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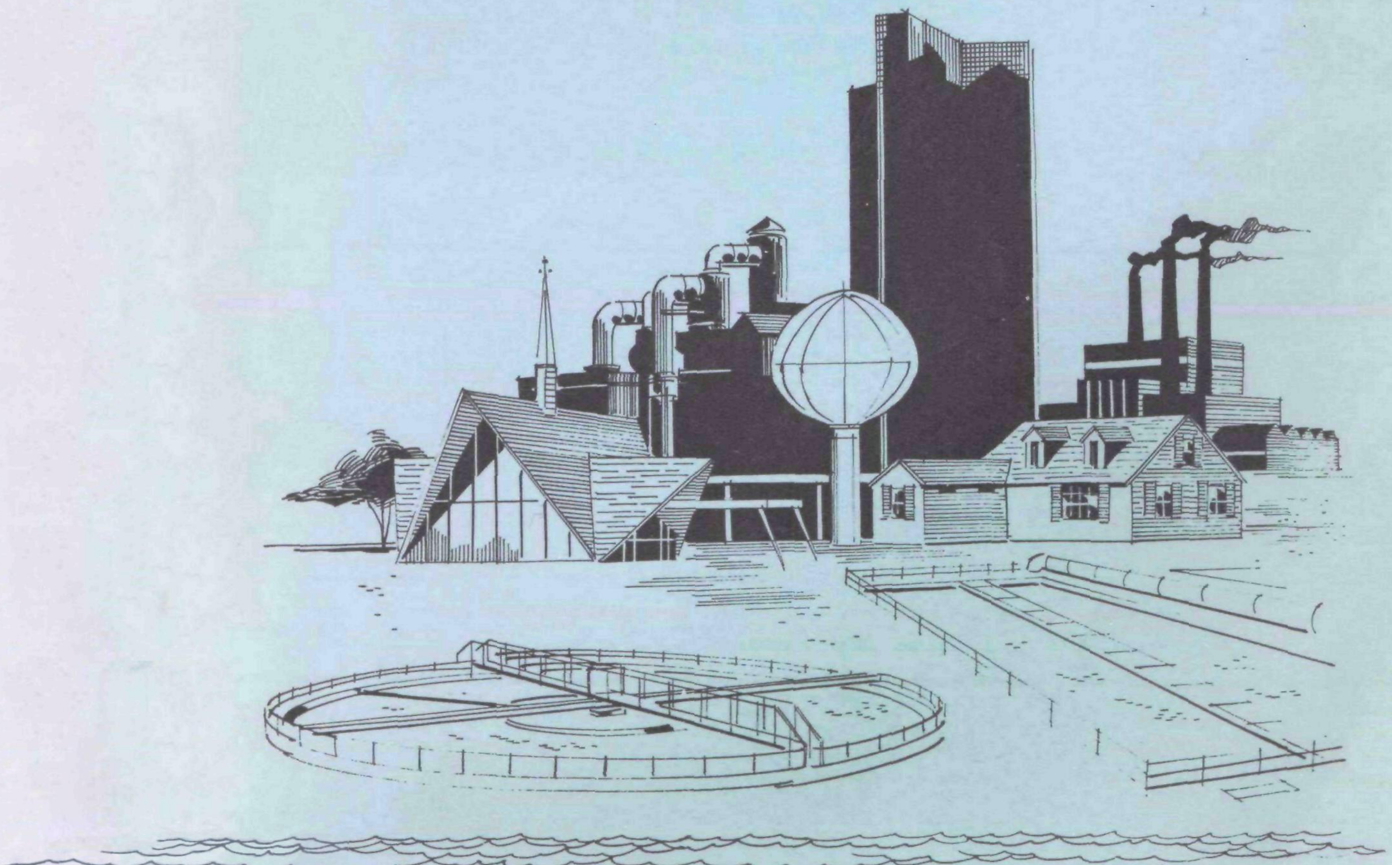
Combined Treatment of Municipal Kraft Linerboard and Fiberboard Manufacturing Wastes



U.S. ENVIRONMENTAL PROTECTION AGENCY

WATER POLLUTION CONTROL RESEARCH SERIES

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COMBINED TREATMENT OF MUNICIPAL KRAFT LINERBOARD, AND FIBERBOARD MANUFACTURING WASTES

by

Macon, Georgia, Board of Water Commissioners
Georgia Kraft Company
Armstrong Cork Company

for the

ENVIRONMENTAL PROTECTION AGENCY

INDUSTRIAL POLLUTION CONTROL
Program Number 11060 DPD
February, 1971

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ABSTRACT

The successful treatment of domestic waste from one drainage basin of the City of Macon, Georgia, along with wastewater from an 850 ton-per-day kraft linerboard mill and a 600 ton-per-day groundwood-cold caustic structural insulation board mill was obtained in a 120 gallon-per-minute capacity plant. A pro-rated quantity of the total flow of each waste was treated.

