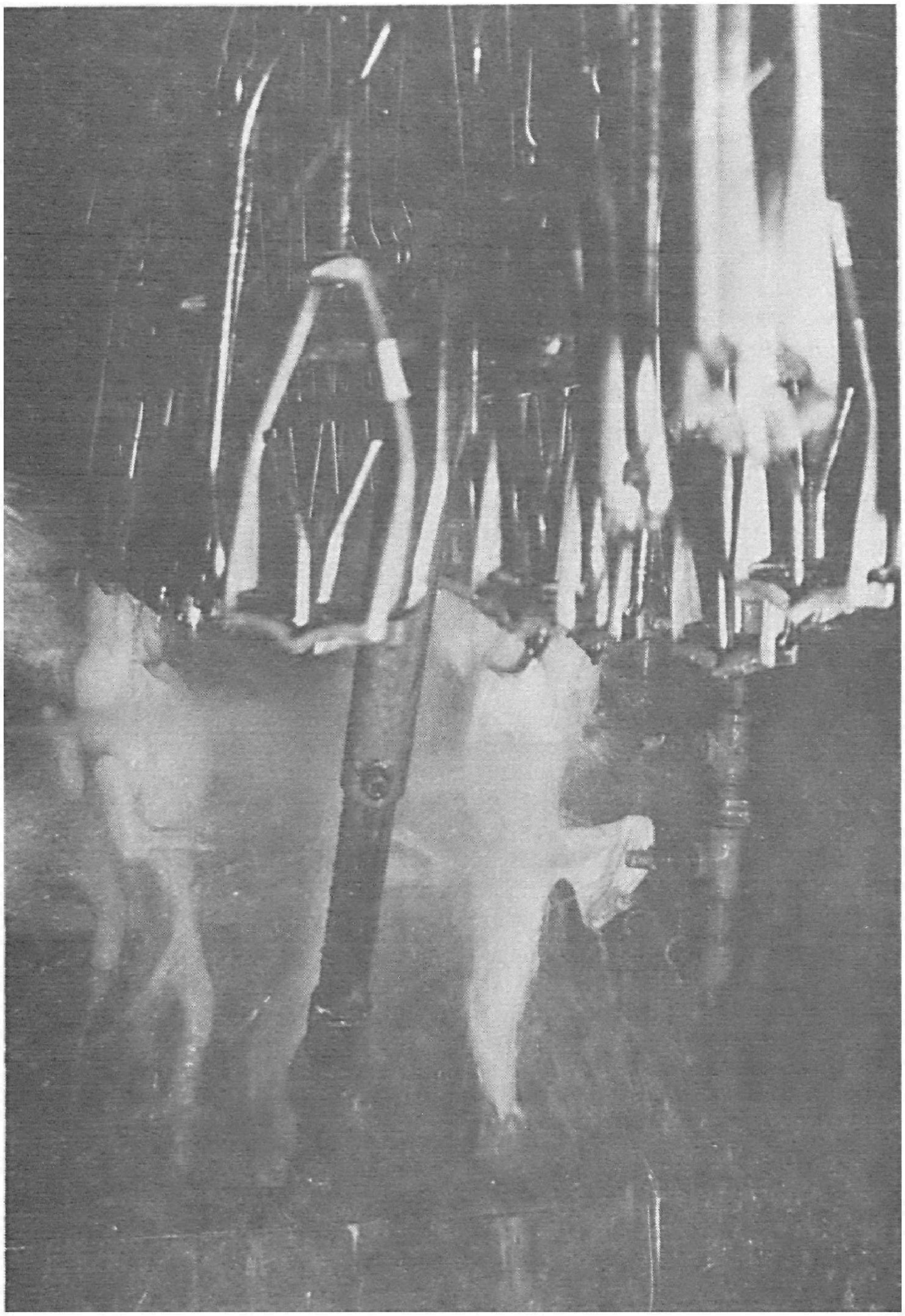


Figure 33. Final bird washer spray pattern

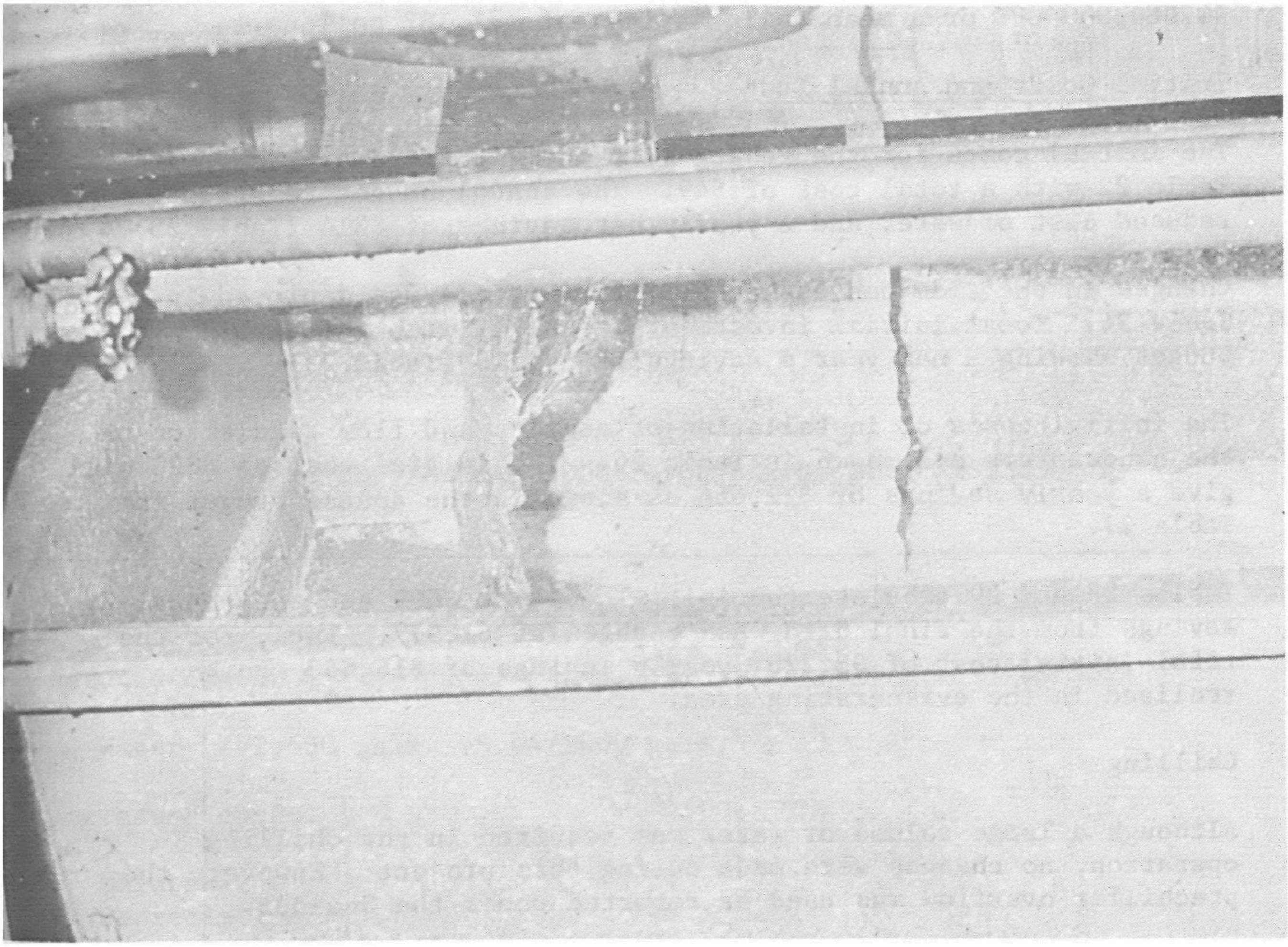


Figure 34. Collection chamber - final bird washer

Impact on Water Use

The installation of the controlled handwash nozzles reduced water use by 2.2 GPM for each of 96 handwashers. The annual water savings from this change was 27,372,000 gallons. The side pan wash system yielded a net water savings of 7,776,000 GPY. The rehang belt wash system nozzles produced a water savings of 751,680 GPY. Changes brought about in the final washer made savings of 5,184,000 GPY. Total impact on water use in the eviscerating area was a yearly reduction of 41,084,000 GPY or a mean daily savings of 171,182 gallons.

Initial Costs and Annual Budget

The initial costs for the rehang belt modifications are shown in Table 22 with a total cost of $49. The annual budget relates a reduced cost of water and a yearly net savings of $314 (Table 23).

Changes in one side pan wash cost $871 initially as depicted in Table 24. Total initial investment was $1742 with the annual budget showing a net yearly savings of $2,718 (Table 25).

The initial costs of installation of nozzles and flow regulation on the handwashers are shown in Table 26. The initial cost of $820 will give a yearly savings of $11,654 as shown in the annual budget in Table 27.

Tables 28 and 29 tabulate the initial cost at $609 and the annual savings from the final bird wash changes at $1,977. Thus, for the total initial cost of $3,220, yearly savings of $16,663 can be realized in the eviscerating area.

Chilling

Although a large volume of water was required in the chilling operation, no changes were made during this project. However, the prechiller overflow was used as reported under the Scalder.

Grading, Weighing and Packing

Normal operations do not require a large amount of water in this area. Product drippage and ice spillage problems were encountered but not attacked. Effective cleaning methods were developed for this area.

Table 22. INITIAL COSTS OF THE REHANG BELT SYSTEMS ON EVISCERATING AND PACKING LINES.

Item	Quantity and/or rate	Amount
Material:		$ 9.
10 veejet brass nozzles	$5.60	
8 1/4" couplings	2.72	
2 3/4" galvanized caps	.74	
Tax: 2% of material cost		0.
Labor: 4 hours @ $10/hour		40.
Total Costs		$ 49.

Table 23. ANNUAL BUDGET FOR REHANG BELT SYSTEMS

Item	Quantity and/or rate	Amount
Reduced costs:		$ 331.
Water 751,680 gals. @$.44/1000 gals.[a]		
Increased costs:		37.
Maintenance	$ 1.	
Depreciation	24.	
Interest on Investment	2.	
Recurring Labor Cost	10.	
Net savings per year		$ 294.

[a] Six nozzles in eviscerating area brought about a reduction from 9.1 to 4 gallons per minute and 4 nozzles in the pack-out area reduced water from 1.5 to 0.8 gallons per minute, a savings of 5.8 gallons per minute.

Table 24. INITIAL COSTS OF THE SIDE PAN WASH SYSTEM FOR ONE LINE

Item	Quantity and/or rate	Amount
Material:		$ 605.
1 2" electrical solonoid valve	$186.	
1 timer	16.	
Timer accessories	13.	
Piping and fittings	324.	
1 pressure gauge	4.	
1 galvanized pipe and angle iron	27.	
2 2" gate valves	35.	
Tax: 2% of material cost		12.
Freight:[a]		2.
Labor: 25.2 hours @ $10/hour		252.
Total costs		$ 871.

[a] Shipping charge for the timer.

Table 25. ANNUAL BUDGET FOR SIDE PAN WASH SYSTEM FOR TWO LINES

Item	Quantity and/or rate	Amount
Reduced Costs:		$ 3,421.
Water 7,776,000 gals @ $.44/1000 gals.[a]		
Increased Costs:		704.
Maintenance	$120.	
Depreciation		
Valves and timer	254.	
Piping	70.	
Interest on Investment	60.	
Recurring labor cost	200.	
Net savings per year		$ 2,718.

[a] Each side pan wash operated with a continuous flow of fresh water at 45 GPM before the modification. The timing mechanism provides a periodic flow of fresh water during a two minute cycle. The flow is cycled with a ratio of 20 percent on and 80 percent off. The new flow rate is 15 GPM or a reduction of 30 gpm for each pan.

Table 26. INITIAL COSTS OF THE MODIFICATION OF THE HANDWASHERS

Item	Quantity and/or rate	Amount
Material:		$ 539.
96 unijet brass nozzles @ $.95	$ 91.	
20 valves	166.	
96 gas cock valves	123.	
3/8" 90° galvanized ell	10.	
aluminum piping	94.	
fittings and 4 gauges	55.	
Tax: 2% of material cost		11.
Labor: 27 hours @ $10/hour		270.
Total costs		$ 820.

Table 27. ANNUAL BUDGET FOR HANDWASHERS

Item	Quantity and/or rate	Amount
Reduced costs:		$12,043.
Water 27,371,520 gals. @ $.44/1000 gals.[a]		
Increased costs:		389.
Maintenance	$ 54.	
Depreciation		
Nozzles	46.	
Valves	144.	
Piping, fitting and gauges	16.	
Interest on investment	29.	
Recurring labor cost	100.	
Net saving per year		$11,654.

[a] The installation of nozzles on the 96 handwashers brought about an average reduction from 2.85 GPM to 0.65 GPM, a savings of 2.20 GPM.

Table 28. INITIAL COSTS OF THE FINAL BIRD WASH SYSTEM

Item	Quantity and/or rate	Amount
Material:		$ 421.
2 lunk ball valves and		
3 galvanized unions (1 1/4")	$ 61.	
64 brass nozzles	116.	
4 pressure gauges	15.	
4 gate valves	70.	
piping and galvanized caps	159.	
Tax: 2% of material cost		8.
Labor: 18 hours @ $10/hour		180.
Total costs		$ 609.

Table 29. ANNUAL BUDGET FOR THE FINAL BIRD WASH SYSTEM

Item	Quantity and/or rate	Amount
Reduced costs:		$ 2,281.
Water 5,184,000 gals. @ $.44/1000 gals.[a]		
Increased costs:		304.
Maintenance	$ 36.	
Depreciation		
Valves, nozzles and other	131.	
Piping	16.	
Interest on investment	21.	
Recurring Labor Cost	100.	
Net savings per year		$ 1,977.

[a] The modifications brought about a reduction from 100 to 60 GPM. This savings of 40 gallons per minute is multiplied by 540 minutes per day and 240 days per year to obtain the water savings.

Impact on Water Use

The conversion of the plant from ice pack to dry pack using CO_2 snow reduced the water use for packing. Although this was primarily a marketing move, a water reduction of 5000 GPD or 1,200,000 GPY was realized.

Offal Recovery

Problem

Flume waters from the eviscerating area and the chiller overflow water transport the offal (flesh, pieces of fat, trimmed pieces and intestinal materials) to the offal recovery area. The prime means of separation was a vibrating screen (Figure 35). Clogging problems often allowed solids to pass the screen and flush over to the floor drains. The shape and nature of the solids made the clogging problems. Grease often congealed on the surfaces of the screen and in acute situations, would completely bind the screening preventing water through the screen with water and solids overflowing the screen.

Description of Change

A 20 mesh screen was used to replace the 10 mesh screen with an increase in problems of binding and solids flush over. However, vigilent attention to the washing of the screen and the installation of 1/4" by 1/4" hardware cloth to the bottom of the screen to prevent solids carrying over combined to give better recovery of solids. As the water use was decreased, the problems became minimal and it was concluded that the screens had been previously hydraulically overloaded.

Impact on Water Use and Waste Load

Water use was increased as the smaller screen mesh required more washing. No record of water use was available as the bird age, condition, size and time of the year all influenced this operation. Waste load was believed to be decreased as evidenced by the overall results observed.

Final Wastewater Collection and Control

Problem

Wastewater from all areas of the plant flow into the final wastewater collection system. Solids of all types that pass through or over the

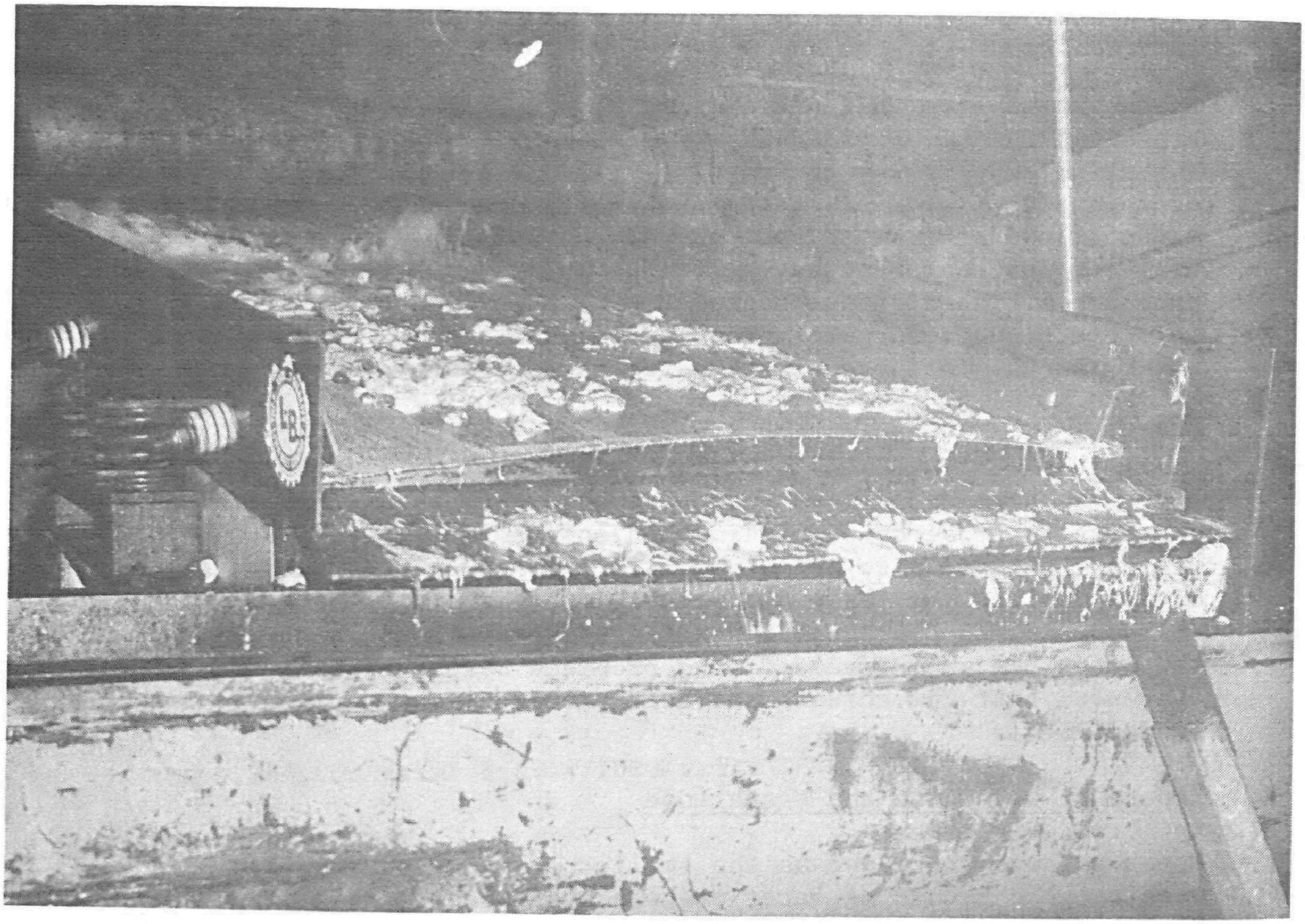


Figure 35. Offal recovery screen

screens were encountered. There was a lack of control of solids including grease that were discharged to the municipal system. Grease and solids recovery were thought necessary to alleviate the observed problems.

Description of Change

A small scale settling basin with approximately 7 minutes retention time was installed as shown in Figure 36. The basin was baffled to recover grease. Grease and solids recovery were practiced.

To further reduce the solids and grease (and BOD) in the plants final wastewater effluent a commercial air flotation cell (AFC) and skimming mechanism was purchased including the associated pumps, sumps, tanks and by-product holding chamber. The unit installed was a Pacific Flotation Separator, Model 1250 (Carborundum Co.) as shown in Figure 37. The system pressurizes 100 percent of the wastewater from the plant before discharge into an all steel chamber (diameter = 50 ft). Air is infused into the pressurized stream through an ejector. Grease and other solids come to the surface on the air bubbles where these materials are skimmed from the surface by a scraper blade assembly (Figure 38). The waste materials are collected in a 1000 gallon holding tank for discharge into the by-product truck for processing by the renderer (Figure 39).

Impact on Wastewater Characteristics

The reduction in selected wastewater parameters by the basin and the AFC are contrasted, Tables 30 and 31. The settling basin provided a 16 percent reduction in BOD_5 which was greater than anticipated. Reductions by both units combined were 28% for BOD_5, 45% for suspended solids and 56% for grease. These removals are equal to or less than what air flotation commonly obtains by itself on this industrial waste. However, flocculants or other chemical aids are often used to increase recovery in AFC units.

Initial Costs and Annual Budget

An initial cost and annual budget was not computed for the settling basin because the construction methods employed could not be duplicated. However, the reduced costs of the surcharge were equivilent to $5626. Initial costs of the settling basin are thought to be less than $1000.

The initial cost of the air flotation cell was $50,082. (Table 32). Annual net savings were found to be $4040. (Table 33) assuming that the AFC would perform singly as it performed in tandem with the settling basin.

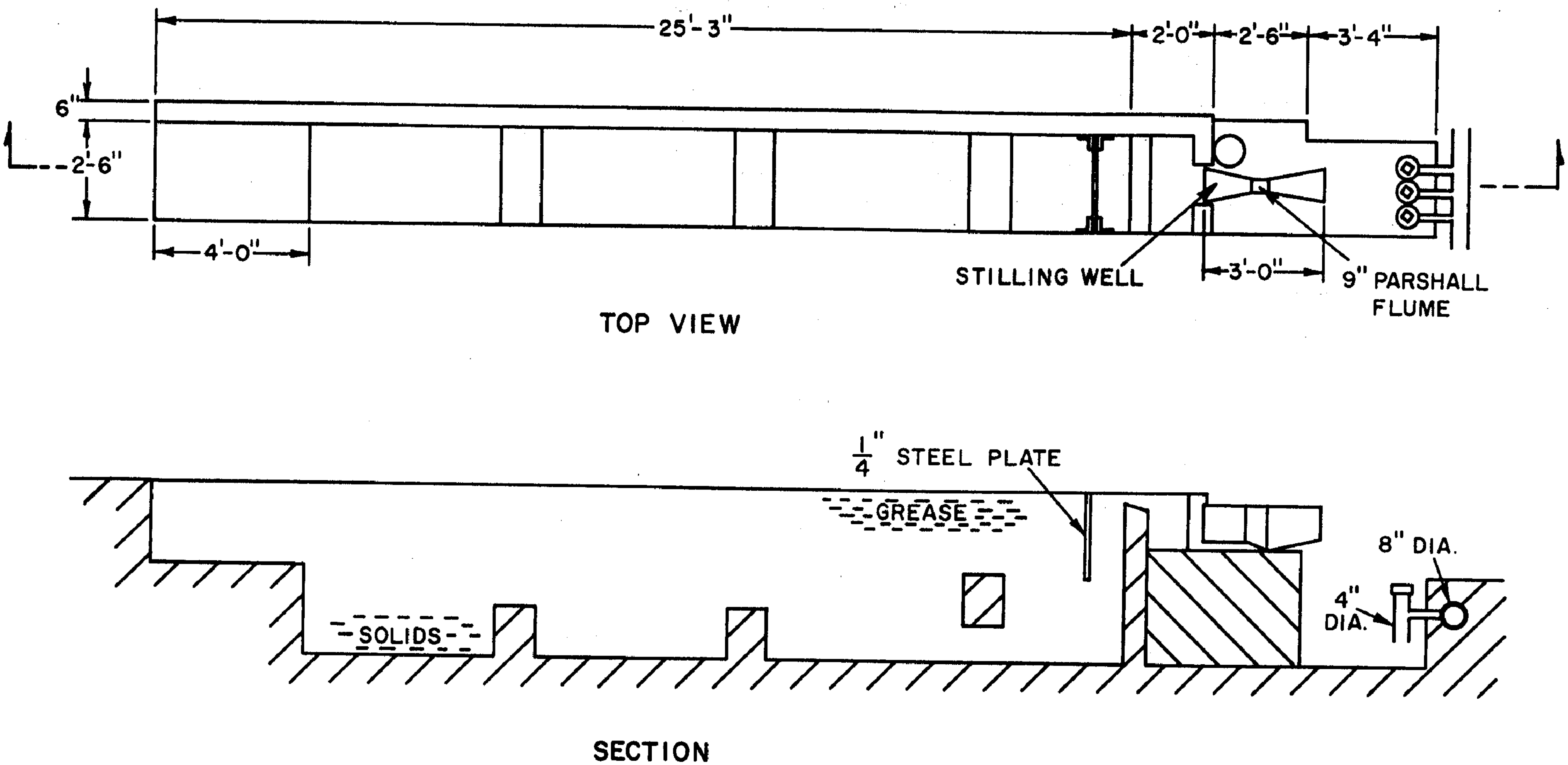


Figure 36. Settling basin

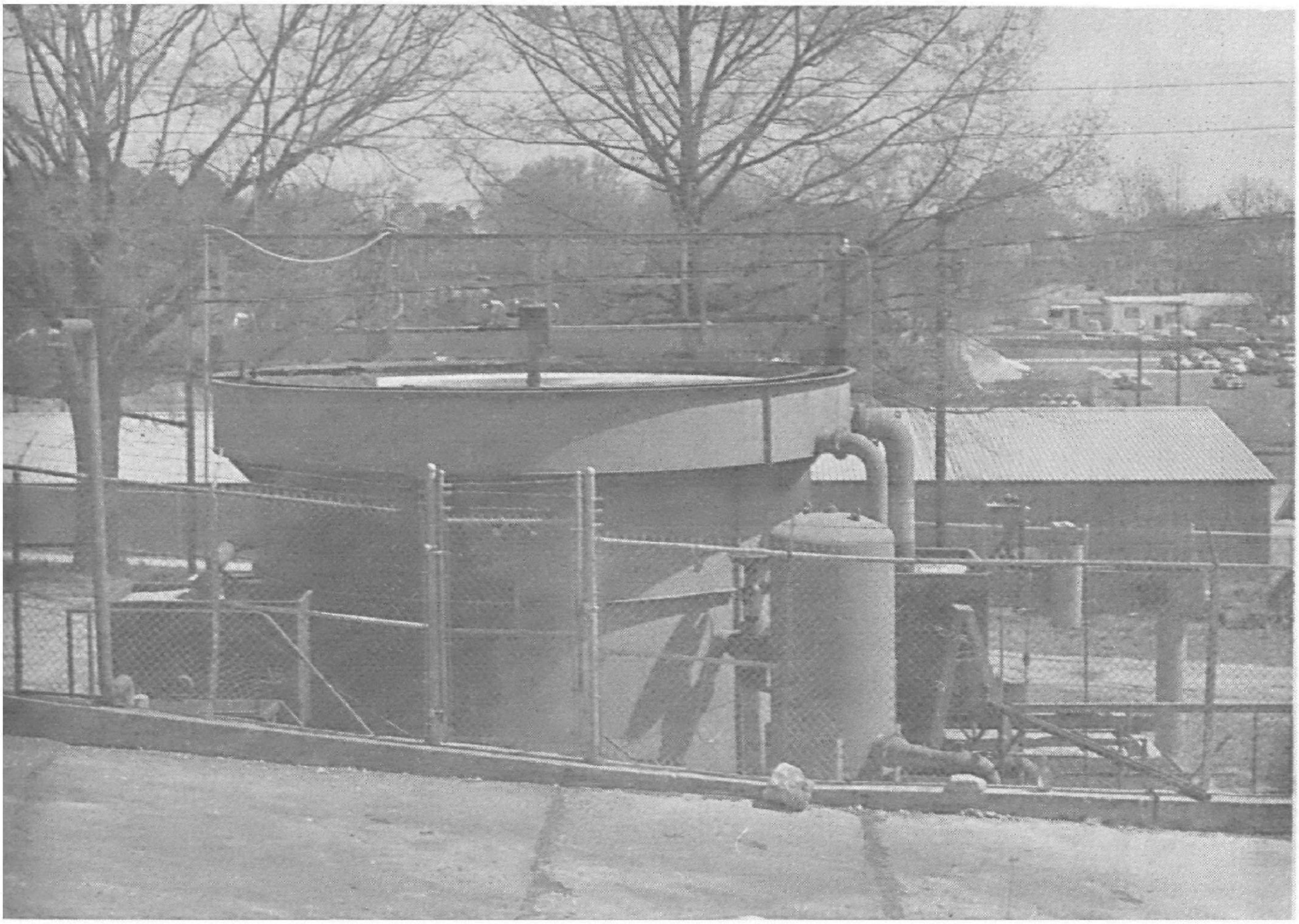


Figure 37. Air flotation cell

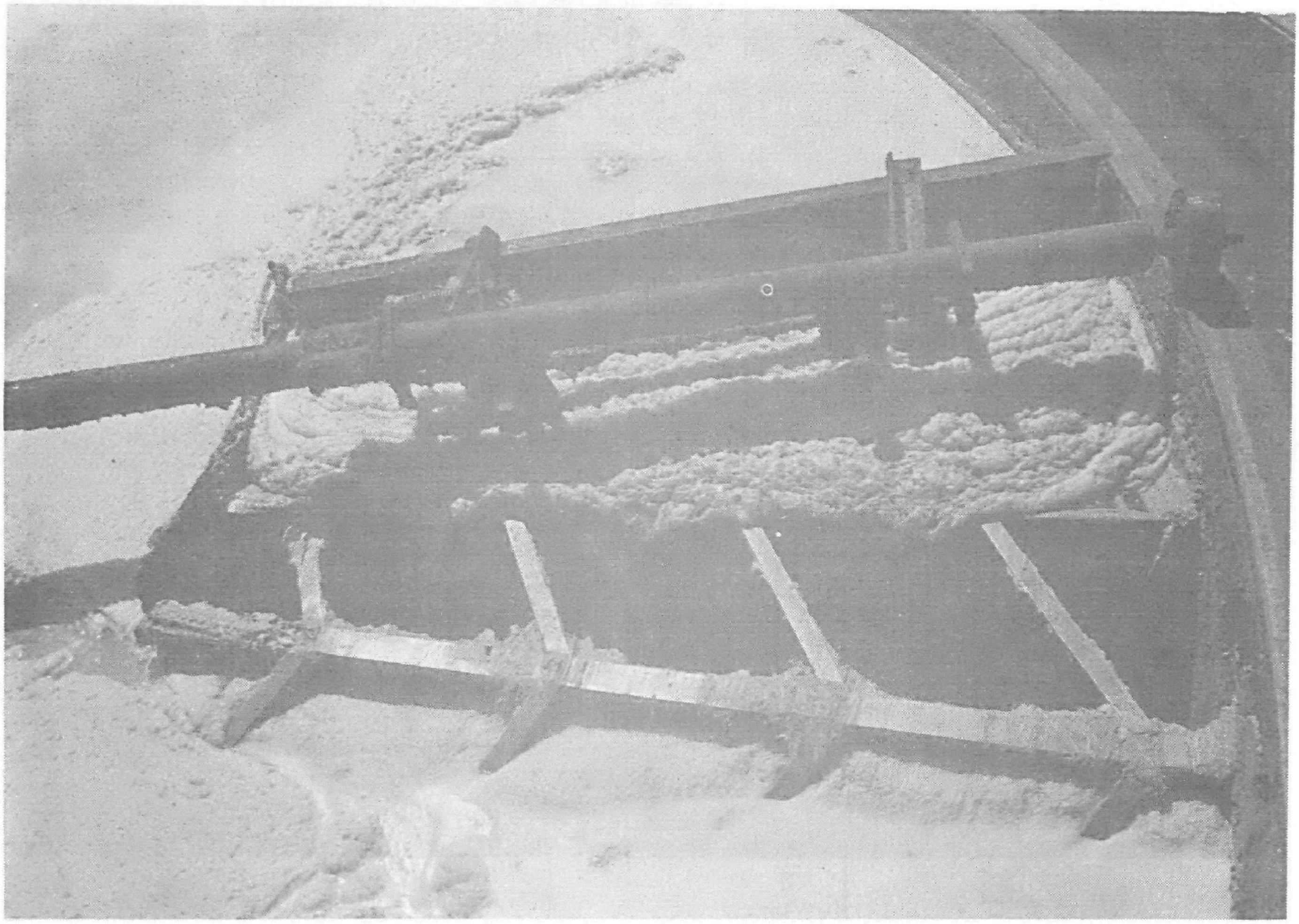


Figure 38. Air flotation cell scrapper blade discharging skimmings to collector

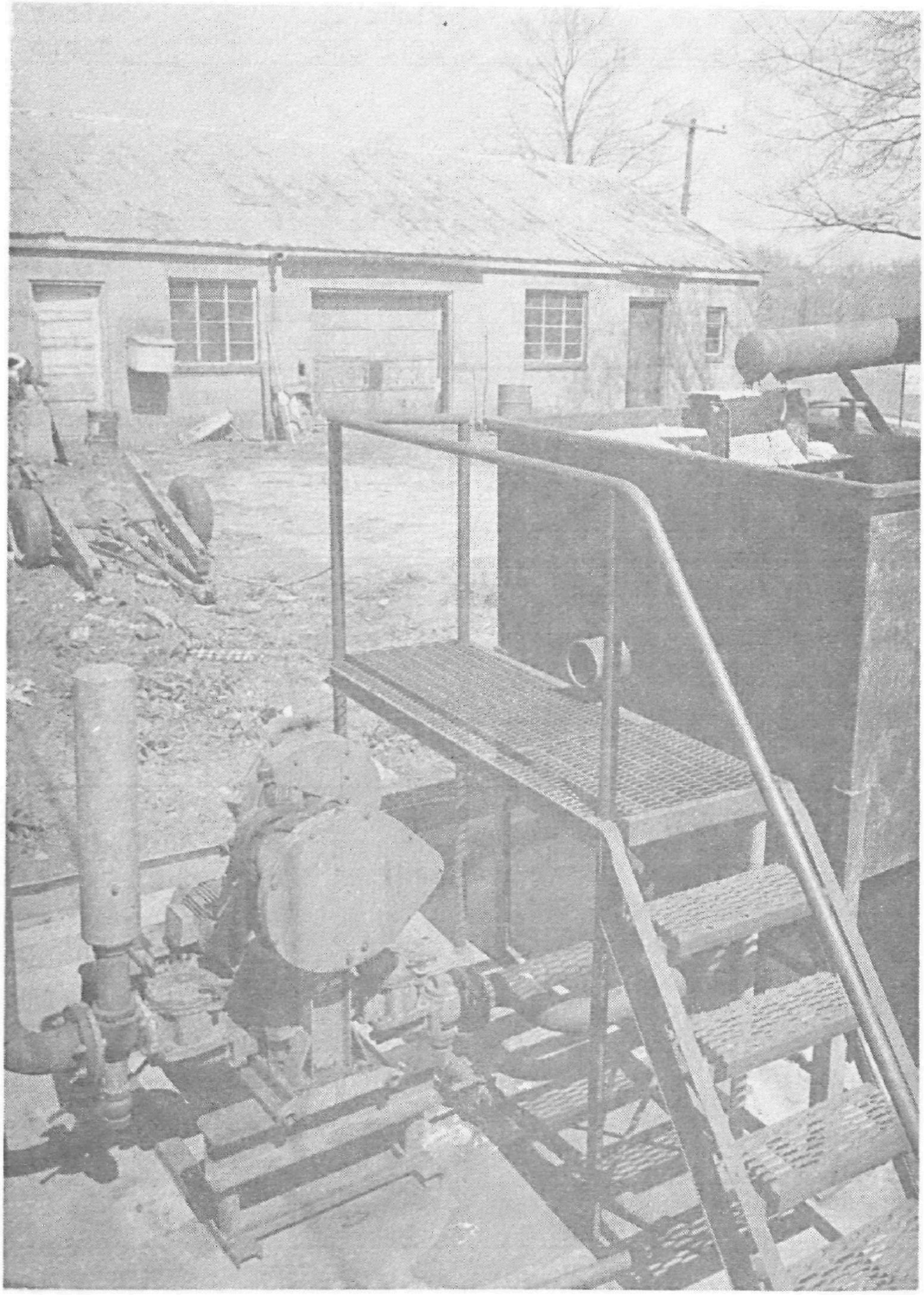


Figure 39. Air flotation cell skimmings collection tank and pump

Table 30. EFFECT OF SETTLING BASIN ON WASTEWATER CHARACTERISTICS AND SURCHARGE

Wastewater Characteristic	Plant Effluent	After Basin
	(mg/l)	
BOD	390	329
COD	936	708
TS	729	599
SS	390	267
Grease	144	130
Surcharge Reduction	$5,626/yr	

Table 31. EFFECT OF AFC ON WASTEWATER CHARACTERISTICS AND SURCHARGE

Wastewater Characteristic	After Basin	After AFC
	(mg/l)	
BOD	329	282
COD	708	617
TS	599	521
SS	267	214
Grease	130	64
Surcharge Reduction	$4,339.20/yr	

Table 32. INITIAL COSTS OF THE AIR FLOTATION CELL

Item	Quantity and/or rate	Amount
Material:		$31,883.
Chamber and Pumps		
Installation - including site preparation, welding, plumbing and electrical		18,199.
Total (Includes tax and labor)		$50,082.

Table 33. ANNUAL BUDGET FOR AIR FLOTATION CELL

Item	Quantity and/or rate	Amount
Revenue: Grease and materials[a] @ $19.48/ton		$ 899.
Reduced Costs:		9,946.
Surcharge[a]		
Increased Costs:		6,859.
Maintenance - 2% of cost	$1,002.	
Cleaning and Operation - 1/4 man year	1,350.	
Depreciation	2,504.	
Utilities - water and electricity	250.	
Interest on Investment	1,753.	
Net savings per year		$ 3,986.

[a] Assuming that the AFC would attain the combined reduction of the primary settling chambers and the AFC if the primary settling chamber was removed.

Clean-up

Problem

The clean-up of the processing equipment, building and receiving yard area required a large and quite variable volume of water. Excess water was used to "sweep" the floor and hoses were left running when not in use. The areas where blood and drippings from the chickens contacted materials were very difficult to clean. Large quantities of sanitizers and detergents were used to assist the workers in their chores.

Description of Changes

Management control of the operation materially reduced the excess water and chemical usage. Meters were installed on the clean-up hoses to psychologically remind the worker to turn off the water when it was not in use. Also, nozzles and quick cut-off valves were installed on the end of the hoses to assist the worker in cleaning and to enable him to easily shut off the water hose when not in use. Changes were made in the chemical formulation to evaluate the effectiveness of other cleaning compounds.

A high pressure cleaning system with a foaming attachment (Bionics - Hydromate, American Chemate Corporation, Maywood, Illinois) was installed. This system was used with various chemical formulations until the best combination was reached for quickest cleaning without damage to equipment. The selection of the machine and chemicals was based on minimum volume of water, reducing the time needed for clean-up, reducing the chemicals used and reducing the overall costs of the total clean-up operation.

Impact on Water Use

Water use in clean-up was found to be very dependent on the attitude of the clean-up crew and the USDA inspection staff. A new USDA inspector almost always signaled a 1-6 month increase in water use for clean-up after which a reduction could be accomplished. The changing of the clean-up foreman usually signaled an increase in water use for only the best practices lead to reduced water use. A foreman with several months experience and training could achieve a daily reduction of 66,000 GPD using the equipment installed for this study. This is assuming the USDA inspector had a reasonable attitude. This resulted in a potential yearly savings of 15,840,000 gallons.

Initial Costs and Annual Budget

The cost of the cleaning systems was only $7,200 as shown in Table 34. Other costs are budgeted in the Water and Waste Monitoring and Control Budget as they are also used during the day. Reduced costs as shown in Table 35 indicate labor is the major reduced cost with water and chemical savings other major components. Increased costs are minimal and the net yearly savings are projected at $31,853. Clean-up operations were found to be very controlable with strict management control and poor employee attitude can make the projected savings disappear. Figure 40 demonstrates poor practices during clean-up as a clean floor is being washed with a hose that has no nozzle.

Water and Waste Monitoring and Control

Problem

This is a overview of the problems presented in each separate process change. The major difference is that the poultry plant lacked the management mechanism to respond adequately to water and waste problems. Therefore, the first priority was on setting up a management scheme to respond not only to this research and development activity but to the normal water and waste needs of a poultry processing facility. The evaluation of the water use and waste load from any facility requires water meters and some methods of representative sampling of the wastewater flow. A real problem in evaluating changes is the maintenance of the necessary records on production, water use, wastewater characteristics and other pertinent factors that influence the water use and waste load. The testing of representative wastewater samples is needed to establish wastewater characteristics and coupled with effluent flow to establish the plant waste load.

Description of Changes

Cumulative use water meters were installed in the following locations to establish the rate of use and the total use of each location (Figure 41): (1) Hose stations, (2) Scalder, (3) Chiller, (4) Pre-chiller, (5) Main-water supply, (6) Main lines feeding the eviscerating area, (7) Final bird washer, (8) Whole bird washer, (9) Gizzard splitters and (10) other irregular or major flows as needed. Water meters installed varied from 5/8 inch to 3 inch with an 8 inch and two 4 inch meters on the supply lines. Adjustable pressure regulators were installed on the eviscerating trough supply and on the side pan wash (Figure 28). A Parshall flume was utilized on the feather recovery effluent and the offal recovery effluent. The final plant discharge was monitored using a Parshall flume, a flow totalizer and a Trebler sampler installed for composite and proportional samples.

Table 34. INITIAL COSTS OF THE CLEAN-UP OPERATION CHANGES

Item	Quantity and/or rate	Amount
Material:		$ 7,200.
2 High pressure cleaners with foaming attachments		
Total Costs (includes tax)		$ 7,200.

Table 35. ANNUAL BUDGET FOR CLEAN-UP OPERATION CHANGES

Item	Quantity and/or rate		Amount
Reduced Costs:			$35,050.
Water	15,840,000 GPY @ $.44/1000 gal	$ 6,970	
Chemicals	$72.00/day to 57.50/day	3,480.	
Labor	160 man hrs/day to 119 man hrs/ day @ $2.50/hr	24,600.	
Increased Costs:			3,197.
Maintenance (20% of cost)		$ 1,440.	
Electricity		65.	
Depreciation - 5 years		1,440.	
Interest on Investment		252.	
Net savings per year			$31,853.

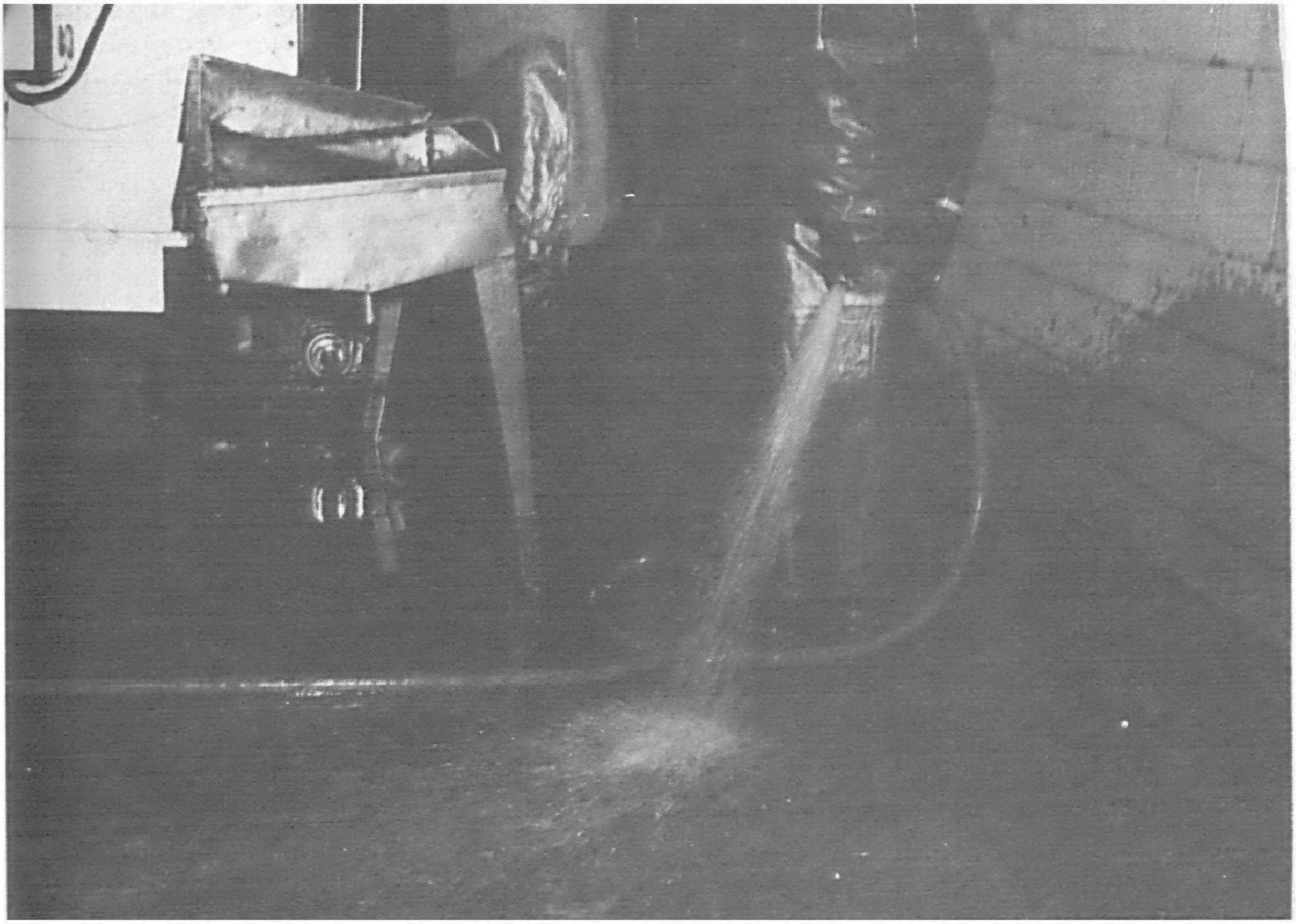


Figure 40. Poor floor washing practice

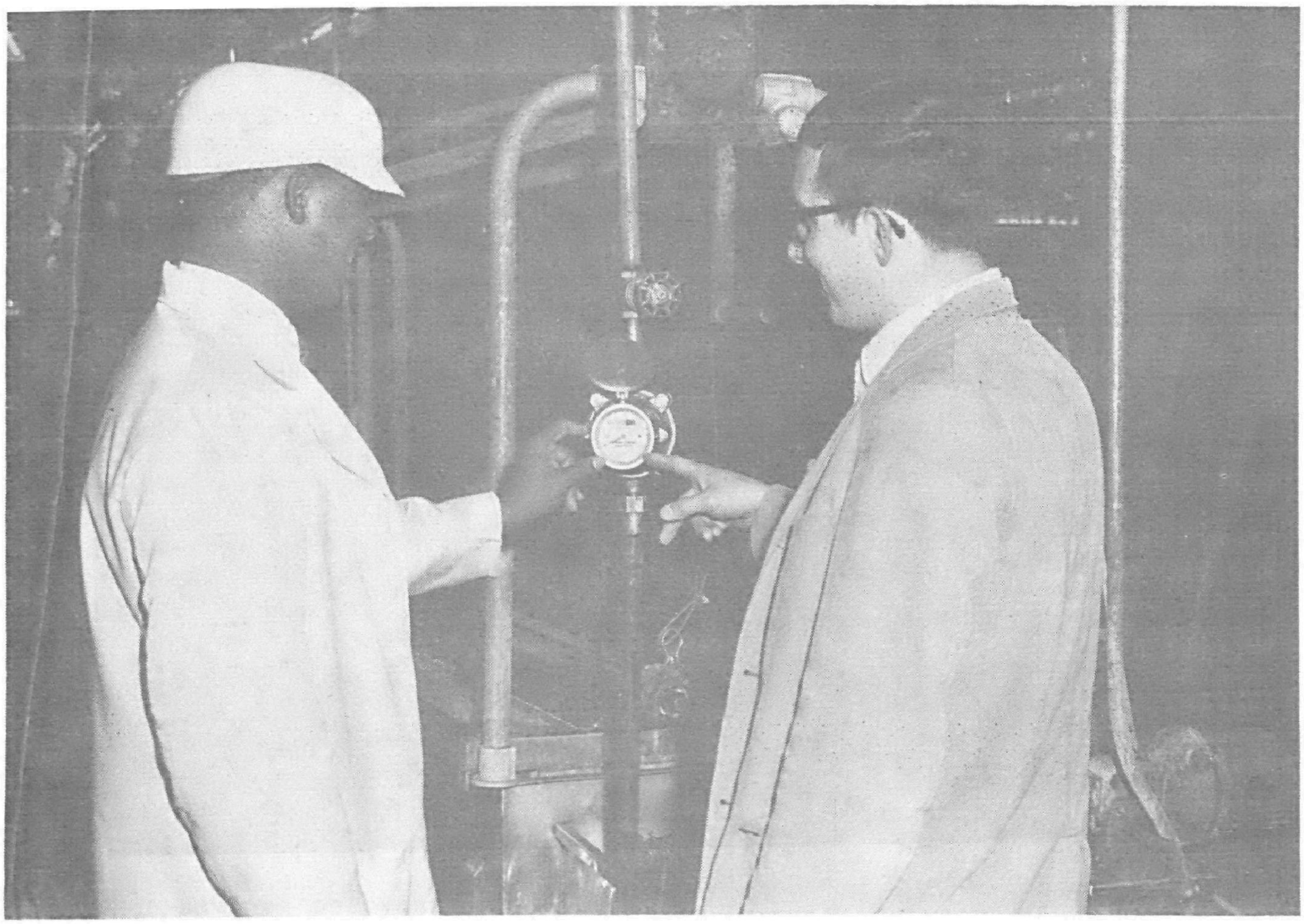


Figure 41. First water meter installed on giblet chiller

Benchmark information indicated a wide range in volume of water being applied to the many unit operations. Many of the variations could be attributed to fluctuations in the city water main pressures. However, many of these fluctuations were compounded by the excessive use of water throughout the plant.

Several regulating and control devices were installed to take the guess work out of adjusting water valves and regulating water flows to operating equipment. Water meters were installed on main water lines and at central water distribution points. Pressure regulating valves were installed on equipment where varying pressures affected the efficiencies of product cleaning and limited the functions of the equipment. Water pressure gauges were installed at almost every place in the plant where an employee is responsible for the adjustment of a water valve or water regulating unit. Employees were taught to adjust the pressure with a regulating valve to obtain proper flow rate. Quick cut off valves were installed to assist employees in cutting off water flows when not needed (Figure 42). Wherever possible the flow rates for individual outlets have been set by a stopwatch at a fixed valve. The valve handles were removed to prevent workers from changing the flow rate. Another simple method utilized for regulating the flow was to install restricted plumbing which was capable of only delivering the desired amount.

An in-plant project director was appointed to work on this project and to supervise the water and waste activities in the plant. He was responsible to see that modifications, sampling and testing were performed. An old kitchen was modified to serve as a wastewater analysis laboratory.

Initial Costs and Annual Budget

Total costs were$20,754, Table 36. The annual budget is different from other annual budgets in that reduced costs are assigned to the respective process change, Table 37. Thus a yearly cost of $16,123 is projected with no revenues shown.

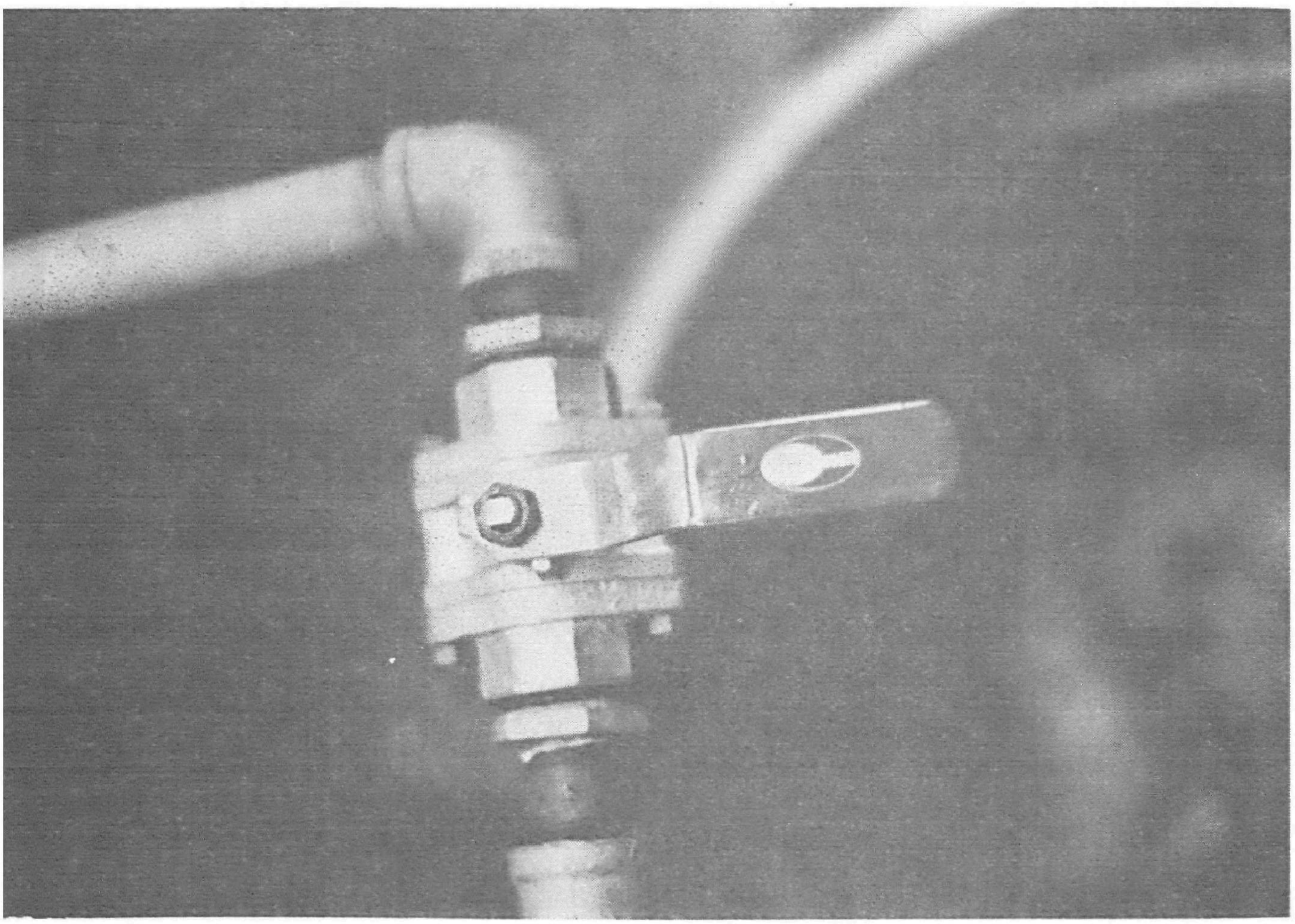


Figure 42. Quick cut off valve

Table 36. INITIAL COSTS OF WATER AND WASTE MONITORING AND CONTROL.

Item	Quantity and/or rate	Amount
Laboratory Space Renovation (200 ft^2)		$ 3,000.
Laboratory		
Equipment	$ 4,466.	
Glassware	875.	
Chemicals	1,250.	
		$ 6,591.
Sampling		
Sampler with Refrigerator	$ 1,000.	
Flow Recorder with Totalizer	1,000.	
Flume	100.	
Installation Materials	250.	
		$ 2,350.
Pressure Regulators		
Plant Source	$ 700.	
Eviscerating	400.	
Materials	500.	
		$ 1,600.
Water Meters	$ 2,500.	
Materials	500.	
		$ 3,000.
Flow Regulation		
Gauges (Pressure)	$ 500.	
Valves	850.	
Materials	250.	
		$ 1,600.
Materials:		$18,141.
Labor: 225 hours @ $10/hr		2,250.
Tax: 2% of Material Cost		363.
Total Costs		$20,754.

Table 37. ANNUAL BUDGET FOR WATER AND WASTE MONITORING AND CONTROL

Item	Quantity and/or rate	Amount
Increased Costs		
Salary - Water and Waste Supervisor		$ 8,500.
Maintenance		1,814.
Depreciation		3,683.
Meters, Regulators, Sampler	$ 1,390.	
Valves and gauges	675.	
Laboratory - 100% in 5 years	1,318.	
Laboratory Space - 100% in 10 years	300.	
Interest on Investment		726.
Utilities expenses		150.
Recurring Costs		1,250.
Supplies	$ 500.	
Chemicals	750.	
Cost per Year		$16,123.

RESULTS

Water Use

Water Use Reductions

The quantity of water used in the operation of equipment and/or process in the poultry processing plant is listed in Table 38. The use is given in terms of gallons per minute (GPM) for the constant uses and a total is given for all uses. The rate was found to be independent of the number of birds processed in a given time period. The focus of the developmental activities was to change the rate of use for selected water using processes. The number of birds processed in a given time period is determined by the speed of the line. An upper limit on the line speed is provided by the design capacity of the plant. The most important factor influencing the rate at which the line can move is the quality of birds entering the plant. The incidence of diseased birds increases the inspection time, decreases the line speed and increases the water use.

A significant point observed in Table 38 is that the gizzard operation uses 31 percent of the total daily water use and 45 percent of the process water use. Major efforts in this area are detailed in Appendix B, Special Study. The handwash outlets are the next largest uses of water.

The total water use in the plant was some 576,000 GPD for processing and clean-up. During the project water used in clean up was reduced to 40,000 GPD. However, clean-up use when the final tests were made had increased from 46,000 GPD to some 164,574 GPD. This can be attributed to changes in management, foremen, inspectors and cleaning procedures. Major water users include the handwashers at 56,000 GPD and the chillers at 40,000 GPD.

The pattern of daily water use can be observed in Table 39. We note that the mean water use is 5.58 GPB for processing, 2.23 GPB for clean-up and 7.81 GPB total use. Water use on Mondays and clean-up water use on Fridays were eliminated because of the difficulty of obtaining water meter readings during the weekend that were representative.

The effect of modifying plant processes to reduce water use had a major impact on water use in a number of processes, Table 40. The most predominate among these was the hand-wash outlets along the eviscerating lines. The reduction in water use from 285 GPM to 100 GPM

Table 38. POTABLE WATER USE AFTER PROCESSING CHANGES

Process	Potable Water Use	Total Volume
	(GPM)	(gal)
Killing Station	4	2,242
Scalder		5,892[a]
Pickers	38	21,295
Neck Scalder	1.5	841
Whole Bird Washer	30	16,812
Hang Back Belt	9.1	5,100
Eviscerating Trough		
Hand Wash Outlets	100	56,040
Side Pan Wash	30	16,812
Gizzard Machine and Flume	320	179,328
Final Bird Wash	60	33,624
Lung Vacuum Pump	14.2	7,958
Giblet Chiller	4.5	2,522
Neck Chiller	4.0	2,242
Chillers	72.1	40,405
Packing Ice		1,200
Bird Pick Up		2,941
Hoses		5,440
Clean-up		164,574
Unaccounted Uses		10,732
Total Use		576,000

[a] Potable water use for start-up only.

Table 39. DAILY WATER USE IN POULTRY PROCESSING

Use	Tuesday	Wednesday	Thursday	Friday	Mean
			(Gallons/Broiler)		
Processing	5.93	5.05	5.89	5.43	5.58
Clean-up	1.97	2.06	2.68	-	2.23
	7.90	7.11	8.57	5.43	7.81

Table 40. OBSERVED WATER REDUCTIONS

Area of plant	Activity	Reduction in potable water use From	To
		(GPM)	(GPM)
Evisceration	Use of improved nozzles		
	Final bird washers	100	60
	Hand washers	285	100
	Cycling of side pan wash	90	30
	Rearrangement of giblet handling	360	320
Scalding and defeathering	Use of improved nozzles in whole bird washers	37	30
	New design of feather flume for reuse of offal flume waters	94	0
	Use of chiller water in scalder to replace fresh water	40	0
		(GPD)	(GPD)
Clean-up	New high-pressure cleaning system with foam	112,000	46,000

represents a yearly savings of 27,000,000 gallons. The cycling of the side pan wash reduced the water use by 60 GPM. The large variation between measured water flow Table 40 and total water use on Table 38 can be explained by the fact that water use is dependent on management and employees. Overall water use increased after the water-waste supervisor left the project. The water use figures on Table 40 represent a compilation of earlier water use figures for individual processes and the total water use for a selected series of process days. The compilation in Table 38 does not define the best possible operations for each process. An example is clean-up which was reduced to 46,000 GPD with strict attention but went up to 164,574 when management pressure was released and inspection procedures changed.

Due to the pressures of production and outside factors, water use changes were made in individual units at different points in time. Thus, totals of individual units could not be merged to form a combined day agreeing with observed use. The total use of 7.81 GPB would be reduced to 6.20 GPB if the clean-up operation was at its lowest observed level of water use. This lower figure represents the best achievable water use without major equipment or process changes.

Costs and Revenues of Water Flow Modifications

Water flow modifications were of three types: (1) modification of processes and equipment already in the plant; (2) reuse of water; and (3) new processes and equipment. A summary of the budgets for changes to reduce fresh water use is given in Table 41. These changes required an investment of $14,555 with an annual cost of $6,369.

The impact of these changes was to reduce annual water use in the plant by 74.3 million gallons (Table 42). The average cost of reducing water use was 8.6 cents per 1000 gallons. This compares favorable with the water rate of 21 cents per 1000 gallons and the combined water and sewer rate of 44 cents per 1000 gallons at the lowest cost increment. Water reduction changes had a net benefit of 35 cents per 1000 gallons and provided an annual net savings of $56,454 above process costs (Table 41).

These features were common to water flow modifications. (1) Flow rates for the various processes were reduced. (2) There was a net savings or reduction in total cost from each of the changes. (3) The initial cost or investment could be recovered within the first year except for the use of chiller water in the scalder. (4) Initial investment was small in comparison with annual net benefits.

Table 41. INVESTMENT AND ANNUAL COSTS AND RETURNS FOR WATER FLOW MODIFICATIONS

Water flow modifications	Investment	Annual costs and returns			
		Process cost	Water reductions	Labor savings	Net savings
	(Dollars)				
Rehang belt washers	49	37	331	--	294
Hand washers	820	389	12,043	--	11,654
Final bird washers	609	304	2,281	--	1,977
Whole bird washers	512	183	684	--	501
Improved feather flow-away	2,123	578	5,377	2,214	7,013
Cycling of side pan wash	1,742	704	3,421	--	2,717
Chiller water in scalder and feather flow-away	1,500	1,177	1,622	--	445
Whole bird washer in scalder[1]	804	578	2,281	--	1,703
Plant clean-up	7,200	3,197	6,970	24,600[2]	31,853[2]
Total[1]	14,555	6,369	32,729	26,814[2]	56,454

[1] Whole bird wash water is an alternative source to the use of chiller water and is not included in total.

[2] Includes $3,480 in reduced chemical use.

Table 42. ANNUAL WATER REDUCTIONS AND RATIO OF PROCESS COST AND WATER REDUCTIONS

Water flow modifications	Annual water reduction	Process cost per 1,000 gallons of water reduction
	(Million gallons)	(Cents)
Rehang belt washers	0.8	4.6
Hand washers	27.3	1.4
Final bird washers	5.1	6.0
Whole bird washers	1.6	11.4
Improved feather flow-away	12.2	4.7
Cycling of side pan wash	7.8	9.0
Chiller water in scalder and feather flow-away	3.7	31.8
Whole bird washer in scalder[1]	5.4	10.1
Plant clean-up	15.8	22.2
Total[1]	74.3	
Average[1]		8.6

[1] Whole bird wash water is an alternative source to the use of chiller water and is not included in total or average.

The relative profitability of water flow modifications and the impact on reductions in fresh water use indicate that in-plant changes provide major opportunity for reducing the level of fresh water use in similar processes in other plants. Individual process and equipment changes can be made. That is, making one change does not require that other changes be made at the same time.

Process and equipment changes should not only be technically but economically feasible. Thus, the annual return on the process cost which includes capital and operating costs is important in deciding on both the modifications to be made and the sequence in which they are made.

Returns per dollar of annual process cost are displayed in Figure 43. The display facilitates a comparison of the relative profitability of each change and the impact on fresh water use. The highest return of $30 per dollar of annual process cost occurred with the use of high efficiency nozzles and valves on the handwashers. The reduction in water use was large. Approximately one third of the water reduction was achieved in this one change. All changes except two provided a return of more than a dollar for each dollar of process cost.

The firm's profit would be increased by these changes since each provided a return on annual process cost greater than one dollar. Priority can be given to the changes on the basis of returns. Also, information displayed in Figure 43 highlights the water reduction achieved by each change. This may also be a prime factor in deciding on the sequence in which modifications are made.

Water flow modifications that reduce process water requirements improve the efficiency of water use. Water reductions may, through technical linkages, improve the waste recovery efficiency of pretreatment methods. This is discussed in a later section of this chapter on joint water and waste reductions.

Each of the water flow modifications was economically feasible and reduced potable water use. Opportunities for further water reductions were identified during the study for which additional research is required to determine the technical, economic and operational feasibility of these processes. These include:

1. Modifications in giblet processing. Giblet processing required approximately 40 percent of the fresh water used in the Gold Kist plant at the end of the study. Gizzard splitters require 240 gpm with the gizzard contents providing an important part of waste load in the final effluent. There may be situations in

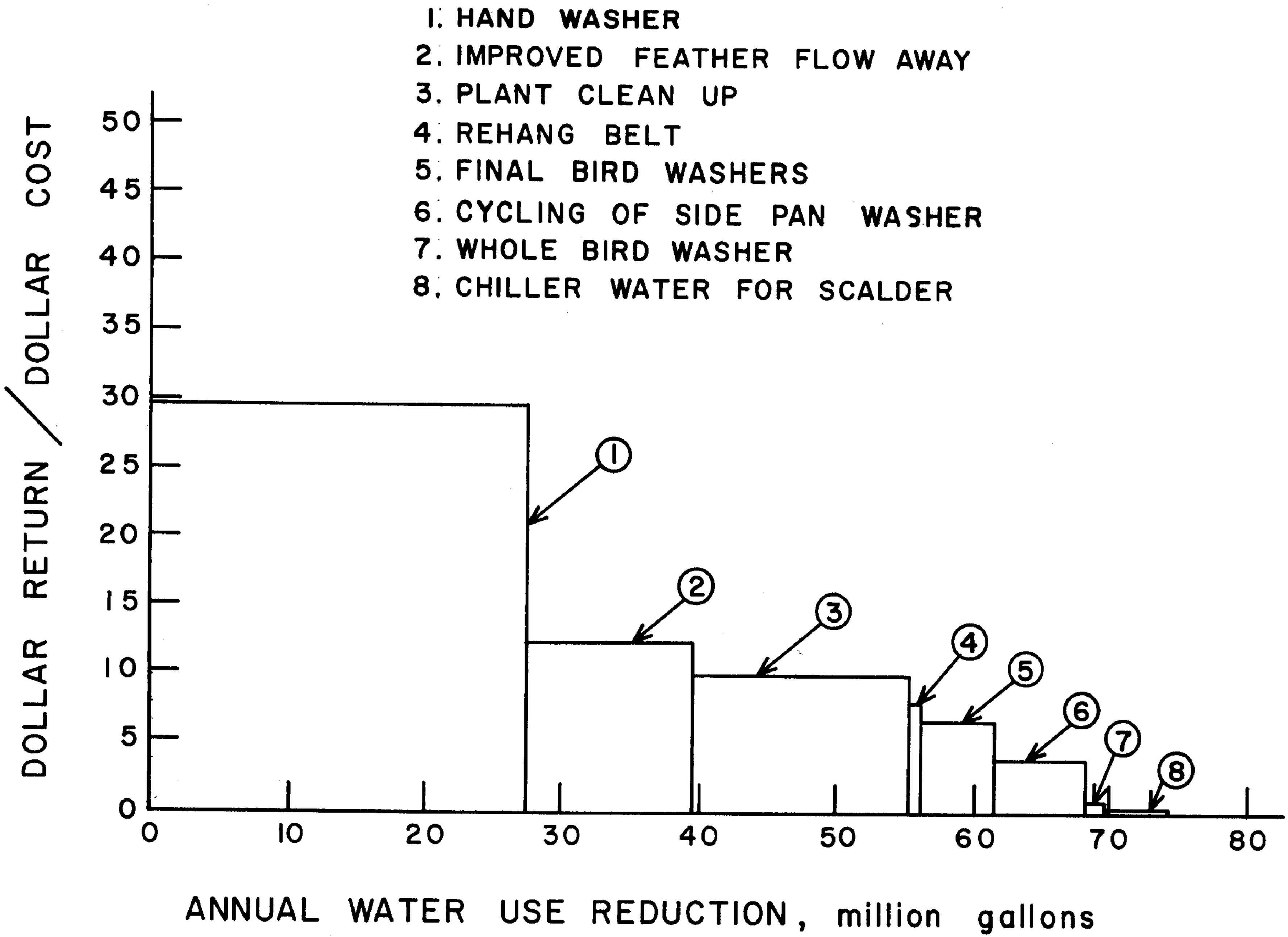


Figure 43. Returns per dollar of annual cost for water flow modifications

which discarding the gizzard and rearranging the handling of other giblets parts may be economical. Reuse of process waters in the gizzard splitter was found to be technically feasible. Additional study is needed to determine acceptability from the standpoint of sanitation, Appendix B.

2. Development of improved nozzles. Hand and product washing are main uses of fresh water. Further research on improved nozzles is needed to determine effective processes, spray patterns, droplet sizes and ease of operation for the many uses of nozzles throughout the plant.

3. Reuse of water. Sanitation requirements limit the reuse of water in poultry processing. Areas of potential reuse include the gizzard splitter and side pan rinse.

4. Scalding and chilling. New approaches to scalding and chilling that minimize the use of water are needed.

5. Packing. Dry ice is used in packing and has the advantages of replacing the use of ice. A main advantage may be the reduction in the weight of the final pack which reduces shipping weight and storage space.

Wastewater Characteristics

The compilation of wastewater characteristics can be observed in Table 43. One must note that the figures represent sampling at the plant drain, after the settling basin and then the effluent after the AFC on its way to the city sewers. Wastewater from poultry processing is best characterized by using waste load as is reported in the next section.

The BOD_5 of 390 mg/l is less than figures commonly found in the literature such as 427 mg/l[1] and 473 mg/l[12] for poultry processing effluents. Industrial contacts have indicated higher BOD is common in the poultry processing industry and the 615 mg/l BOD_5 reported by Camp[11] may be more representative of the industry although good data is not available. The COD/BOD_5 ratio varies from 2.2 to 2.7 for these wastewaters. The BOD_5 of 390 mg/l can be compared with the Benchmark results of 560 mg/l. The observed reduction occured because of changes made and was simultaneous with water use reductions.

Table 43. FINAL WASTEWATER CHARACTERISTICS

Sampling Point	BOD_5	COD	TS	SS	GREASE
		(mean mg/l)			
Process Effluent	390	936	729	540	141
After Settling Basin	329	710	599	267	98
After AFC	282	621	521	214	64

Waste Load

Introduction

The opportunities explored for waste load reduction included isolation and collection of blood, improvements in offal and feather recovery and decreases through removal in the settling basin and in the AFC. The special tank installed on the by-products truck to collect the blood and lung tank discharge should have also eliminated a large source of waste.

Production processes were found to be constant in water use per unit of time while the amount of waste which gets into the plant wastewater is constant per unit of product. Opportunities explored for water and waste load reductions included improved management, new and modified in-plant equipment and processes, pretreatment of wastewaters and primary wastewater treatment. Most traditional poultry processing techniques were not compatible with economic water and waste management and were modified to achieve reductions in water use and waste load. Waste reduction methods involved improving and developing pretreatment and by-product recovery methods to reduce the waste load per unit of product in the final effluent.

Waste Load

The waste load from the plant is displayed in Table 44. The process wastewater BOD_5 of 390 mg/l is less than the normal 427-615 mg/l often seen for the wastewaters of poultry processing plants. More important is the waste load of 25.38 lbs BOD_5/1000 broilers received. Most poultry processing plants have waste loads of approximately 2 to 3 times this figure. Camp[11] reported a most modern plant that discharged 39 lbs BOD_5/1000 broilers. Most poultry processing plants discharge approximately 60 lbs BOD_5/1000 broilers as found during the Benchmark studies.

The waste load after pretreatment and after the AFC is displayed in Table 44. The BOD_5 load has been lowered from 25.38 to 18.36 lbs/1000 broilers received by settling and AFC treatment. The grease has been lowered from 9.37 to 4.16 lbs/1000 broilers through these same two processes.

The real significance of the water and waste improvements in the plant can best be demonstrated by Table 45 which gives a comparison of the Benchmark and Final Results. The BOD_5 load has been reduced from a level of 3,970 lbs/day to 1,355 lbs/day with an increase in production. The decrease is perhaps best demonstrated by the lbs/1000 broilers received reduction of 57.37 to 18.36. Grease has been reduced from

Table 44. WASTE LOADS

Characteristic	Process Effluent (mg/l)	(lbs/day)	(lbs/1000 broilers rec'd)
BOD_5	390	1,873	25.38
COD	936	4,496	60.92
TS	729	3,502	47.45
SS	390	1,873	25.38
Grease	144	692	9.37
	After Settling		
BOD_5	329	1,580	21.41
COD	710	3,411	46.21
TS	599	2,878	38.99
SS	267	1,283	17.38
Grease	98	471	6.38
	After AFC - Effluent to Durham		
BOD_5	282	1,355	18.36
COD	621	2,964	40.16
TS	521	2,503	33.92
SS	214	1,028	13.93
Grease	64	307	4.16

Table 45. COMPARISON OF BENCHMARK AND FINAL RESULTS - WASTE LOADS

Waste Load			Benchmark	Final*
BOD_5	lbs/day		3,970	1,355
	lbs/1000 broilers		57.37	18.36
	lbs/1000 lb LW		15.72	4.89
	lbs/1000 lb KW		21.24	6.63
COD	lbs/day		5,118	2,964
	lbs/1000 broilers		73.96	40.16
	lbs/1000 lb LW		20.26	10.56
	lbs/1000 lb KW		27.36	14.50
Solids	Total	lbs/day	4,941	2,503
		lbs/1000 broilers	71.40	33.92
		lbs/1000 lb LW	19.56	9.04
		lbs/1000 lb KW	26.44	12.24
	Dissolved	lbs/day	2,283	1,475
		lbs/1000 broilers	32.99	19.99
		lbs/1000 lb LW	9.04	0.33
		lbs/1000 lb KW	12.22	7.21
	Suspended	lbs/day	2,658	1,028
		lbs/1000 broilers	38.41	13.93
		lbs/1000 lb LW	10.52	3.71
		lbs/1000 lb KW	14.23	5.03
Grease	lbs/day		1,063	307
	lbs/1000 broilers		15.36	4.16
	lbs/1000 lb LW		4.21	1.11
	lbs/1000 lb KW		5.69	1.50

* Final effluent after settling and AFC treatment.

15.36 to 4.16 lb/1000 broilers received. Suspended solids was reduced from 38.41 to 13.93 lbs/1000 broilers received.

Costs and Revenues of Waste Reduction Changes

Two approaches were followed in reducing the waste load in the final plant effluent. First, a method was developed for improving the collection of blood. Second, existing pretreatment processes were improved and an air flotation cell was installed. The first approach involved keeping the waste out of the effluent while the second involved recovery of waste from the effluent. All wastes can be used in by-product processing for animal and poultry feed.

A summary of the budgets for changes to reduce the waste load in the plant effluent is given in Table 46. Waste abatement changes reduced the annual waste load by 204,300 pounds of BOD_5 (Table 47). These changes required an investment of \$57,756 with an annual net savings \$19,728. The average cost of reducing the waste load was 4.1 cents per pound of BOD_5 (Tables 46 and 47). These costs compare favorably with a surcharge rate of 8 cents per pound of BOD_5.

Annual waste reductions totaled some 204,300 pounds of BOD_5 for the blood recovery modifications and the installation and operation of the AFC (Table 47). The return per dollar of annual cost averaged \$5.00.

Limitations on the level of grease and feathers permitted in the plant effluent, imposed by the Durham waste treatment authorities, increased the need for improved recovery of these materials. An air flotation cell was installed to remove solids and grease. The use of screens of a higher mesh was feasible after fresh water use had been lowered and the hydraulic load on the screens reduced. Reducing water use in order to achieve improved waste recovery was quite important.

A modification that intuitively reduces the waste load is a head puller as shown in Figure 44. Heads were removed, deposited in plastic trash barrels and disposed of as offal. Use of the system shown is questionable with some USDA inspectors. No costs were developed for this item and reductions in waste load could not be determined. The dry carry-off of solids should reduce the waste load by preventing the leaking of solubles from the solids and also the washing off of bits and pieces. A good example of this is the use of the "dry belt" to carry away viscera.

Table 46. INVESTMENT AND ANNUAL COSTS AND RETURNS FOR WASTE REDUCTION MODIFICATIONS

Waste reduction modifications	Investment	Annual costs and returns				
		Process cost	Surcharge reduction	By-Product Sales	Labor and Chemical saving	Net saving
Improved blood recovery	7,674	1,672	6,039	7,791	3,584	15,742
Air flotation cell	50,082	6,859	9,946	899	-	3,986
Total	57,756	8,531	15,985	8,690	3,584	19,728

Table 47. ANNUAL WASTE REDUCTIONS AND RETURNS PER DOLLAR OF ANNUAL COST

Waste reduction modifications	Return per dollar of annual cost (dollars)	Annual waste reduction (1,000 lbs BOD_5)
Improved blood recovery	9.42	80.0
Air flotation cell	0.58	124.3
Total		204.3
Average	5.00	

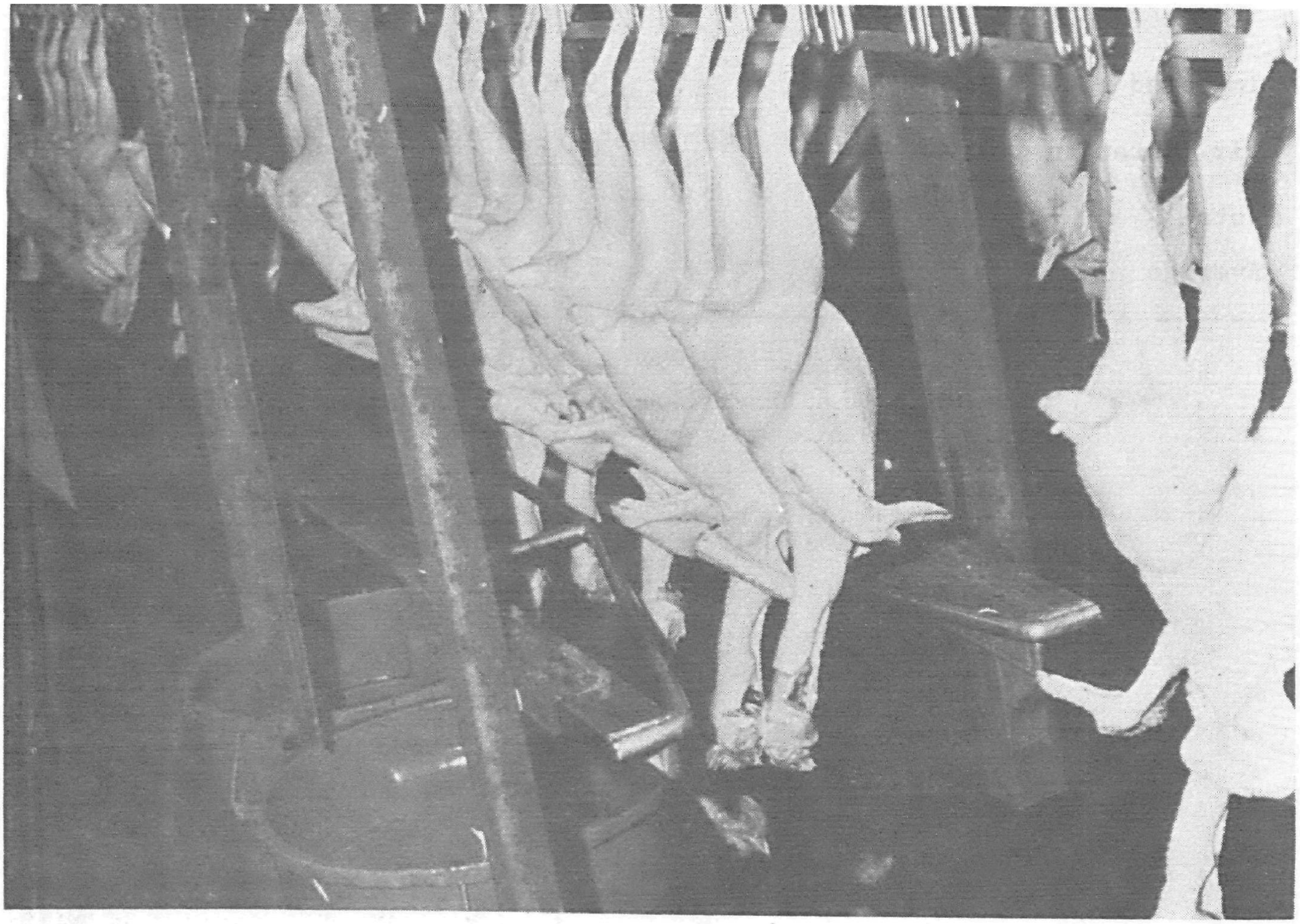


Figure 44. Head puller

Feathers and trash lost from empty coops on return trips in the hauling of broilers is a major problem. A coop cleaner was installed to remove feathers and trash in the plant. Budgets could not be prepared for the coop cleaner nor could absolute figures be applied to waste reductions.

Opportunities for Further Waste Reductions

Opportunities for further waste reductions include:

1. Modifying giblet processing. It was estimated that approximately 25 percent of the waste load resulted from giblet processing and handling. Discarding gizzards and hearts and modifying the handling of livers and necks provide an opportunity to reduce the waste load. Studies are needed to determine under what conditions this would be economically feasible.

2. Grease recovery is possible from the final bird wash water and chiller water and is a potential source of animal fat that has commercial uses.

3. The elimination of the scald tank and its replacement with a steam or water mist system should help to reduce waste load by concentration of wastewater.

4. The elimination of the immersion chiller with water spray, conventional refrigeration or cryogenic systems should prove beneficial in reducing waste load.

5. A most important change forseen for current processors could be the "dry belt" transport of viscera, heads and feet to the offal truck.

Water and Waste Reduction Relationships

Interdependence of Water and Waste Reductions

A relationship between water and waste reductions was not apparent when individual process and equipment changes were reviewed. This would be expected as water flow modifications did not involve either waste recovery or limiting the amount of waste entering the feather or offal flow-away flumes. Neither did waste reduction modifications limit water use. However, improved employee attitudes toward water use and waste provided observable reductions in both.

Water use per unit of time and waste load per unit of output are technically fixed parameters. A reduction in water use with a fixed waste load leads to an increased concentration of all waste characteristics in the wastewater. However, the concentration of BOD_5, grease and solids decreased during the water use reductions of this study, Figure 45. A major result of the study was to uncover this important relationship between water and waste reductions. During the 14 month period from October, 1969 to December, 1970, in plant changes were limited to water reducing modifications. Reductions in water use per bird during this period resulted in a corresponding reduction in waste discharges per bird (Figure 45). The amount of BOD_5 per bird declined at approximately the same rate as the reductions in potable water use. This relationship reflects improved efficiencies of the pretreatment process-screening and solids removal in the basin and AFC as the hydraulic loading was lowered. Further research is needed to evaluate the importance of operating pretreatment processes at or near design capacity in achieving reductions in waste loading. Since the selection and sizing of pretreatment and waste treatment processes depend to a major extent on hydraulic loading, the implication of complementarities between water and waste reduction are important in assessing the cost of achieving environmental objectives.

This relationship between water used reductions and waste discharge may have also been a result of improved employee attitudes and practices or a result of reduced water use leading to less washing of organics from viscera, feathers and other waterborne matter. Water use reductions at hose stations were partially a result of employees getting less waste on the floor. The hose station water use reductions were also indicative of dry/solid waste clean-up instead of washing to the drain as had been the previous practice. We can postulate that less water use in the evisceration trough, the feather flume and the viscera flume mean less washing of the waterborne matter and therefore less removal of organics. However, this has not been tested by experimentation.

This major finding involved the interdependence of water and waste reductions. The technical linkages between water and waste reduction are of major importance in deciding on the economic feasibility of individual processes. These interrelationships are of special importance if the firm is required to pay municipal surcharges on waste or water volume discharges or to provide a wastewater treatment facility to achieve specified reduction in waste loads.

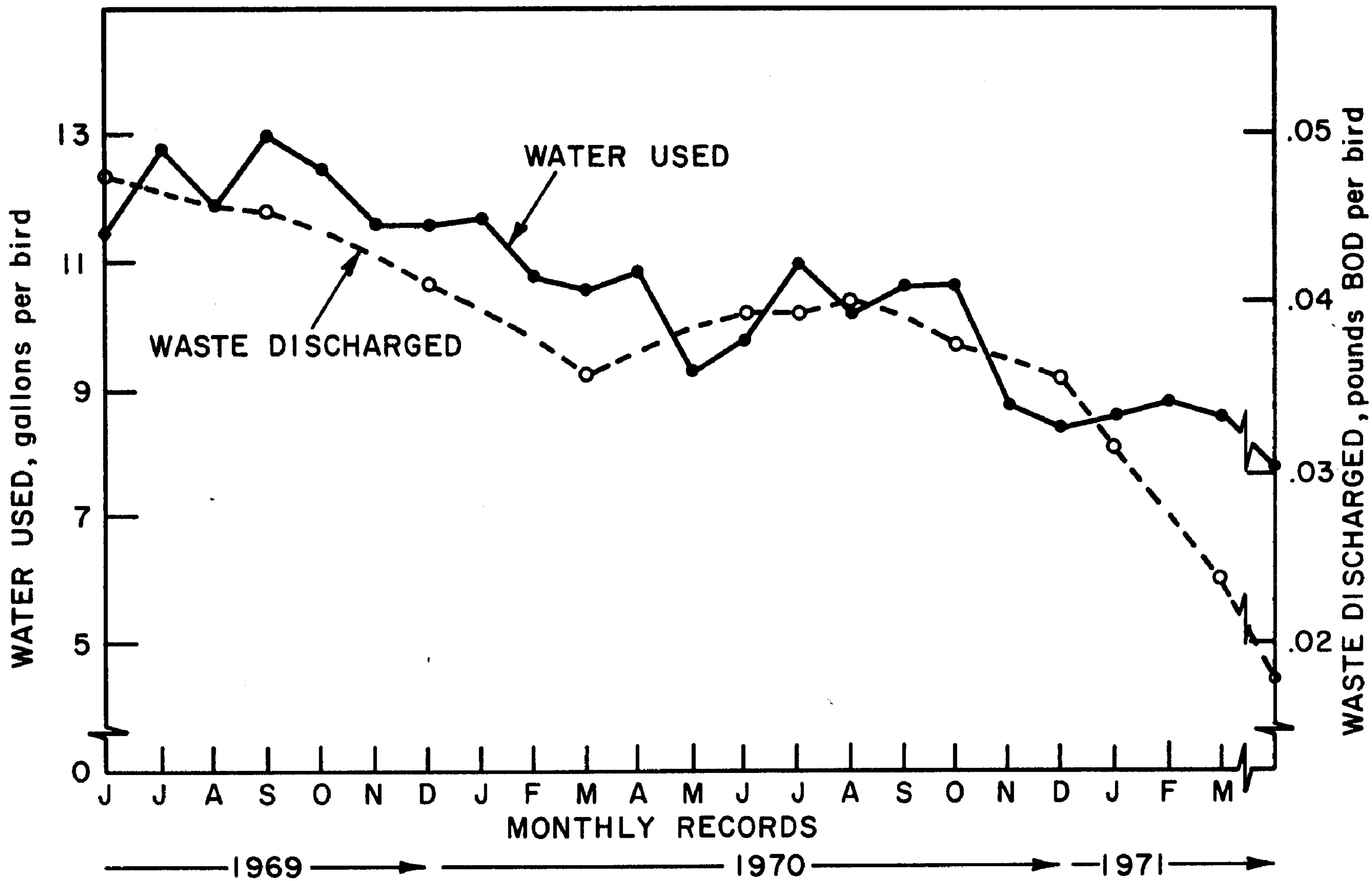


Figure 45. Quantity of water and waste per broiler

Allocating Cost Reductions

Waste abatement costs were reduced when water flows were modified. First, there was a decrease in sewer surcharges. This was achieved by removing a greater proportion of the BOD_5 in the final plant effluent. Second, the hydraulic loading, a major factor in determining the size requirements of the air flotation cell, was lowered. The investment and operating costs of the cell were reduced in direct proportion to changes in fresh water use.

The reductions in waste abatement costs should be allocated to water process and equipment changes to the extent they are identified. Since the relationship between water and waste reductions were established in the study, analysis of individual processes and the total plant can be used to examine technical and economic relationships.

Technical and Economic Relationship

During the 18 month period from July, 1969 to December, 1970 water use per bird was reduced 30 percent by water flow modifications while waste discharged per bird declined by 33 percent. This was a daily reduction of 1320 pounds of BOD_5 and 262,000 gpd of water use. Without the complementarity between water and waste reductions, reducing water use by 262,000 gpd would have required a surcharge of $105.60 per day, 1320 pounds of BOD_5 at 8 cents per pound. This is equivalet to 40.3 cents for each 1000 gallons of reduced water use.

Investment and operating costs of the air flotation cell were lower due to water flow modifications. A cell designed for 1320 gpm, the average use during processing at the beginning of the project in July, 1969, had an estimated initial cost of $72,000. A 30 percent decrease in fresh water use to a level of 924 gpm, lowered the cost of the cell to $50,000. This was a proportional reduction of 30 percent in the initial cost of the air flotation cell. There was a cost of $54 per gallon per minute of design capacity. The reduction in costs of the AFC was greater than the costs of the water flow modifications (Table 48).

Wastewater water treatment was not studied. However, investment and operating costs of waste water treatment facilities would be reduced by water flow modifications. In-plant process and equipment changes for both water and waste reduction should be considered for improving existing pretreatment or treatment processes or when new systems are installed. The reduction in investment for additional treatment processes may be greater than the cost of making the in-plant changes to reduce the hydraulic load of treatment processes. Table 48 tabulates that dollar investment for water flow can be more than

Table 48. REDUCTION IN COST OF AFC CONTRASTED WITH INITIAL COST OF WATER RELATED CHANGES

Process	Initial cost of water flow modifications	One time Reduction in the cost of the air flotation cell[a]
	(Dollars)	
Rehang belt	49	313
Hand washers	820	11,405
Final bird wash	609	2,160
Whole bird wash	512	648
Improved feather flow-away	2,123	5,092
Cycling of side pan wash	1,742	3,240
Chiller water in scalder and feather flow-away	1,500	1,536
Whole bird wash water in scalder	804	1,696
Plant clean-up	7,200	b

[a] Allocated on the basis of $54 per gallon per minute reduction in initial investment cost of the air flotation cell.

[b] Plant clean-up does not effect sizing requirements for air flotation cell.

recovered in the initial cost of the AFC.

A summary of the cost and income effects of the complementarity between water and waste reduction is given in Table 49. The reductions in sewer surcharges, cost of the air flotation cell, and water, chemical, and labor costs are of the same magnitude. The benefits from water flow modifications were approximately tripled due to complementarity of water and waste reductions.

Identifying and establishing the complementary relationship between water and waste reduction and the favorable impact on reducing cost was perhaps the most important result from the project. The implementation of sewer surcharges by municipalities and effluent standards for waste treatment systems will increase waste abatement requirements. A better understanding of the complementary relationship between water and waste reductions will be useful in deciding on process and equipment changes required for improved waste abatement.

Microbiological Evaluation

The Benchmark microbiological report submitted earlier covered the analysis of samples obtained during the period of March to May 31 for a total of eight evaluations. After that, additional evaluations were made at various intervals for over a year until July, 1971. During these evaluations only the water samples from the designated points and the finished carcass samples were obtained for determination of total counts and the coliform counts. Final carcass samples were also checked for the presence of Salmonella. All water flow modifications were completed by July, 1971, and further microbial tests were not performed.

The results first obtained were analyzed separately for the period (June 1 to September 30, 1970) so that a comparison may be made with the Benchmark results (March to May 31, 1970) during which period no changes in the machinery or water circulation were made. Also the range of microbial counts, mean and median counts were calculated for the entire period of sampling (March to September 30, 1970). The summarized data is reported in Figure 46, 47 and 48. Few changes were made in the use of water during processing during this March to September time period. The initial results were extended with the assumption that both of these periods of processing operation were compatible and suitable for benchmark data.

Table 49. BUDGETS FOR FLOW MODIFICATIONS INCLUDING SEWER SURCHARGE REDUCTIONS

Process	Annual Cost and Returns for flow modifications			
	Process cost	Water, Chemical and labor reductions	Sewer Surcharge reductions[a]	Net Savings
		(Dollars)		
Rehang belt	37	331	303	597
Hand washers	389	12,043	11,031	22,685
Final bird wash	304	2,281	2,089	4,066
Whole bird wash	183	684	627	1,128
Improved feather flow-away	578	7,591	4,925	11,938
Cycling of side pan wash	704	3,421	3,134	5,851
Chiller water in scalder and feather flow-away	1,177	1,622	1,486	1,931
Whole bird wash water in scalder	578	2,281	2,176	3,879
Plant clean-up	3,197	35,050	6,384	38,236

[a] Allocated on the basis of $.403 per 1000 gallon reduction in annual water use.

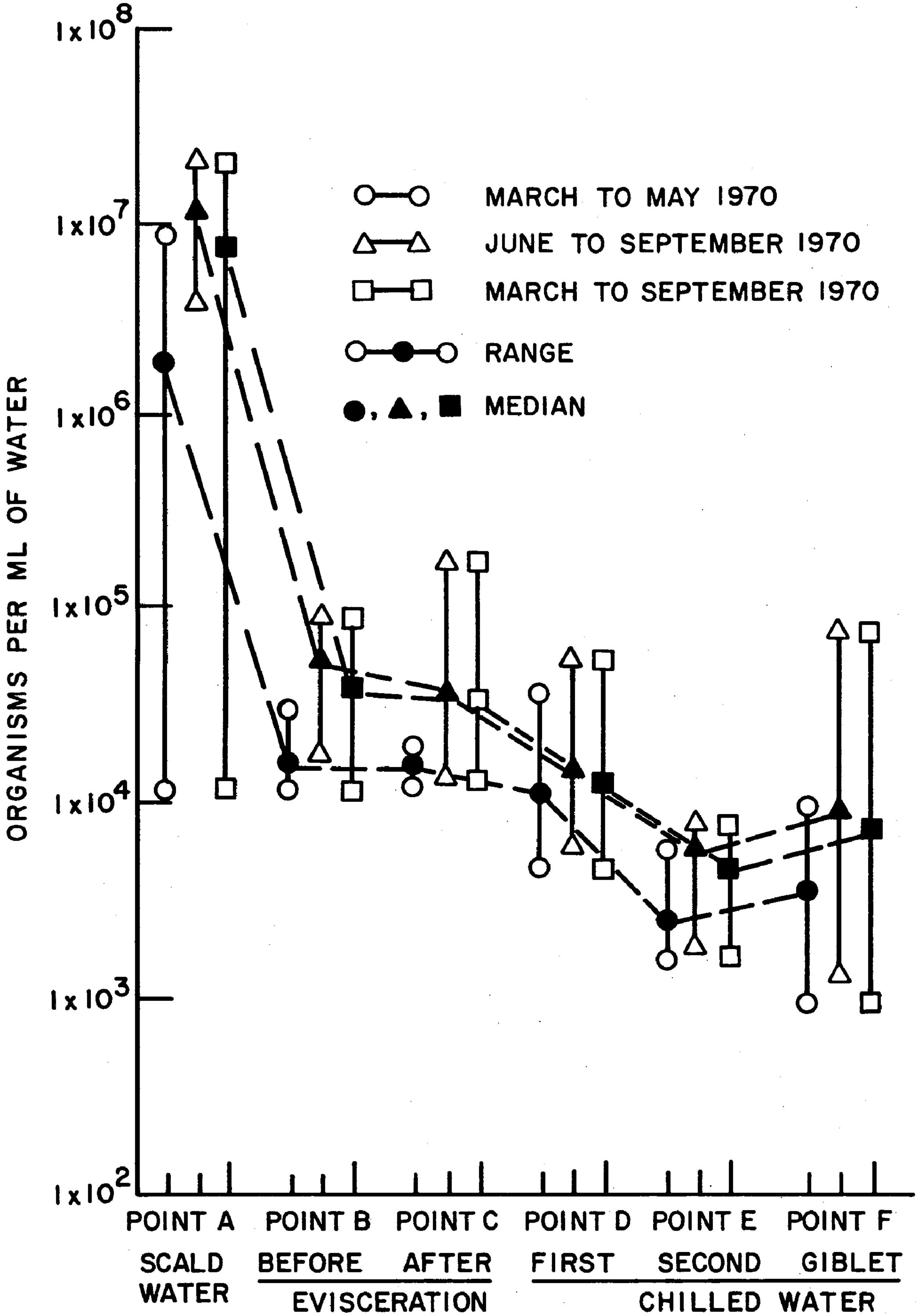


Figure 46. Total counts at various processing points

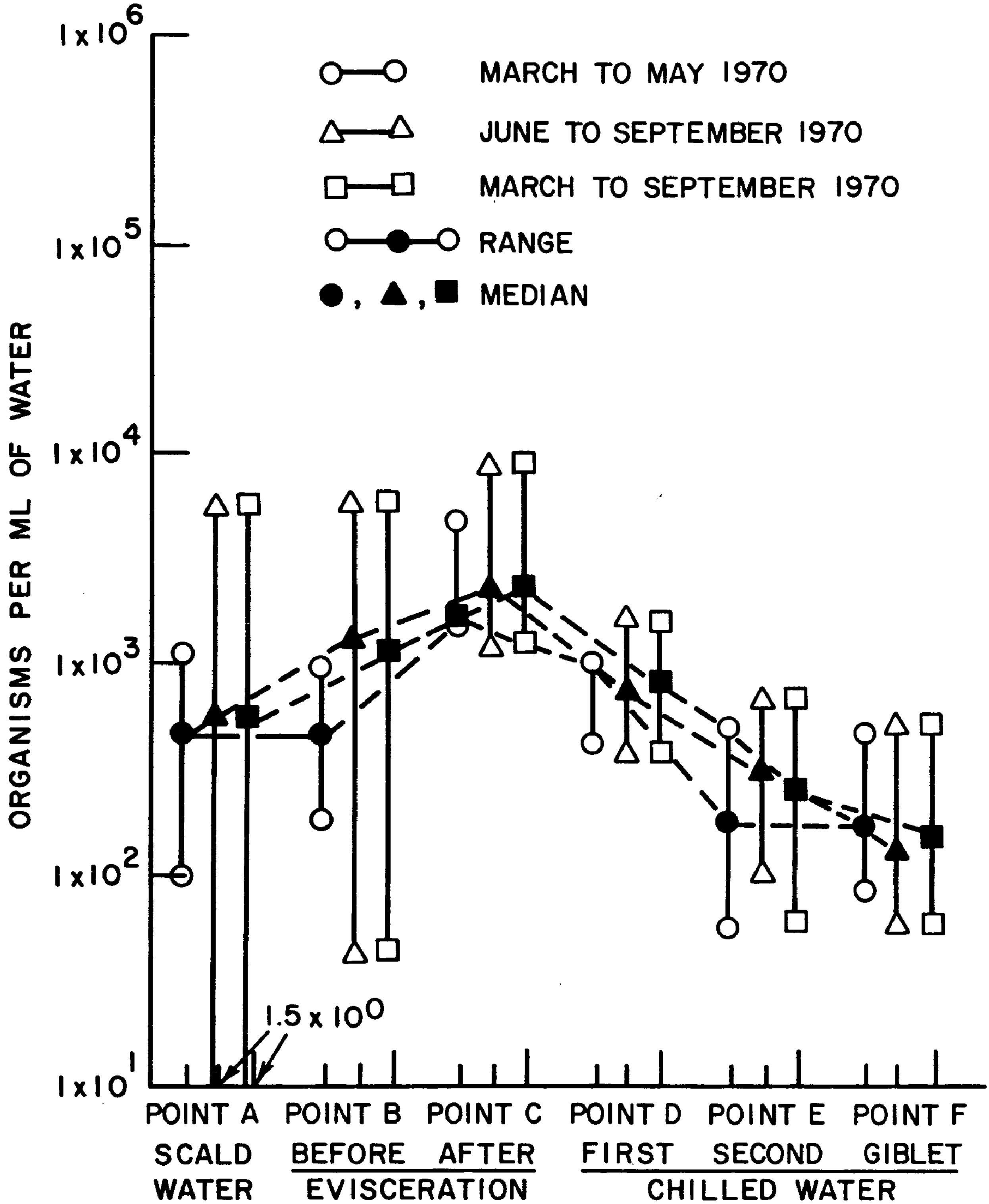


Figure 47. Coliform counts at selected points

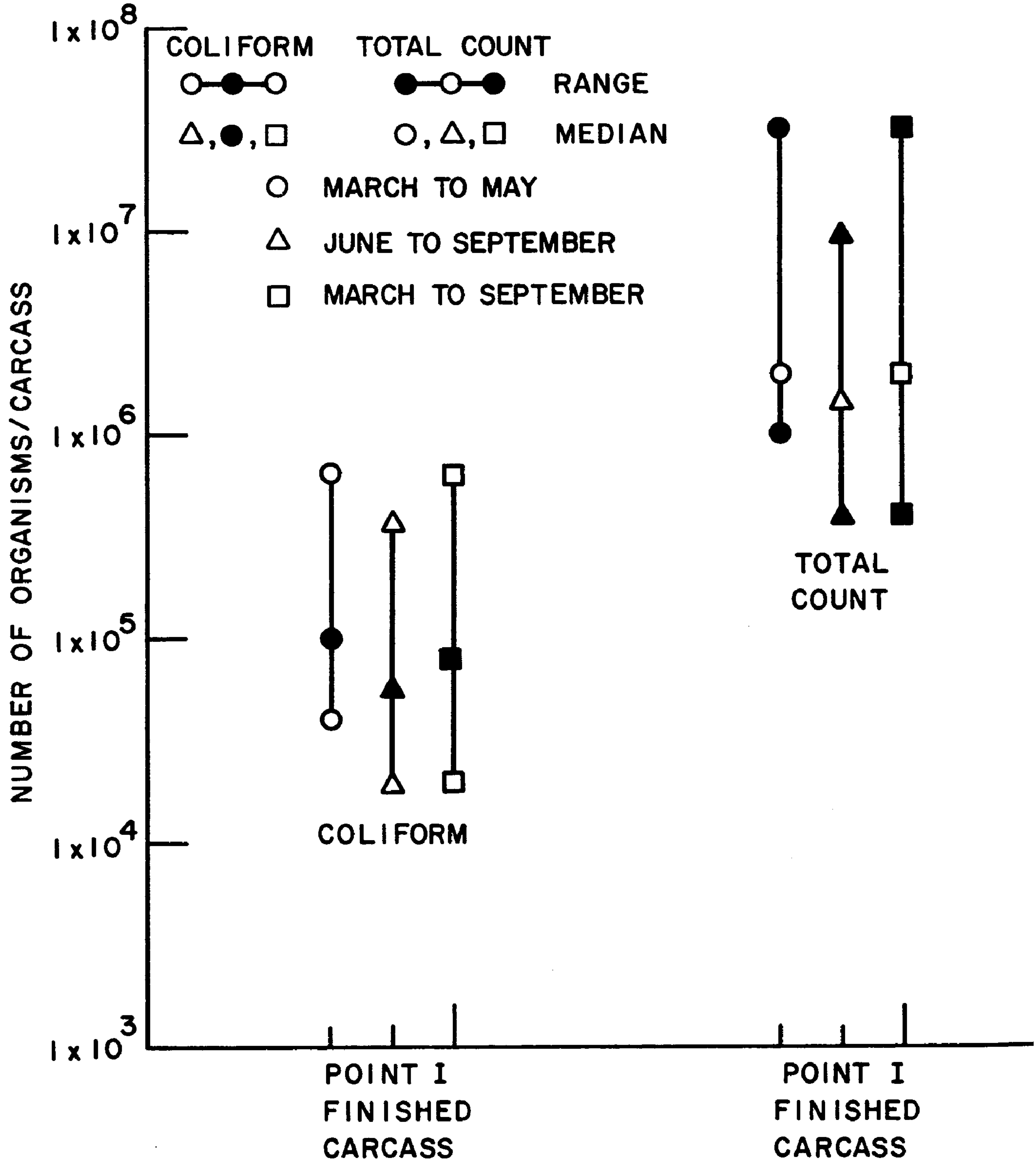


Figure 48. Total and coliform counts of whole carcass

On overall examination of these results one first observes the similarity of the trend in microbial counts at the different sampling points obtained during the two initial sampling periods (Figure 46 and 47. March to May; June to September).

The seasonal effect on the total microbial flora is reflected in the counts of scald water at sampling point A. As expected the total counts are much higher during the hot and humid climatic period of June to September compared to the samples analysed during the mild weather of March to May 1970. The higher initial counts of the scald water during the period under report also explains partly the increase in total counts observed at the other sampling points except at the finished carcass level (Figure 48). Surprisingly, the seasonal effect of increase in counts is not observable in the carcass samples. The microbial level of the finished carcass has shown a slight decrease in total counts as well as in coliform counts during the second period of studies.

During the second 8 week period, Salmonella was detected in 4 carcass samples out of 24 tested as compared to 9 out of 23 in the first period.

Keeping in mind the limitations in the number of samples tested, it may be concluded that the overall trend in the microbial counts during both the sampling period were similar and that the microbiological quality of the finished carcass has not changed significantly. For the remainder of the sampling period which totaled one year before the Special Study (Appendix B), similar results were observed with no trends apparent.

With current technology, there is no better way of determining the actual (consumer) safety of a product such as poultry than by the use of microbiological evaluation. This, of course, assumes that chemical toxicants or carcinogens have not been introduced into the poultry through feed or water during their growth. Also, this study sought to evaluate quality changes that take place during processing and our microbial testing program of water and carcass did this. For this reason, microbiological testing for total count, coliform count and presence of salmonella was conducted on the whole carcass after processing during the time period in which water flow and waste reduction modifications to equipment and process were being made. Water samples were also analyzed but the final quality of the finished product was felt best judged by the whole carcass evaluation. A summary of the results is presented in Table 50.

Results from the period from March, 1970 to March, 1971 were used in comparison with the Special Study (Appendix B) during which maximum reuse and continued use of water occured. The mean value for total count and coliform count and the presence of salmonella all were less during the Special Study than previously. The results were not significantly different but the presence of salmonella showed a 36 percent reduction from 21.5 percent to 13.8 percent incidence rate.

The media values of both total and coliform bacteria were also lower during the Special Study (Appendix B) during which maximum water reuse and continued use occured. This Special Study took place in the middle of 1971 at which time all water use modifications had been completed. However, the reductions in total count and coliform count were not significantly different (Appendix B, Tables 7, 8 and 9). The mean total count of the whole carcass was 2.8×10^6 during the continued use period (Table 50). The mean carcass coliform count was 1.1×10^5 during the continued use period (Table 50). Salmonella was detected in 18 out of the 130 carcass evaluations.

It can be concluded that no reduction in the consumer safety of the finished product occured during the water and waste reductions. In fact, slight improvements were observed which may be due to factors other than equipment modifications such as seasonality factors, weather, improved plant sanitation or other such factors. Poultry processing plants may reduce their water use and waste loads using the changes outlined in this study without fear of degrading the microbiological quality of their product.

Table 50. BIOLOGICAL EVALUATION OF FINISHED CARCASS

	Total Count* (mean)	Coliforms* (mean)	Salmonellae No. carcasses Tested	No.+
March 1970 to March 1971	3,400,000	120,000	102	22
April - June 1971	2,800,000	110,000	130	18

* Counts per whole carcass.

TOTAL PLANT EVALUATION

A benchmark of water use and waste loads was established for the total plant prior to the modification of in-plant processes and equipment. The levels of water use and waste load achieved by the end of the project were compared with the benchmark information to determine the overall impact of changes made in the plant.

Technical Results

Reductions in fresh water use and waste loadings were achieved by regulating and controlling water flows, improving housekeeping practices, and making process and equipment changes. Water and waste monitoring information provided the data for evaluating the overall technical results obtained in the study. Costs and revenues were related to the technical changes to provide economic evaluation. The following reductions in total water use and waste loading in the final effluent were achieved with several other improvements.

1. Average daily fresh water use was reduced by 32 percent, from 850,000 GPD to 576,000 GPD.

2. The plants daily waste load was reduced by 66 percent, from 3,970 to 1,355 pounds of BOD_5.

3. The BOD_5 in the final effluent was reduced by 50 percent, from 560 mg/l to 282 mg/l.

4. The level of grease was reduced by 57 percent, from 150 mg/l to 64 mg/l.

5. Blood from the killing room was effectively eliminated from the plant effluent and recovered for by-product sales.

6. Feathers in the plant effluent were controlled to acceptable levels.

7. Feathers and dry materials from empty coops were effectively removed prior to placing coops on trucks after unloading.

8. The microbiological quality of the final product was not lowered.

9. Other important benefits from the project included improved working conditions in the killing room, an increase in the operating rate of the plant from an average of 7,299 to 7,868 birds processed per hour, reduced chemical use reduced

labor requirements and improvements in equipment arrangements such as giblet fluming.

Water and Sewer Costs

Savings in water and sewer costs are a major component of the cost reductions from in-plant changes. The Durham water and sewer rate of \$.44 per 1000 gallons of water and \$.08 per pound of BOD_5 on all waste above 250 mg/l were used in the analysis. The total plant analysis included the affects of all changes made during the project period.

The average monthly cost of water and sewer services, adjusted for number of birds, declined by \$5,344 from a three month average of \$10,164 during May - July, 1969 (Table 51). This was a reduction of \$3.98 per 1000 birds processed.

Overall Benefits and Costs

Annual benefits and costs are estimated from the results achieved during the fourth quarter of fiscal 1972. All changes including the installation of the air flotation cell were completed by July, 1972. Performance rates per 1000 birds for a test period during July 1972 was used in developing annual benefits and costs for the plant (Table 51, 52).

Research and development costs were not included in the evaluation. It was recognized that obtaining information for decisions on in-plant changes may be an important management cost. The purpose of the development and demonstration project was to provide development capital and process information and make it readily available through published results and on-site demonstrations. Finally, there were costs to the firm for training plant personnel and supervising operations during the implementation of plant modifications which were covered to some extent by including the cost of one full time person for water and waste management.

The total investment in in-plant changes was \$93,065 (Table 52). Annual cost, including water and waste monitoring and a full-time in-plant manager, was \$31,023. Net annual income and cost savings of \$72,193 were achieved in the Gold Kist Plant. Annual savings per dollar of annual cost were \$2.33. Net annual savings per 1000 birds was \$4.08.

Table 51. WATER AND SEWER COSTS COMPARISON INCLUDING SURCHARGE[a]

Item	3 month average (May-June-July) 1969	1972[c]	Change 1969-1972
Water Cost	$ 3,238	$ 2,199	$ 1,039
Sewer Cost	3,546	2,408	1,138
Surcharge[b]	3,390	223	3,167
Total	$10,164	$ 4,830	$ 5,344
Gallons per bird	11.5	7.81	3.69
BOD_5 in effluent	560 mg/l	282 mg/l	298 mg/l

[a] The average water and sewer rate was $0.51 per 1000 gallons of water and a sewer surcharge of $0.08 per pound of B.O.D. was charged on all waste above 250 mg/l.

[b] Computed based on sampling and testing results in July 1972 after completion of AFC and actual water use data.

[c] Adjusted to 1969 number of birds processed.

Table 52. SUMMARY OF INITIAL AND ANNUAL COSTS AND INCOME FOR PROCESS AND EQUIPMENT CHANGES AND WATER AND WASTE MANAGEMENT, 1972

Item	Initial Investment	Annual: Cost	Annual: Income and cost savings
		(Dollars)	
Additional cost			
Processing and equipment changes	72,311	14,900	
Water and waste monitoring and management[a]	20,754	16,123	
Total	93,065	31,023	
Additional revenue or reduced cost			
Water sewer and surcharge reductions[b]			64,128
Labor and chemical savings			30,398
Byproduct sales			8,690
Total			103,216
Net annual savings			72,193
Annual savings per dollar of annual cost			2.33
Net annual savings per 1,000 birds			4.08

[a] Average monthly savings, Table 50.

[b] Average monthly savings, Table 50.

Community Effect

The reductions in water use and waste have important implications for the city of Durham. The 32 percent reduction in water use comprised approximately 2.4 percent of the water used in Durham. Reducing the use of water in the Gold Kist plant resulted in increasing the amount available for other users. This result has major implications for those cities faced with the need to expand water supplies. Likewise, the reduction in waste and hydraulic loads had major significance to the municipal waste treatment facilities.

Summary

Table 53 details the important facts about operation of the Durham, Gold Kist poultry processing plant after the conclusion of the research and development activities. Water use was 7.81 GPB or 2081 GAL/1000 lb. LW. Production was 73,800 BPD. BOD_5 was 282 mg/l or the load was 18.36 lbs BOD_5/1000 BPD. Annual costs for water, sewer and surcharge totaled $3.61/1000 BPD. Annual savings of $4.08/1000 BPD can be realized with an initial investment of $93,065 and annual costs of $31,023.

Table 53. FINAL RESULTS SUMMARY

Water Use	5.58 GPB	Processing	576,000 GAL/DAY
	2.23 GPB	Clean-Up	2,081 GAL/1000 lb LW
	7.81 GPB	Total Use	2,818 GAL/1000 lb KW
	576,000 GPD		
Production	73,800 BPD (received)		LW= 3.75 lbs
	9.38 hrs (processing)		KW= 2.77 lbs

Wastewater Discharge to City (after settling basin and AFC)

Characteristics

BOD	COD	TS	SS	Grease
(mg/l)				
282	617	521	214	64
(lbs/day)				
1,355	2,964	2,503	1,028	307
(lbs/1000 broilers received)				
18.36	40.16	33.92	13.93	4.16

Costs and Cost Savings - Water and Waste Reductions

Initial Investment	$93,065.
Annual Costs	$31,023.
Annual Costs - Water, Sewer and Surcharge	$3.61/1000 Broilers
Annual Savings - Water, Sewer and Surcharge	$3.92/1000 Broilers
Annual Savings	$4.08/1000 Broilers

SECTION VI

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SECTION VII

PUBLICATIONS AND MANAGEMENT PROGRAM

INTRODUCTION

A necessary consideration for a research and development project of a viable industry is the presentation of progress made for discussion and evaluation. Numerous contacts were made to explain the progress of this study to industry leaders and these efforts are detailed.

A goal was to develope guidelines for the management of water and wastes in poultry processing. A program was developed from experiences gained during this study and follows. This program will allow plants to achieve significant reductions in water and waste in poultry processing. Continual management attention will be necessary to maintain the reductions. The water and waste supervisor will be the key to any successful water and waste reduction program.

PRESENTATIONS, PAPERS AND REPORTS

October 1, 1969. "Municipal Water and Sewer Charges". Workshop on Municipal Water and Sewer Charges as Related to Water Use and Waste Control. Presentation by Mr. Don Etheridge, Rougemont, N. C.

December, 1969. Water and Waste Management in Poultry Processing. Panel Discussion by Crosswhite, Macon, Carawan, Ward, Hamza, and Carter at Seminar - Dept. of Poultry Science, N. C. State University, Raleigh, N. C.

February, 1970. Poultry Processing - Water and Waste. Presented by W. M. Crosswhite to Water Resources Discussion Group, N. C. State University, Raleigh, N. C.

June, 1970. Network Theory Applied to Water Management in Poultry Processing. Robert Carl Ward. A thesis submitted to the Department of Biological and Agricultural Engineering.

September 8, 1970. Water and Waste Management in Poultry Processing. Presentation by Roy Carawan, William Crosswhite, Byron Hawkins and John Macon to N. C. Poultry Processors Assoc., Greensboro, N. C.

February 4, 1971. Implementation of Effective Pollution Control by Food Processors. William M. Crosswhite. Paper presented at Southern Agricultural Economics Association, Jacksonville, Florida.

March 12, 1971. An Economic Study of Municipal Surcharges on Industrial Wastes Presentation by Dr. J. A. Seagrave to Advisory Committee of the Water Resources Research Institute of the University of North Carolina, Raleigh, N. C.

March 23-26, 1971. Water and Waste Management in Poultry Processing. Dr. W. M. Crosswhite, R. E. Carawan, and John A. Macon. Proceedings, National Symposium on Food Processing Wastes, Denver, Colorado.

April, 1971. Use, Continued Use, and Reuse of Both Process and Waste Waters in Poultry Processing Operations. J. A. Macon, W. M. Crosswhite, and R. E. Carawan. A paper presented for the 20th Southern Water Pollution Control Conference, Chapel Hill, North Carolina.

April, 1971. Surcharges for Industrial Wastes, J. A. Seagraves. A paper presented for the 20th Southern Water Pollution Control Conference, Chapel Hill, North Carolina.

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June, 1972. An Application of Network Theory to Water Management in Poultry Processing. Robert C. Ward, David A. Link, and William M. Crosswhite. Water Resources Bulletin, American Water Resources Association, Vol. 8, No. 3.

September, 1972. The Technology of Water and Waste Management in Poultry Processing - The Gold Kist Study. Presented by John Macon at EPA Technology Transfer Seminar, Atlanta, Ga.

January, 1973. The Technology of Water and Waste Management in Poultry Processing - The Gold Kist Study. Presented by John Macon at EPA Technology Transfer Seminar, Little Rock, Ark.

January, 1973. Effect of Spray Parameters on Food Cleaning: Poultry As An Example. Ahmed Abdel - Rihim Ahmed Hamza. A thesis submitted to Dept. of Civil Engineering, N. C. State University, Raleigh.

April, 1973. Management of Water and Wastes in Food Processing - Talk Prepared for Tri-State Dairy and Food Engineering Conference by Roy E. Carawan.

April, 1973. Water and Waste Management in Poultry Processing. Presentation by Roy E. Carawan to Seminar sponsored by Department of Agricultural Engineering, The Ohio State University, Columbus, Ohio.

Spring, 1973. The Gold Kist Story. Presentation by John Macon to Maryland Broiler Council, Salisbury, Md.

June, 1973. Symposium on Water and Waste Management in Poultry Processing. Co-Chairman, Roy E. Carawan. Annual meeting. Institute of Food Technologists meeting, Miami, Fla.

June, 1973. Future Water and Waste Reductions in Poultry Processing. Hershell R. Ball and Roy E. Carawan. Presented at annual meeting of Institute of Food Technologists, Miami, Fla.

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July, 1973. Upgrading Existing Poultry-Processing Facilities to Reduce Pollution. In-Process Pollution Abatement. The Gold Kist Case Study. John A. Macon. Environmental Protection Agency, Technology Transfer.

PROJECT SPINOFFS

Application for Research, Development and Demonstration Grant from Federal Water Pollution Control Administration entitled "Demonstration of Water Pollution Control Technology Transfer Through University Extension Programs" for July '71 - June '70. Project not funded.

GUIDELINES FOR WATER AND WASTE MANAGEMENT PROGRAM

A plan for presentation to the poultry industry has been developed. The basic principle of the plan is that water should be managed as a raw product with a real cost. Also, that wastes going into the plant effluent streams are product or by-product losses which cost dollars and that surcharges or waste treatment charges are going to be added to further tax these lost dollars. An outline of the proposed program follows.

Poultry Processing Water - Waste Educational Program

Objectives

The objectives of the water and waste management program follow:

1. Acquaint poultry plant personnel with water and waste terminology.

2. Relate poultry product or by-product losses to wastewater characteristics and our environment.

3. Relate poultry and by-product waste to financial losses at poultry plants.

4. Relate past surveys of individual plants and compare them with the plant in question.

5. Develop and initiate action program to reduce water and waste within the plant.

The Program

The water and waste management eduction program for poultry processing plant personnel follows:

A. Management Phase - 2 hours - Describe federal, state and local regulatory involvement, discuss waste terminology, research and survey findings, relate cost and product losses, discuss water, sewer and surcharges, introduce cost of waste treatment and describe the need and duties of water waste supervisor and water and waste program.

B. Water - Waste Supervisor Phase - 40 hours - Instruct water-waste supervisor (appointed by management) in respect to recent research findings, plan activities that need to be carried out in the employee phase of the program and other details of a water and waste management program.

C. Employees Phase (may involve supervisor or all employees) - 4 hours "Washing Profits (Your Salary!) Down the Drain" - This program should illustrate good and bad waste practices, explain good water and waste management, relate product losses to cost and familiarize the employees with waste terminology and current techniques in controlling water and waste in a poultry processing plant. The activation and involvement of the employees is critical for they will often suggest needed solutions within their areas of responsibility in the overall attack on the plant water-waste program. Special efforts should be made during these sessions to relate the effects of a poultry processing plant on "Our Environment".

D. Follow up phase - 8 hours - A tour and evaluation session conducted with management, the water-waste supervisor, and the supervisors will help determine progress made within the plant after an initial time period of effort.

Outline and Need and Duties of Water-Waste Supervisor

Since the water-waste supervisor will be management's representative responsible for the total water-waste program, his responsibilities are detailed:

1. Every poultry processing plant should have one person who is completely responsible for the water and waste program. He should have latitude to develop the program and the authority to implement his plans reporting directly to the plant manager. He should not be overloaded with duties which would keep him from devoting at least the majority of his time to water and waste problems.

2. A survey of the plant must be made. Sketches, drawings and maps should be detailed to indicate the size, capacity and location of water lines, meters, sewer lines, junctions, man holes and other parts of the water-waste system. Operating data should be compiled relating to water use, waste generated including BOD and other importing waste parameters and flow from the main and minor sewers. This data should also include the production rate, chemical usage, and other pertinent data needed for management study.

3. The water-waste supervisor in the management team should then examine the plant critically. An examination of why water is being used at each location should be determined and an indication should be made of where wastes are originating. Then a plan should be developed to reduce water use and waste.

4. Using the results of this management team, the major water using and waste contributing areas in the plant should be attacked. Nozzles should be installed on all hoses. Level controllers might be used to control overflow of vat with needed water. Leaking water or product valves should be replaced. The machine maintenance program should be checked to see if it is sufficient to prevent product and/or water losses.

5. Simultaneously, a water and waste savings eductional program should be instituted. Employees should be informed and involved in the program or it will not work. The water-waste supervisor must be responsible for the program, but it is the operating personnel who will determine if your program will be a success.

6. If pretreatment or treatment is required, competent engineering firms should be engaged to study your situations and recommend any needed improvements. A program should be developed that will prevent problems with the treatment or pretreatment systems.

7. Management must remember the program must be continued or it will die. Mention of the program must be frequent. The water-waste supervisor must follow the operations assuring that proper water and waste procedures are followed each operating day.

Specific Recommendations

The water waste supervisor should study the process and equipment changes evaluated in this project as all were proven technically and economically feasible. Successful implementation of these and other needed changes are a part of a broad program of water and waste management. An adequate program for control of water and waste must include the following:

1. Continual records that will assure knowledge of changes in the operating procedures of the plant. This should include water use, wastewater characteristics, and production. (See Tables 54 and 55.

2. The person designated specifically responsible for water and waste management should have reasonable powers to make and enforce changes. His specific responsibilities should include determination of water use and rate of use. This will necessitate the installation of meters, pressure guages and valves in at least the major flow areas. Pressure regulators must be installed on the larger line as this will help maintain a constant water flow at all individual units. Careful records and analyses should be made to provide the chiller and scalder with the minimum approved quantities of water.

3. Each unit process should be studied to determine possible water use reduction. The dry sweeping of waste throughout the plant into recepticles can help reduce waste if this is done before the washing of the floors. The receiving area is a major area that should receive attention.

4. Open type garden hoses should be replaced with hoses with nozzles to give high velocity spray, reduce water flow and the ability to stop discharge at the point of application.

5. The clean up operation should be examined for excess water use and wastes sent to the sewers. The use of high pressure cleaning systems and/or foam cleaning systems may reduce water usage.

6. Broilers should be stunned just prior or after cutting to maximize bleeding and prevent body movement and the splattering of blood. The blood should be confined to an enclosed area where it should be collected and sent to the by-products plant.

7. Screened chiller water is permitted as scalder feed water and should be so used.

8. If additional water is needed for the fluming of feathers, reuse the screened feather flume or offal flume water and possibly the scalder or whole bird wash overflow.

9. Shower nozzles should be replaced with spray nozzles on the bird washers and other water application points.

10. Hand wash goose necks should have flow reduction devices such as nozzles. Body or foot control valves can supply water when it is needed for the hand washers.

11. The side pan wash and the eviceration trough can be cycled to prevent full time water flow.

12. The ice flush addition to the chiller water can be credited against the needed water for chiller water overflow.

13. A major consideration for any poultry processing plant should be the incorporation of a dry viscera removal system.

14. A major consideration for a poultry processing plant should be the incorporation of the new scalding systems which eliminate the scalder bath and may assist in the dry removal of feathers.

15. All offal and feather screens should be kept in good working order using the smaller screen mesh that will provide satisfactory operation. A clogged screen will overflow solids to the detriment of your pretreatment or treatment facility. Frequent cleaning is required with the smaller mesh screen, but the additional screening ability is worth the manpower and cost.

16. Dry removal of waste such as the heads should be practiced providing that regulatory approval is obtained.

17. By-product recovery systems should be studied to improve the efficiency of by-product recovery.

18. Employee awareness of the cost of poor water and waste management should be provided. Employees should be encouraged to be careful with water use and product or by-product wasting practices.

19. Handle with extreme care all sanitary*fittings, valves, rotary seals and thumb parts during every phase of operation and cleaning to prevent marring which may cause leaks.

20. Mark all valves clearly, especially multiport, so that it is practically impossible for inexperienced help to turn the valve the wrong way discharging product to the drain or floor.

21. Do not use a constantly running water hose in any room. Eliminate the cause of spillage, rather than just wash it away after it has occurred.

22. Sanitary*pipe lines should be installed so that they are properly supported to eliminate vibration induced leaking joints (where welded lines are not used or points in welded lines where CIP gaskets are utilized) and to insure that the lines are properly pitched to insure drainage of the lines.

23. Water hoses should be turned off when not in use. Hoses equipped with automatic shut-off valves should be utilized to avoid excessive water usage.

24. Adequate weirs or flumes and continuous sampling equipment should be provided at the outlet of all poultry processing plants for monitoring waste strength and volume.

25. Eliminate steam-water mixing tees for making hot water and utilize regular hot water systems to prevent use of shut-off valves at the end of hose lines. This can result in a major reduction of wastewater volume.

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* Food type.

Table 54. RECORD OF WATER USE AND WASTES IN POULTRY PROCESSING PLANT

I. Receiving and unloading area

   A. Solids -- droppings from coops and birds, dry

      1. Quantity per unit of birds processed
      2. Method of removal and end use

   B. Liquids -- clean-up water

      1. Source -- fresh water from hoses
      2. Quantity used per clean-up area (gpm/hose, total time used)
      3. Pollutants -- droppings and some feathers
      4. Point of discharge

   C. Number of birds received

II. Killing station -- vain slit for gravity flow

   A. Solids -- coagulated blood, some feathers, few loose heads and whole birds

      1. Quantity per unit of birds processed
      2. Method of collection
      3. Quality
      4. End use or disposal

   B. Liquids

      1. Flow away blood portions -- quantity
      2. Characteristics of fluid content in above
      3. Clean-up water
         (a) Source -- fresh water from hoses
         (b) Quantity -- gpm/hose, time hose used
         (c) Detergents if used -- amount
         (d) Point of discharge
         (e) Quality -- BOD, TS, SS, pH

Table 54.(continued). RECORD OF WATER USE AND WASTES IN POULTRY PROCESSING PLANT

III. Scalding Tank

A. Solids -- some feathers, droppings, loose heads, occasional bird

1. Quantity -- settled and not carried out by overflow
2. Method of removal
3. End use or disposal

B. Liquids -- continuous overflow of hot polluted water plus clean-up fresh water; also stream heat

1. Quantities
   (a) Overflow rate -- source is fresh water
   (b) Cleanup -- total vol. -- source fresh water
2. Characteristics
   (a) Overflow -- temp., BOD, SS, TS, ph
   (b) Cleanup -- BOD, SS, TS
3. Point of discharge
4. Stream outlets or heating system

C. Additives (if used)

1. Type, brand
2. BOD

IV. Defeathering -- removal by rotary cylinder with attached rubber tips

A. Solids -- bulk quantity of feathers, some heads, a few birds

1. Quantity
   (a) Weight -- wet and dry per type of equipment
   (b) By bulk volume per type of equipment
   (c) Percent heads and whole birds lost/run
2. Characteristics -- after screening
   (a) BOD of solids
   (b) Volatile solids

B. Liquids -- sprays for machines and rec. flume vol.

1. Spray -- fresh water supply
   (a) Vol./unit of operation
   (b) Check for substitution by air
2. Flume water -- recirculated from feather screen
   (a) Temperature
   (b) Volume received
   (c) Volume added
   (d) Characteristics -- BOD, COD, SS, TS, pH
   (e) Design of flume -- shape, elevation
   (f) Design of separation basin below screen
3. Clean-up waters -- quantity and quality

V. Singeing -- dry operation

A. Solids -- if produced

B. Liquids -- clean-up water volume and characteristics

VI. Washing after defeathering and singeing

A. Solids

1. Kind or characteristic
2. Quantity
   (a) Weight wet and dry
   (b) Volume

B. Liquids -- fresh water spray

1. Spray volume
2. Conditions of discharged effluent
   (a) BOD
   (b) TS, VS, SS, pH
   (c) Grease
   (d) Nitrogen
3. Clean-up volume and condition

Table 54.(continued). RECORD OF WATER USE AND WASTES IN POULTRY PROCESSING PLANT

VII. Evisceration

A. Discarded solids -- feet, inedible viscera, crops, grits, sand, gravel from gizzard cleaning, flesh trimmings, fat

1. Identify stations of operations and solids removed at each
    (a) Quantity that does not enter flume
    (b) Method of removal from bird
    (c) System of disposal

B. Liquids

1. Evisceration washings
    (a) Source of water
    (b) Volume for each use
    (c) Point of discharge
2. Flume water
    (a) Source if other than B-1
    (b) Rate of flow
    (c) Characteristics -- solids (all determinations), BOD, COD, pH, temp., grease, total nitrogen
    (d) Design of flume -- shape and elevation
3. Clean-up water
    (a) Evisceration operations -- quantity and quality
    (b) Offal separation -- screen cleaning, quantity and quality

VIII. Chilling

A. Source of solids

1. Quantity -- weight and volume
2. Characteristic -- BOD, volatile solids

B. Liquids

1. Source of supply -- amount of ice or fresh water
2. Rate of addition
3. Temperature of effluent
4. Point of discharge -- Is re-use made of same?

Table 54.(continued). RECORD OF WATER USE AND WASTES IN POULTRY PROCESSING PLANT

IX. Grading, weighing, packing

A. Liquids

1. Drainage from birds
2. Ice fallout
3. Volume
4. Characteristic

B. Number of birds packed

Table 55. DAILY WATER BALANCE SHEET FOR POULTRY PLANT

Number of Birds Processed	
Source - Input	Source - Output
(amt. added - vol.)	(amt. discharged)
1. Drinking	1. Overflow fountains
2. Sanitary requirements	2. Sanitary discharges
3. Steam generation	3. Blow-down and direct use
4. Ice making	4. Volume used for ice
5. Processing liquids added	5. Processing liquids discharged
a) Clean-up rec. and unload	a) Same
b) Clean-up killing area	b) Liquid blood plus clean-up
c) Fill scalding tanks plus addition	c) Overflow volume plus cleanup
d) Sprays for defeathering plus cleanup	d) Effluent plus cleanup
e) Cleanup of singeing equip.	e) Same
f) Final wash of whole bird	f) Same
g) Flume water for evisceration	g) Same
h) Washing of eviscerated bird	h) Same
i) Chilling water	i) Same
j) None	j) Drainage and ice

SECTION VIII

GLOSSARY

AFC - Air flotation cell used to separate fats and other solids from wastewater discharge.

Biochemical oxygen demand (BOD) - (1) The quantity of oxygen used in the biochemical oxidation of organic matter in a specified time, at a specified temperature, and under specified conditions. (2) A measure of the amount of oxygen an impure water system requires in a specified time to decompose the polluting agents in the system. (3) A standard test used in assessing wastewater strength. All references in the text are to 5-day BOD (BOD_5) incubated at 20 C.

BOD load - The BOD content, usually expressed in pounds per unit of time, of wastewater passing into a sewer, waste treatment system or into a body of water. All references in the text are to BOD_5.

Broiler - A bird grown eight to nine weeks with a liveweight of approximately 3.7 pounds.

Chemical oxygen demand (COD) - A measure of the oxygen-consuming capacity of inorganic and organic matter in water or wastewater. It is expressed as the amount of oxygen consumed from a chemical oxidant in a specific test. It does not differentiate between stable and unstable organic matter and thus does not necessarily correlate with BOD. Also known as OC and DOC, oxygen consumed and dichromate oxygen consumed, respectively.

Chicken - A catch-all classification of poultry with an average weight of approximately 4.8 pounds.

Cleaning-in-Place (CIP) - Clean-up system designed to mechanically clean equipment using chemicals and pumping system.

Consumptive use - Water that is internalized in a plant or product such as the water retention in the poultry chiller.

Continued Use of Water - Water being continuously used in processes prior to the process for which it was first used, i.e., counter flow of product and process water.

Composite wastewater sample - A combination of individual samples of water or wastewater taken at selected intervals, generally hourly for some specified period, to minimize the effect of the variability of the individual sample. Individual samples may have equal volume or may be roughly proportioned to the flow at time of sampling.

Discharge - (1) As applied to a stream or conduit, the rate of flow, or volume of water flowing into the stream or conduit at a given place and within a given period of time. (2) The passing of water or other liquid through an opening or along a conduit or channel. (3) The rate of flow of water, silt, or other mobile substances which emerge from an opening, pump, or turbine, or pass along a conduit or channel, usually expressed as cubic feet per second, gallons per minute, or million gallons per day.

Dissolved oxygen (D.O.) - Uncombined oxygen in solution in a liquid.

Dissolved solids (DS) - The total amount of dissolved material, organic and inorganic, contained in water or wastes. Excessive DS can make water unsuitable for industrial uses, unpalatable for drinking, and even cathartic. Potable water supplies may have a dissolved solid content from 20 to 1000 mg/l, but sources which have more than 500 mg/l are not recommended by the U.S. Public Health Service.

Domestic wastewater (sewage) - Wastewater derived principally from dwellings, business buildings, institutions, and the like. It may or may not contain groundwater, surface water, or storm water. Durham, N. C. uses 250 mg/l as the equivilent of domestic wastewater.

Effluent - Wastewater or other liquid, partially or completely treated, or in its natural state, that flows out of a containing space such as a reservoir, basin, treatment plant, or part thereof.

Eviscerated poultry - Poultry which has had its blood, feathers, shank and feet, oil sac, lungs, vicera and any other inedibles removed.

Filter - A device or structure for removing solid or colloidal material, usually of a type that cannot be removed by sedimentation, from water, wastewater, or other liquid. The liquid is passed through a filtering medium.

Flume - (1) A long narrow channel for gravity flow of liquid from one point to another. An open conduit of wood, masonry, or metal constructed on a grade and sometimes elevated. (2) To transport in a flume, as fruits or vegetables.

Gallons per bird (GPB) - Volume of water per broiler received to the processing plant.

Gallons per day (GPD) - A common volume per unit time expression of liquid flow rate.

Grease - Organic matter in water that can be recovered through extraction by organic solvent.

Industrial wastewater - Wastewater in which the liquid wastes from industrial processes, as distinct from domestic or sanitary wastes, predominate. See Domestic wastewater.

Influent - Water, wastewater, or other liquid flowing into a reservoir, basin, or treatment plant, or any unit thereof.

Land disposal - (1) Disposal of wastewater onto land by spray or surface irrigation. (2) Disposal of solid waste materials by incorporating the solid waste into the solid by cut-and-fill techniques or by sanitary landfill operations.

Loading - The quantity of waste, expressed in gallons (hydraulic load) or in pounds of BOD, COD, suspended or volatile solids (organic load) which is discharged into a wastewater treatment facility.

Milligrams per liter (mg/l) - A unit of the concentration of water or wastewater constituent. It is 0.001 g of the constituent in 1,000 ml of water. It has replaced the unit formerly used commonly, parts per million, to which it is approximately equivalent, in reporting the results of water and wastewater analysis.

Million gallons per day (MGD) - A common volume per unit time expression of liquid flow rate.

Nutrient - A substance which promotes cellular growth in organisms.

Offal - Includes head, feet, and viscera.

Organic nitrogen (ON) - Nitrogen existing in organic compounds.

Parshall Flume - A channel with a restriction which is used to measure flow in open channels.

Parts per million (ppm) - The number of weight or volume units of a minor constituent present with each 1 million units of the major constituent of a solution or mixture. Formerly used to express the results of most water and wastewater analyses, but more recently replaced by the ratio milligrams per liter.

pH - A value that expresses the degree of acidity or alkalinity of a substance or solution. The extreme readings are 0 and 14. Pure (neutral) water has a pH value of 7.0--it is neither acid nor alkaline. The degree of alkalinity increases as the numbers increase above 7.0. Conversely, for values below pH 7.0, the degree of acidity increases as the numbers decrease. Alkaline water will tend to form a scale, acid water is corrosive. A solution with a pH of 11.0 is 10 times more alkaline than one with a pH value of 10.0, and 100 times greater than pH 9.0.

Pollution - Broadly, pollution means any change in water quality that impairs it for the subsequent user.

Pollutional load - (1) The quantity of material in a waste stream that requires treatment or exerts an adverse effect on the receiving system. (2) The quantity of material carried in a body of water that exerts a detrimental effect on some subsequent use of that water.

Population equivalent - A means of expressing the strength of organic material in wastewater. Domestic wastewater consumes an average of 0.17 lb. of oxygen per capita per day, as measured by the standard BOD_5 test. This figure has been used to measure the strength of organic industrial waste in terms of an equivalent number of persons. For example, if an industry discharges 1,000 pounds of BOD per day, its waste is equivalent to the domestic wastewater from 6,000 persons (1,000/0.17 = 6,000).

Potable water - Water defined by the United States Public Health Service as safe for drinking. Used to indicate water as received from the City of Durham.

Preliminary treatment - (1) The conditioning of a waste at its source before discharge to remove or to neutralize substances injurious to sewers and treatment processes or to effect a partial reduction in load on the treatment process. (2) In the treatment process, unit operations, such as screening and comminution, that prepare the liquid for subsequent major operations.

Primary treatment - (1) The first major (sometimes the only) treatment in a wastewater treatment works. Commonly considered to include bar racks, grit chambers, comminution, sedimentation and sludge digestion treatment operations, may include flocculation or disinfection.
(2) The removal of a substantial amount of suspended matter, but little or no colloidal and dissolved matter.

Reconditioning - Screening, separating and/or filtering to prepare for reuse.

Recycling - An operation in which a substance is passed through the same series of processes, pipes, or vessels more than once.

Reuse of water - The recycling of water in any process with or without screening and/or other reconditioning.

Screen - A device with openings of uniform size, used to retain or remove solids in flowing water or wastewater and to prevent them from entering an intake or passing a given point in a conduit. The screening element may consist of parallel bars, rods, wires, grating, wire mesh, or perforated plate, and the openings may be of any shape, although they are usually circular or rectangular.

Secondary wastewater treatment - The treatment of wastewater by biological methods after primary treatment by sedimentation. Common methods of treatment include trickling filtration, activated sludge processes, and lagoons.

Sediment - Solid material settled from suspension in a liquid.

Sewage - The spent water of a community. Term now being replaced in technical usage by the term wastewater. See Wastewater.

Sewer charge - A charge or a schedule of charges for the collection or the collection and treatment of wastewater to users who are connected to the system. It may be based on water consumption, wastewater flow, strength of wastewater, number and type of plumbing fixtures, or some combination of these.

Sewer system - Collectively, all of the property involved in the operation of a sewer utility. It includes land, wastewater lines and appurtenances, pumping stations, treatment works, and general property. Occasionally referred to as a sewerage system.

Slug - A high concentration of a substance in a flowing liquid; generally beginning and ending abruptly and lasting for a relatively short period of time.

Slurry - A watery mixture or suspension of insoluble matter (such as mud, lime, wood pulp).

Surcharge - A service charge made for providing wastewater collection and/or treatment service. A specific charge in contrast to an ad valorem tax often based on BOD_5 load discharged in excess of that of domestic wastewaters (BOD_5 = 250 mg/l). Others bases include suspended solids load and hydraulic load which may be used individually or in combination with BOD_5 load.

Suspended solids (SS) - (1) Solids that either float on the surface of, or are in suspension in, water, wastewater, or other liquids, and which are largely removable by laboratory filtering. (2) The quantity of material removed from wastewater in a laboratory test, as prescribed in "Standard Methods for the Examination of Water and Wastewater".

Tertiary treatment - Treatment beyond normal or conventional secondary methods for the purpose of increasing water re-use potential.

Total nitrogen (TN) - The sum of nitrogen existing in the forms of ammonia nitrogen and organic nitrogen.

Total solids (TS) - A measure of both suspended and dissolved solids present in water; expressed in mg/l or ppm.

Trickling filter - A structure containing an artificial bed of coarse material, such as broken stone, clinkers, slate, slats, or plastic materials, over which wastewater is distributed or applied in drops, films, or spray from troughs, drippers, moving distributors, or fixed nozzles, and through which the wastewater trickles to the underdrains, giving opportunity for the formation of zoogloeal slimes which clarify and oxidize the wastewater.

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.

USDA - United States Department of Agriculture.

USDA - CMS - United States Department of Agriculture, Consumer Marketing Service which is responsible for inspecting and regulating poultry products processing.

Viscera - The heart, lungs, liver, and intestines of the bird.

Volatile Solids (VS) - The quantity of solids in wastewater lost on ignition of the dry solids at 600C.

Wastewater - The spent water of a community or industrial plant. From the standpoint of source, it may be a combination of the liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, and storm water that may be present. In recent years, the word wastewater has taken precedence over the word sewage.

Wastewater influent - Wastewater as it enters a wastewater treatment plant or pumping station.

Wastewater treatment - Any process to which wastewater is subjected to remove or alter its objectional constituents and thus render it less offensive or dangerous.

Water consumption - The quantity, or quantity per capita, of water supplied in a municipality or district for a variety of uses or purposes during a given period. It is usually taken to mean all uses included within the term municipal use of water and quantity wasted, lost, or otherwise unaccounted for.

Water treatment - The filtration or conditioning of water to render it acceptable for a specific use.

SECTION IX

APPENDICES

APPENDIX A

GOLD KIST PLANT WITH SELECTED EQUIPMENT LISTED

PICKING ROOM EQUIPMENT

1. Gainsville Equipment Co., Gainsville, Ga., Whole Bird Wash (Two)
2. Barker Poultry Equipment Co., Ottumwa, Iowa, Barker Hock Picker (Two)
3. Gainsville Equipment Co., Gainsville, Ga., Body Picker, CR100 (Two)
4. Gainsville Equipment Co., Gainsville, Ga., Body Picker, CR100 (One)
5. Barker Poultry Equipment Co., Ottumwa, Iowa, Barker Body Picker (One)
6. Bird Singe, Home made by Gold Kist Poultry, (Two)
7. Gainsville Equipment Co., Gainsville, Ga., Neck Scald, (Two)
8. Barker Poultry Equipment Co., Ottumwa, Iowa, D600 Picker, (Two)
9. Gainsville Poultry Equipment Co., Gainsville, Ga., Whole Bird Scalder
10. Marietta Poultry Equipment Co., Marietta, Ga., Poultry Killing Machine, (Two)

EVISCERATING ROOM EQUIPMENT

11. Gainsville Equipment Co., Gainsville, Ga., Whole Bird Knocker
12. Gainsville Equipment Co., Gainsville, Ga., Hock Cutters, (Two)

13. Gainsville Equipment Co., Gainsville, Ga., Feet Knocker, (Two) (Modified by Jack Horton and Burt Gunter, Gold Kist Poultry)

14. General Research Co.*, Canton, Ga., Eviscerating Table, (Two)

15. General Research Co., Canton, Ga., Gizzard Machine, (Four)

16. General Research Co., Canton, Ga., Gizzard Peel, (Four)

17. General Research Co., Canton, Ga., Gizzard Conveyor, (Two)

18. General Research Co., Canton, Ga., Gizzard Wash, (Two)

19. Food Tech Co., Dallas, Texas, Lung Gun, (Ten)

20. General Research Co., Canton, Ga., Whole Bird Wash, (Two) (Modified by Jack Horton and Burt Genter, Gold Kist Poultry)

PACKING AREA ROOM EQUIPMENT

21. Altenpohl, Drainrite Sizing Systems, West Conshokocken, Penn.

22. Barker Poultry Equipment Co., Ottumwa, Iowa, Mark IV Chiller, Serial #130

23. Barker Poultry Equipment Co., Ottumwa, Iowa, Mark IV Chiller, Serial #131

24. John Mohr & Sons, 3200 E. 96th St., Chicago, Ill., Neck Cutter, Model #205-3

*Division of Barker Poultry Equipment Co., Canton, Ga.

ROOF EQUIPMENT (COOLING)

25. Refrigeration Engineering, Inc., Los Angeles, Calif., RECOLD DRI-FAN CONDENSOR, Serial #C-2413, Model #DFC 31.

26. Vilter Manufacturing Co., Milwaukee, Wis., Serial #55-3374, Size 85-U, Condensor

27. Imeco, 3031 W. Belmont Ave., Chicago, Ill., Evaporative Condensor, AJ*4347-R, 10 H.P., 132 G.P.M. water

28. Marlet Double-Flow Cooling Tower

29. Ice Storage Tower

UPSTAIRS EQUIPMENT

30. Morris & Associates, Inc., Raleigh, N. C., Water Chiller, Model #WC-100H-1600, Serial #645B-1265

31. Morris & Associates, Inc., Raleigh, N. C., Water Chiller, Model #WC-100H-1600, Serial #645A-1265

32. Bell & Gossett, Inc., Morton Grove, Ill., Hydro-Flow Centrifugal Pump, 1531 Type B, 1 3/4 H.P.

33. Worthington Corp., Holyoke, Mass., Air Compressor, Serial #AH-1388, Size: 3 5/8 / 2 1/16 X 1 5/8 Model #3C-2

34. The Peerless Electric Co., Warren, Ohio, 3 H.P., Serial #GD 88415

35. The Vilter Mfg. Co., Milwaukee, Wis., "Briquette Machine"

36. The Vilter Mfg. Co., Milwaukee, Wis., "Briquette Machine"

37. The Vilter Mfg. Co., Milwaukee, Wis., Serial #6-6-2-18, Size #1, Volt 220

38. Acme Steel Co., Chicago, Ill., Box Stitcher, Model #H20AYA, Serial #B-24461

APPENDIX B. SPECIAL STUDY ON REUSE AND CONTINUED USE OF SELECTED PROCESS WATERS

SUMMARY

Two applications of the use of selected process waters were evaluated in a commercial poultry processing plant. Study I was a comparison of two sources of make-up water for the scald vats; whole bird wash water on overflow water from the chill vat. Study II was an evaluation of the replacement of potable water in selected parts of the gizzard splitting and peeling machine with a combination of chiller overflow water and final bird wash waters.

The whole bird wash water contained a lower amount of BOD, COD, total solids, grease and bacteria than water taken from the chill vat. When whole bird wash water was substituted for chiller water in the scald vat, the levels of wastewater indices and bacteria in the scalder effluent were lower. Whole bird wash water compared favorably with chiller water as a source of input water for the scald vat.

The total bacteria and coliform counts for gizzards collected at the exit of the reel washers were not statistically different when using either fresh water or a combination of chiller and final bird wash water in the gizzard splitting and peeling machine. The results indicate that bacteria levels on gizzards were not significantly affected by the application of the continued use of process water in the gizzard splitter. These results were anticipated because there are so many other sources of bacteria and coliform in the early stages of gizzard cleaning and the gizzards pass through several washes with potable water after the splitting and peeling operations.

Final carcasses, including giblets, were examined to determine the overall effect on biological quality of process and equipment changes including the use of process water that had been made in the Gold Kist Plant. A comparison of carcass samples taken before the

experimental period for continued-use water and during the experimental period was made. The median number of both total bacteria count and coliform bacteria incidence was lower on carcass samples examined during the special testing period. It was concluded that the continued-use of process water in the scald vat and gizzard splitting and peeling machine did not adversely affect the bacteriological quality of the birds processed in the Gold Kist plant. Satisfactory operations did exist during the experiment. Proper use of a system for applying these waters will produce considerable savings in fresh water use. These reductions in water use were achieved under inspection by the USDA staff.

It is recommended that the re-use of process waters in the two areas examined in this study should be permitted under controlled conditions. Processing plants should gather data for comparisons of product quality with and without or before and after the process changes. Equipment should be designed to provide for solids removal in the collection basin and for cleaning the systems.

Regulatory agencies should encourage the development of improved methods for continued-use of process water in poultry processing. The cooperation between industry, university and federal agencies demonstrated in this study should be continued.

BACKGROUND

A major research and development project on water and waste management in the Gold Kist poultry processing plant at Durham, North Carolina, began on July 1, 1969. The study was conducted in cooperation with the Office of R. and D., Environmental Protection Agency, Washington, D. C., and North Carolina State University at Raleigh, North Carolina.

The purpose of the project was to change plant equipment and operations and to demonstrate effective in-plant control of both water use and discharge of waste from poultry processing operations. An extensive program of measuring and testing of all process waters established (1) the quantities of water used by processes, (2) the physical, chemical and microbiological characteristics of the waste waters from each process, and (3) the microbiological characteristics of carcasses, giblets and process water from selected processes.

Water conservation and waste abatement measures were applied in selected areas of the plant. All work was conducted under the approval and inspection of the USDA plant inspection team. Water use per bird was reduced by approximately one-third and waste discharge by approximately three-fourths.

The use of process waters in poultry processing is governed by the regulations and interpretations of the USDA-CMS. The following quotes are taken from Regulations Governing the Inspection of Poultry and Poultry Products, by the U.S. Department of Agriculture, Consumer and Marketing Service, Consumer Protection Programs, Washington, D.C., July 14, 1968.

1. "Non-potable water is not permitted for washing floors, areas, or equipment, nor is it permitted in boilers, scalder, chill vats or ice-making machines." (Section 81.36, part of paragraph 6, page 6.)

2. "Non-potable water is permitted only in those parts of official plant where no product is handled or prepared...." (7 CFR - Part 81, Section 81.36.)

Water use in poultry processing is characterized by the application of potable water. An assessment of water reduction opportunities in early 1970 focused on continued-use applications of process water and the identification of uses where it seemed reasonable that sanitation and food safety requirements could be met. The "use of process water" is defined for these studies as water collected from one process application for another process. The process water may come in contact with the whole bird, parts of birds and equipment. In either event, use of process water does not involve recirculating water within a process. The process water was collected and distributed through piping and equipment in such a manner that the process water does not reach any water course considered to be part of the plant's waste drainage system.

SPECIAL STUDIES

Two potential applications of process waters were identified. Applications included the substitution of:

1. Whole bird wash water for chiller water in the operation of the scald vat.

2. Combined chiller and final bird wash water for potable water in selected uses in the operation of the gizzard splitting and peeling machine.

Changes in the pattern of water flows required for these changes can be seen by comparing the flow charts in Appendix B, Figures 1 and 2.

Potential potable water reductions by the use of the above process water in the Gold Kist plant was 104,000 gpd in processing 70,000 broilers or approximately 1.5 gallons per bird. This reduction represents a 20 percent decrease in the use of potable water.

Permission was obtained from United States Department of Agriculture - Consumer Marketing Service on April 14, 1971 to conduct limited studies for the use of process water. Continued-use process water was used in the scalding and gizzard splitting operations during the period April 15 to June 30, 1971.

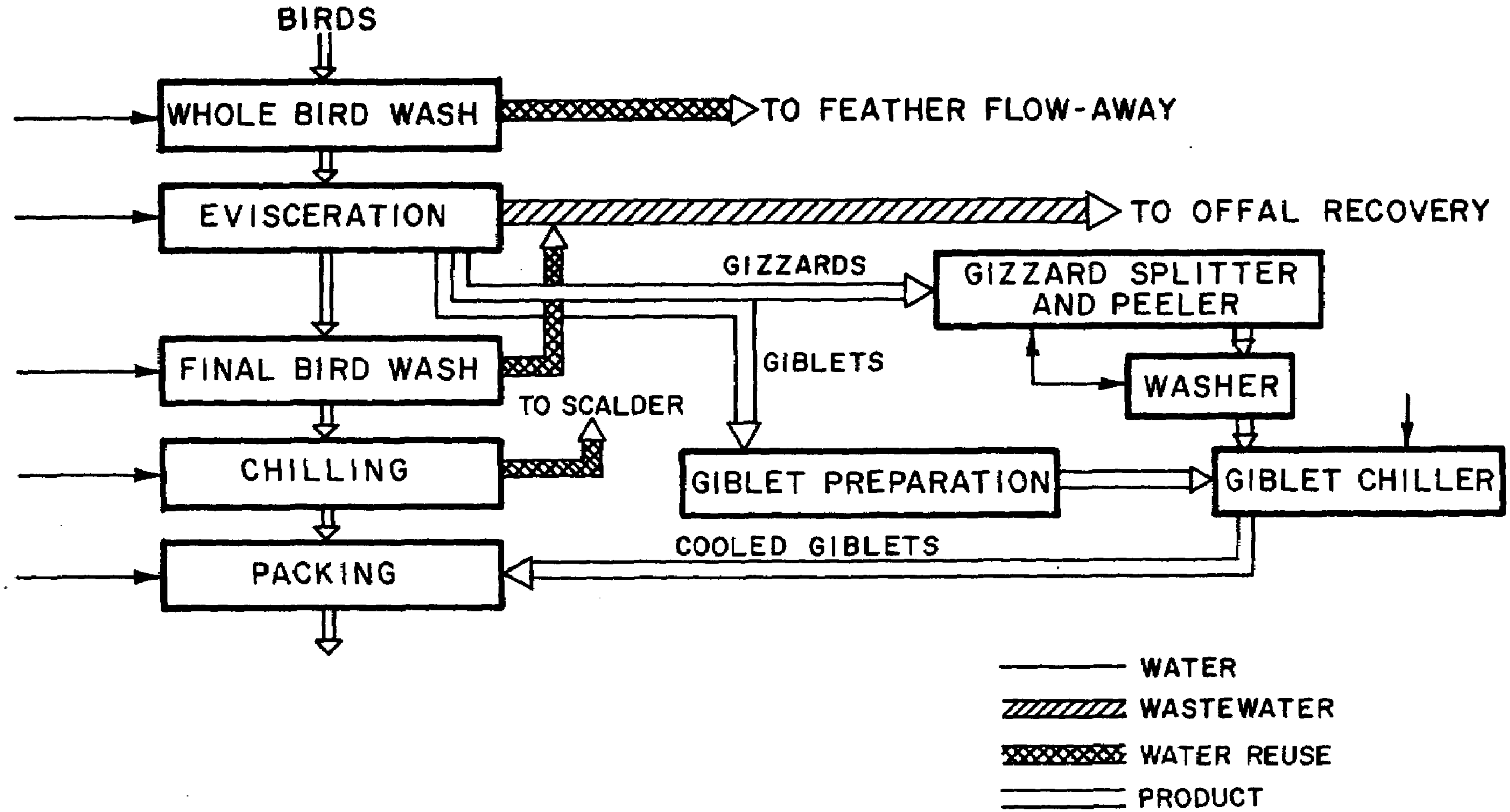
STUDY NUMBER ONE -- SUBSTITUTION OF WHOLE BIRD WASH WATER FOR CHILLER WATER IN THE SCALD VAT

The purpose of this study was to determine the feasibility of using whole bird wash water in the scalding vat. Re-use of chiller water in the scalders is permitted by some consumer protection officers and was being used for this purpose in the Gold Kist plant. Whole bird wash water contains less grease and other materials than chiller water and is warmer in temperature and should be preferable for these reasons. Changes in physical, chemical and microbiological characteristics of water in the scald vat were evaluated when whole bird wash water was substituted for chiller water.

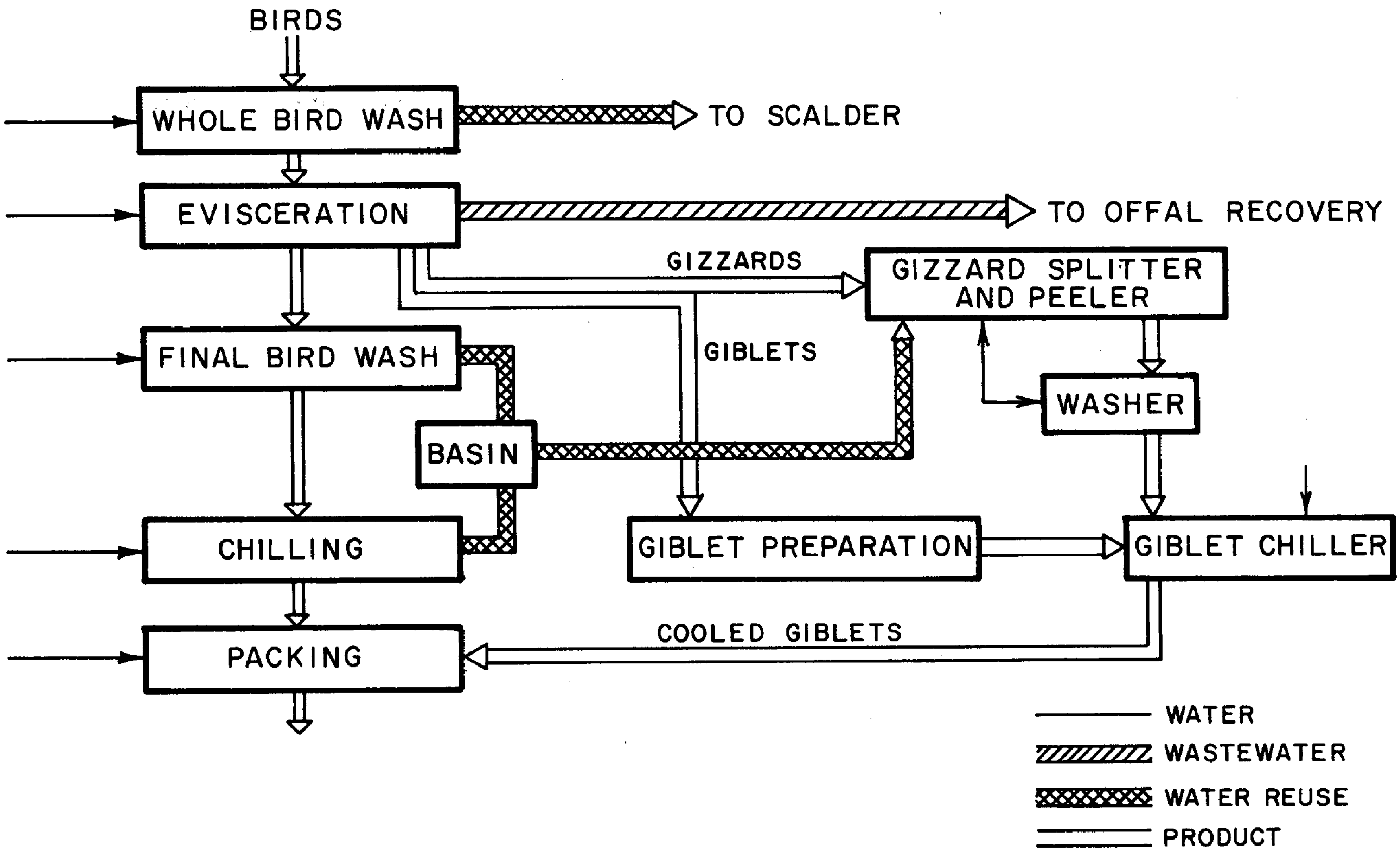
The scald vat provides a heat sump in preparation for defeathering of poultry and serves as a first washer. Body oils, blood, feathers, droppings and dirt are dislodged in the vat. The scald water at discharge is characterized by a high solids content (both dissolved and suspended), high biochemical oxygen demand and high total bacterial count.

PROCEDURE

Rinse water from the whole bird washers was substituted for chiller water in the operation of the scald vat during the period April 15 to June 30, 1971.



Appendix B, Figure 1. Water use for giblets



Appendix B, Figure 2. Water use for giblets with reuse of final bird washer and chiller waters

Appendix B, Table 1. MEDIAN AND RANGE FOR SELECTED WASTEWATER CHARACTERISTICS, CHILLER AND WHOLE BIRD WASHER WATER

Characteristics	Units	Chiller		Whole bird washer	
		Median	Range	Median	Range
BOD	mg/l	500	110-550	70	29-91
COD	mg/l	689	200-1020	80	60-120
Total solids	mg/l	652	532-772	195	130-318
Grease	mg/l	140	90-577	36	21-50

Appendix B, Table 2. MICROBIAL COUNTS FOR WATER SAMPLES

Sampling Points	Total Counts Range	Total Counts Median	Total Counts Mean	Coliform Counts Range	Coliform Counts Median	Coliform Counts Mean
	(Number/milliliter)			(Number/milliliter)		
Scald vat input water:						
Chiller overflow	$4.3x10^3$-$5.3x10^4$	$1.1x10^4$	$1.3x10^4$	$3.5x10^2$-$2.3x10^3$	$9.6x10^2$	$1.0x10^3$
Whole bird washer	$5.6x10^2$-$3.2x10^4$	$7.9x10^3$	$1.6x10^4$	1.4x10 -$2.4x10^3$	$7.8x10^2$	$8.3x10^2$
Scalder effluent:						
Scalder effluent when using chiller water	$1.1x10^4$-$2.0x10^7$	$3.3x10^6$	$6.0x10^6$	2-$5.4x10^3$	$3.0x10^2$	$7.7x10^2$
Scalder effluent when using whole bird wash water	$2.3x10^3$-$5.8x10^6$	$3.2x10^5$	$9.5x10^{5*}$	$4.4x10^2$	5.1x10	$7.7x10^*$

* Total and Coliform counts for scalder effluent statistically significant at .01 level.

Baffles were installed in the two washers to provide control in collecting rinse water. The rinsewater from the front portion of the washer, containing most of the free solids, was continuously discarded. The remaining rinse water was collected in a metal chamber at a rate of 48 gpm where floating solids were removed by allowing excess water to overflow directly into the feather flow-away flume. Approximately 40 gpm of the water from the collection chamber was pumped to distribution points along the scald vat which was filled with potable water prior to start-up each day. Pump speed and control valves were used to control flow rates.

Prior to the study period of April 15, 1971, weekly composite samples of both the chiller water before it entered the scald vat and the overflow water from the scald vat were collected. During the study period, water samples were collected twice a week at three time periods during each sampling day -- early morning, near noon and just prior to the end of daily operations. Water samples were analyzed for biochemical oxygen demand (BOD), chemical oxygen demand (COD), total solids and grease in accordance with Standard Methods for the Analysis of Industrial Water and Waste Waters, 13th Edition, A.W.W.A. and P.H.S..

CHARACTERISTICS OF INPUT WATER

Whole bird washer water had lower median values than chiller water for select characteristics of BOD, COD, total solids, grease, total microbiological count and coliform count (Appendix B, Tables 1 and 2). Whole bird washer water should be preferred to chiller water as a source of make-up water for the scald vat. In the following section, it will be shown that chiller water can be re-used effectively in the gizzard splitting and peeling machines. Here, cool water has a distinct advantage.

RESULTS

Samples of the effluent water were not taken until after steady state levels of water quality were attained. This occurred about 30 minutes after operations began each day. If an upper level to the build-up of chemicals and organisms in the scald vat should exist, then the quality of input water may not be a critical factor. A number of water sources may exist within the plant which could provide water for continued-use in the scald vat.

The median levels for characteristics of the scalder effluent were slightly lower when whole bird washer water was the water source instead of using chiller water (Appendix B, Tables 2 and 3).

Appendix B, Table 3. MEDIAN AND RANGE FOR SELECTED CHARACTERISTICS OF SCALDER EFFLUENT USING CHILLER AND WHOLE BIRD WASHER WATER AS WATER SOURCES

Characteristics		Scalder effluent using chiller water		Scalder effluent using whole bird wash water	
	Units	Median	Range	Median	Range
BOD	mg/1	400	110-920	378	230-600
COD	mg/1	950	520-1500	834	600-1200
Total solids	mg/1	1053	842-1264	698	427-935
Grease	mg/1	260	200-320	203	180-226

CONCLUSIONS

Whole bird washer water provides an acceptable substitute for chiller water for use in the scald vat. The continued-use whole bird washer water should not have a detrimental effect on product quality as measured by microbiological count.

The equipment designed and operated in the study was experimental. Additional studies should be made to verify the results of this study and to provide proper operating equipment with easy access for cleaning and maintenance.

STUDY NUMBER TWO -- SUBSTITUTION OF FINAL BIRD WASHER AND CHILLER WATER FOR FRESH WATER IN THE GIZZARD SPLITTER

The purpose of this study was to determine the feasibility of using the combined process waters from the final bird washer and chiller for selected uses in the gizzard splitters. Specific objectives were to determine the physical, chemical and biological characteristics of the combined process waters and to evaluate the changes in product quality when these waters were substituted for fresh water in the gizzard splitters.

OPERATION OF THE GIZZARD SPLITTER

The gizzard splitters operate as follows. One gizzard at a time is forced into the machine and passes over a rotating slicer. Feed, grit, loose fat, and other materials are forcefully flushed from the gizzard by the use of two large flat sprays of water. Immediately thereafter, the skin lining is stripped or peeled from the gizzard by two concentric gear-like rollers and the lining is also flushed from the machine by a third large flat spray of water.

Sixty gallons of water per minute flow through the three flat spray nozzles in each gizzard splitting machine. In addition, fresh water was applied in all other parts of the splitting machine. This includes the lead-on or feeder troughs and rinse sprays at the exit of the gizzard peeler section.

PROCEDURE

Effluents from a final bird washer and the carcass chiller were collected and settled in a baffled tank. The water was screened before pumping in order to prevent floating grease, meat particles, and other parts from entering the pumping chamber. Excess water in the 300 gallon collection tank overflowed into the offal drain. A stainless steel pump was used to supply the continued-use process water to the flat sprays at a water pressure of 20 psi.

Water and gizzard samples were taken at the following sampling points:

1. fresh water sample taken once during the day,

2. settling basin effluent consisting of combined water from the final bird washer and first chiller,

3. ten gizzards per sample, as they emerged from splitter-peeler,

4. water effluent from the reel washers (Note: fresh water was used on all spray nozzles in the reel washer. The reel wash follows the splitting and peeling operation), and

5. ten gizzards per sample from the reel washer exit.

Samples were collected twice a week at three periods during each sampling day -- early morning, near noon, and just prior to the end of daily operations. The experimental period was April 28 to July 20, 1971 and included 15 sampling days. Procedures for microbiological examinations are outlined later.

CONTINUED-USE WATER CHARACTERISTICS

The water quality characteristics of the combined effluent from the final bird washer and first chiller are given in Appendix B, Table 4. This water for continued-use contained approximately the same levels of BOD and COD as chiller water alone. Total solids and grease levels of the continued-use water were lower than those of chiller water. This can be accounted for by the approximately 200 pounds of floating materials removed each day from the tank that was used to combine the chiller and final bird wash water.

Appendix B, Table 4. WATER QUALITY CHARACTERISTICS OF COMBINED CHILLER AND FINAL BIRD WASHER WATER AFTER SETTLING AND SCREENING

Characteristics	Unit	Range	Median	Mean
Biochemical oxygen demand	mg/l	366-538	493	489
Chemical oxygen demand	mg/l	440-1040	665	663
Total solids	mg/l	340-814	532	575
Suspended solids	mg/l	52-224	124	130
Grease	mg/l	63-147	94	90
Total count	No./ml	$9.3x10^0$ - $1.2x10^6$	$3.4x10^4$	$9.0x10^4$
Coliform count	No./ml	$2.1x10^2$ - $7.9x10^6$	$1.3x10^3$	$3.4x10^3$

RESULTS

The chemical characteristics of the reel washer rinse water using fresh and continued-use water in the gizzard splitter were compared to determine the effects of substituting continued-use water. Biochemical oxygen demand and suspended solids content of reel washer rinse water were about the same when using either fresh or continued-use water in the gizzard splitter (Appendix B, Table 5). Chemical oxygen demand, when using fresh water, was about double the level for continued-use water. Total solids and grease content were higher when continued-use water was used in the splitter.

A high proportion of waste materials in the continued-use water was in the dissolved or liquid state. The low level of suspended solids was achieved by effective grease flotation and screening of other solids prior to pumping. Removing the free solids reduced the problem of clogging of the flat spray nozzles.

Data are not available for determining the level of solids that might be on the gizzards coming from the splitters. The higher levels for total solids and grease in the reel washer rinse water when continued-use water is applied in the splitter indicate that a larger amount of waste materials is removed by the rinsing operations. It may be that there is more loose material on the gizzards from the splitter when continued-use water is used. However, it is possible that the grease or other materials in the continued-use water may mix with the gizzard contents or provide a cover for the gizzard in such a way that the rinsing removes a greater portion of the waste.

The latter outcome is supported by the results of the bacterial count. The bacterial total and coliform counts are higher for gizzards collected from the splitters prior to rinsing (Appendix B, Table 6). The counts are also higher for the reel washer rinse water when continued-use water is used. However, there are mixed results for gizzards collected at the exit of the reel washers. The bacterial total count was higher for the gizzard samples in which fresh water was used in the splitter, while the coliform count was higher for the gizzard samples in which continued-use water was used in the splitters.

The bacterial total and coliform counts for gizzards collected at the exit of the reel washers were not statistically different. The results indicate that the quality of gizzards is expected to be the same using fresh or continued-use water in the gizzard splitter under conditions similar to those of the Gold Kist plant.

Appendix B, Table 5. WATER QUALITY CHARACTERISTICS OF REEL WASHER RINSE WATER USING DIFFERENT SOURCES OF WATER IN THE GIZZARD SPLITTER

Characteristics	Source of water			
	Potable		Continued-use	
	Range	Median	Range	Median
	(mg/1)			
Biochemical oxygen demand	13-19	28	21-49	32
Chemical oxygen demand	20-300	80	20-180	45
Total solids	31-302	149	127-315	213
Suspended solids	12-110	25	4-54	23
Grease	1-297	38	6-180	53

Appendix B, Table 6. MICROBIAL COUNTS FOR REEL WASHER RINSE WATER AND GIZZARDS USING DIFFERENT SOURCES OF WATER IN THE GIZZARD SPLITTER

Sampling points and water sources	Total count			Coliform count		
	Range	Median	Mean	Range	Median	Mean
			(No./Gm)			
Gizzards from the splitting machine using:						
Fresh water	$8.1x10^2$-$3.8x10^4$	$2.7x10^3$	$4.7x10^3$	6.2x10-$6.0x10^3$	$4.8x10^2$	$1.0x10^3$
Continued-use water	$7.3x10^2$-$6.7x10^4$	$5.0x10^3$	$9.2x10^3$	5.8x10-$9.0x10^3$	$5.6x10^2$	$1.1x10^3$
			(No./ml)			
Reel washer rinse water from machine using:						
Fresh water	1.0-$3.3x10^3$	$6.1x10^2$	$7.6x10^2$	0 - 21	1.0	2.0
Continued-use water	2.1-$7.8x10^3$	$8.9x10^2$	$1.6x10^3$	0 - 10	0.5	1.2
			(No./Gm)			
Gizzards from reel washer from machine using:						
Fresh water	3.7x10-$5.9x10^4$	$3.0x10^3$	$9.0x10^3$	2.0 - 160	22	28
Continued-use water	$2.5x10^2$-$1.2x10^4$	$2.6x10^3$	$3.4x10^3$	1.0 - 240	25	42

CONCLUSIONS

An analysis of the data from this study indicates that the use of chiller and final bird wash water for the flushing of poultry gizzards in the splitting machines has no detrimental effect on either the wholesomeness of the gizzards or the whole birds. Satisfactory operations did exist during the experiment. Proper design of a system for applying these waters will produce considerable savings and satisfactory sanitary conditions in both the equipment and the product.

MICROBIOLOGICAL EXAMINATIONS

INTRODUCTION

Total and coliform counts were performed on samples of water and products taken from carcasses collected just prior to packing and from gizzards taken from the reel washers and were tested for the presence of salmonella. Total counts were determined on Difco Plate Count Agar (PCA) after 48 hours of incubation at 32°C. Coliform counts were made on Violet Red Bile (VRB) Agar (Difco). Plates were incubated at 35°C for 24 hours.

The finished carcasses were tested for salmonella contamination using the following procedure. The carcasses were collected in sterile plastic bags and 1,500 milliliters (ml) of sterile water added to the bag containing each carcass. The bag was shaken for one minute. Care was taken to ensure that water went inside the body cavity. One hundred ml of this rinse water was pre-enriched in 400 ml of lactose broth (Difco). One ml of the incubated lactose broth culture was transferred into selenite cystine broth (BBL) and one ml was innoculated into selenite cystine made from the individual ingredients with ducitol substituted for lactose. Streak plates on Brilliant Green Agar, Bismuth Sulfite Agar, and Salmonnella-Shigella Agar (all Difco products) were prepared from selenite cystine (both types) tubes showing growth.

Suspect colonies from the selective media were transferred to triple sugar iron (TSI) agar slants. The time-temperature for incubation was the same for the above tests, 24 hours at 35°C. Isolates showing salmonella-like reactions on TSI slants were tested for the presence of urease and lysine decarboxylase and their ability to ferment lactose and dulcitol to acid and gas. Finally, suspect isolates were tested for agglutination in poly-o-antiserum.

Studies of the continued-use of water were conducted near the end of the development phase of the Gold Kist project. Microbiological evaluations of the final bird carcass were made during the period April 28 to July 20, 1971 to determine the effect on carcass biological quality of process and equipment changes, including the continued-use of water, that took place prior to April 28.

SAMPLING

Carcass samples (102 carcasses) collected during the 34 weeks of sampling from March 10, 1970 to March 3, 1971 were compared with the samples (130 carcasses) collected during the 15-week period from April 28, 1971 to July 20, 1971. Samples were collected in sterile plastic bags at the packing tables as the carcasses were released from the overhead conveyors.

Three samples of one carcass each were collected weekly during the 34-week sampling period. Three samples of one carcass each were collected three times during each testing day -- morning, noon and just prior to the close of daily operations. Procedures for the biological examinations was outlined previously.

RESULTS

The median value of both total bacteria and coliform bacteria were lower during the testing period from April 28 to July 20, 1971 than in the period prior to March 3, 1971 (Appendix B, Table 7). The sample means were not significantly different, however. It was concluded that process and equipment changes, including the continued-use of process water made within the plant and in operation during the final testing period, did not adversely affect the biological quality of the birds processed in the Gold Kist plant. There is no indication that the continued-use of water raised the level of contamination of the final product.

Compared to the 102 carcass samples taken over a period of one year prior to this special study the results indicate that the bacterial total count remained the same.

Coliform counts during the experimental period where 130 carcasses were examined indicate lower median and mean values. However the differences in bacterial coliform counts are not sufficiently large to conclude that a significant improvement was made in plant operations by the application of combined process water in gizzard splitters and whole bird wash water in the scalder.

Appendix B, Table 7. MICROBIAL COUNTS FOR CARCASS SAMPLES COLLECTED FROM CONVEYORS AT PACKING TABLES FOR PERIODS BEFORE AND AFTER CHANGES IN WATER USE

	Total Counts			Coliform Counts		
Period	Range	Median	Mean	Range	Median	Mean
Before	2.2×10^5-2.8×10^7	2.4×10^6	3.4×10^6	5.2×10^3-1.6×10^6	7.6×10^4	1.2×10^5
After	1.4×10^5-2.7×10^7	1.8×10^6	2.8×10^6	1.3×10^3-7.4×10^5	5.7×10^4	1.1×10^5

On the other hand we can believe that the wholesomeness of poultry products shipped from this plant during the experimental study were as good as or better than the products shipped prior to the study. This belief is further fortified by the observation that there was a reduction of incidence rate of salmonella found during both product examination periods when comparing the control of no water reuse with water reuse. The data indicated a change from 21.6 per 100 carcass incidence rate to 13.8 per 100 carcasses or, based on these calculations, an improvement of 36 percent during the time that continued-use process water was applied to the primary product. Other factors such as seasons of the year, flock in process and others surely make this difference not significant but the basic fact remains that a reduction in incidence rate was observed. Further detailed studies with adequate controls are needed for a reliable conclusion.

Appendix B, Tables 8 and 9, show the before and after total and coliform counts for the whole carcass evaluation. No significant differences were observed. For these and previous observations, it is concluded that no detectible change occurred in the microbial characteristics. Also, it is concluded that the product was as wholesome during water reuse and continued use as it was before these changes.

PARTIAL AND ANNUAL BUDGETS FOR CHANGES

The initial costs for modification of the whole bird wash system to allow overflow to the scalder are presented in Appendix B, Table 10. The major cost item was a pump and total costs were $804.09. The net savings on a yearly basis were $1,703. for the change (Appendix B, Table 11).

The temporary manner in which changes were made for Study 2 involving the gizzard machine water supply prevented a reasonable development of budgets. Net savings were very possible using even the most expensive of possible alternatives.

Appendix B, Table 8. MEANS OF TOTAL COUNTS OF CARCASSES

Treatment	Time 1	2	3	Total
Before Study	$3.4x10^6$			$3.4x10^6$
During Study	$3.2x10^6$	$3.0x10^6$	$2.3x10^6$	$2.8x10^6$
Total	$3.4x10^6$	$3.0x10^6$	$2.3x10^6$	$3.1x10^6$

No SD

Appendix B, Table 9. MEANS OF CARCASS COLIFORM COUNTS

Treatment	Time 1	2	3	Total
Before Exp	$1.2x10^5$			$1.2x10^5$
During Exp	$1.1x10^5$	$1.1x10^5$	$1.1x10^5$	$1.1x10^5$
Total	$1.2x10^5$	$1.1x10^5$	$1.1x10^5$	$1.2x10^5$

No SD

Appendix B, Table 10. INITIAL COSTS OF THE MODIFICATION OF THE WHOLE BIRD WASH SYSTEM TO ALLOW OVERFLOW TO SCALDER OF CONDITIONED WATER

Item	Quantity and/or rate		Amount
Material:			$704.99
	1 5 horsepower pump	$350.00	
	1 stainless steel setting chamber	173.00	
	Piping	134.35	
	4 pressure gauges	15.00	
	4 valves	10.64	
	1 5/8" x 3/4" SRG rebuilt meter	22.00	
Tax:	2% of material cost		14.10
Labor:	8 1/2 hours @ $10/hour		85.00
Total Costs:			$804.09

Appendix B, Table 11. ANNUAL BUDGET FOR WHOLE BIRD WASH SYSTEM MODIFICATION

Item	Quantity and/or rate		Amount
Reduced Costs:			$2,281.
Water	5,184,000 gals. @$.44/1000 gals.[a]		
Increased Costs:			578.
Maintenance	1% of material cost	$ 72.00	
Depreciation			
Valves and misc.		24.00	
Piping		13.00	
Pump	100% in 1 year	350.00	
Chamber		6.00	
Interest on Investment	1/2 of initial cost @ 7%	28.00	
Recurring Labor Cost		85.00	
Net saving per year			$1,703.

[a] The substitution of fresh water in the scalder by water from the whole bird washer would result in a reduction of 40 gpm.

RECOMMENDATIONS

The operation of such plant equipment with continued-use water being applied on primary products should be carefully considered to insure the use of properly designed equipment that will permit steady and frequent replacement of continued use water with the frequent of continuous removal of solids that may accumulate from the collection and control of such used waters.

All pumps, piping, and collection units should be so designed that proper sanitation standards can be met and maintained daily. If "clean in place" systems are to be considered, then all equipment should be arranged to provide adequate cleaning capacity, with chemicals, and maintained under specified schedules as prescribed for adequate sanitary conditions throughout the continued-use water system.

Screening of final bird wash water and chiller effluent should be done with fine mesh materials so that the sizes of suspended solids do not exceed the apertures of the spray nozzles.

Collection tank should be designed so that the proper water level is maintained at all times in this unit. This condition can be met by the installation of an automatic float control and supplemental fresh water supply.

APPENDIX C

LABORATORY TESTING DETAILS

Appendix C, Table 1.

Tests

The following tests were made using the procedures adopted by APHA in Standard Methods, 12th edition, or technical developments by FWPCA and others.

	Method
A - Alkalinity	Hach*
B - pH	
C - Chlorides	Hach*
D - Grease	APHA
E - Nitrogen--Ammonia, Nitrite, Nitrate, TKN	APHA
F - Dissolved Oxygen	APHA
G - BOD (Biological Oxygen Demand)	APHA
H - COD (Chemical Oxygen Demand)	APHA
I - Temperature	
J - Volume	
K - Solids-- TS, SS, DS	APHA
L - Potassium	
M - Phosphates	Hach*

* Hach Chemical Co., Ames, Iowa.

Appendix C, Table 2.

Sampling Points and Planned Testing (See Figure 3)

Sampling Point	Testing	Source
1.	A B E G H J K M	Receiving Dock Washdown Water
2.	A B C D E G H I J K	Blood Recovery Wastewater
3.a.	A B C D E G H I J K M	Scalder Entry
b.	A B C D E G H I J K M	Scalder Exit
4.	A B C D E F G H I J K M	Feather Flow-Away Flume
5.	D E G H I J K	Whole Bird Washer Effluent
6.	A B C D E G H I J K M	Eviscerating Trough Effluent
7.	B C D E G H I J K M	Final Bird Washer Effluent
8.	A B C D E F G H I J K M	Offal Flow-Away Flume
9.a.	A B C D E F G I J K M	Giblet Chiller
b.	A B C D E F G I J K M	Prechiller
c.	A B C D E F G I J K M	Final Chiller
10.	B C D E G J K	Packing Wastewater
11.	A B C D E F G H I J K L M	Final Effluent

SELECTED WATER RESOURCES ABSTRACTS

INPUT TRANSACTION FORM

1. *Report No.*
2.
3. *Accession No.* **W**

4. *Title*
WATER AND WASTE MANAGEMENT IN POULTRY PROCESSING

5. *Report Date* May 1974
6.
8. *Performing Organization Report No.*

7. *Author(s)* Roy E. Carawan, William M. Crosswhite, John A. Macon, Byron K. Hawkins

9. *Organization*
North Carolina State University
Gold Kist, Inc. (Byron K. Hawkins)

10. *Project No.*

11. *Contract/Grant No.* 12060 EGV

13. *Type of Report and Period Covered*

12. *Sponsoring Organization* U.S. Environmental Protection Agency

15. *Supplementary Notes*

Environmental Protection Agency report number EPA-660/2-74-031, May 1974

16. *Abstract*

A typical broiler processing plant was used to evaluate changes in equipment and processing techniques to reduce water use and waste load. Production at the plant was through two processing lines and totaled approximately 70,000 broilers per day. Benchmark results indicated a water use of 12.28 gallons per bird received which was reduced by 32 percent to 7.81 gallons per bird received. Benchmark results indicated a daily waste load of 3970 lbs BOD_5 which was reduced by 66 percent to 1355 lbs BOD_5. Changes made are detailed and economic analysis showed all to be profitable for the plant with an average annual net savings of $4.08 per 1000 broilers processed. An initial investment of $93,065 was needed. Annual operating costs were $31,023 with annual net savings of $72,193. A water and waste management program is detailed. Microbiological analyses indicated no deterioration in product quality as a result of the changes.

17a. *Descriptors*

*Industrial Water, *Industrial Wastes, *Food Processing Industry, *Poultry, Water Reuse, Waste Water Treatment

17b. *Identifiers*

Poultry Processing Industry, Process Changes and Evaluation, In-Plant Water Management, In-Plant Waste Control

17c. *COWRR Field & Group*

18. *Availability*

19. *Security Class. (Report)*

20. *Security Class. (Page)*

21. *No. of Pages*

22. *Price*

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