The pilot plant consisted of combined and/or separate primary sedimentation units, followed by two parallel secondary treatment systems. Each secondary system received half of the plant influent. One secondary system consisted of twenty-four to thirty hours of extended aeration, while the other consisted of a high rate plastic media bio-filter followed by twelve to fifteen hours of aeration. Both systems had secondary sedimentation and sludge return.

The secondary systems averaged approximately ninety-two percent (92%) BOD removal with an effluent concentration in the range of 50 mg/l BOD. Auxiliary studies indicated that supplemental nutrients are not required.

Chlorine proved to be the best disinfecting agent, but large amounts were required. An organism in the groundwood-cold caustic operation interfered with the fecal coliform test, making disinfection studies inconclusive.

Settled secondary sludge was bulky, containing one to three percent (1-3%) solids, and was difficult to dewater.

Estimated construction and operating costs for combined and separate treatment plants were prepared. The combined plant utilizing plastic media bio-filters along with fifteen-hour aeration is the most economical. In comparison, the combined system is more economical than separate facilities.

This report was submitted in fulfillment of Project 11060DPD under the sponsorship of the Environmental Protection Agency.

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SECTION I

CONCLUSIONS

1. Municipal sewage, wastewater from an unbleached kraft linerboard operation, and wastewater from a groundwood-cold caustic insulation board mill can be treated in a combined plant.

2. The lack of primary sedimentation for the municipal and kraft mill wastes did not adversely affect the operation of the secondary treatment systems.

3. A combined treatment plant can provide in excess of ninety percent (90%) BOD reduction. This could be obtained by primary sedimentation of only the groundwood-cold caustic insulation board mill waste in combination with either of the two secondary treatment systems studied.

4. The addition of supplemental nutrients did not improve overall treatment plant efficiency.

5. Chlorine was determined to be as effective as any disinfecting agent studied. The chlorine demand for the combined effluent varied from 20 to 100 mg/l, with an average of approximately 60 mg/l. Chlorine dosage required to produce ninety-five percent (95%) kill of indicator organisms averaged 35 mg/l.

6. Disinfection studies were inconclusive due to the presence of the Klebsiella organism in the groundwood-cold caustic effluent which interfered with the fecal coliform test.

7. Settled secondary sludge was bulky, one to three percent (1-3%) solids, and was difficult to dewater.

8. Variations in the strength of the industrial waste flows did not upset the pilot plant operation.

9. Of three separate plants proposed for the individual participants, only the City's plant is comparable in BOD removal to that expected by the combined treatment facility.

10. The total estimated capital and operating costs for the combined treatment facility are less than the total estimated costs for the three separate treatment plants.

SECTION II

RECOMMENDATIONS

Based on the pilot plant data and financial studies, it has been determined that the most economical secondary treatment system is the plastic media bio-filter with fifteen-hour detention in the aeration basin. A full-scale combined treatment plant should be of this design.

Methods of dewatering bulky activated sludge in a more economical way should be investigated.

Due to the quantity of chlorine required for disinfection of the full-scale plant effluent, a detailed study of the effluent quality should be conducted before the need and/or method of disinfection is decided upon.

Investigations on the full-scale plant should be carried out to confirm the conclusions of the pilot studies. Investigations of plastic media bio-filter performance, aeration requirements, nutrient needs, shock loadings, etc. should be performed.

SECTION III

INTRODUCTION

It is well known by both the lay and scientific communities that water pollution control is one of the more urgent and sophisticated problems confronting our nation today. With this awareness, the press for prevention and/or control of pollution has intensified. This intensification has compounded the need for better solutions, both from the economic and the technical viewpoints, to the problems of water pollution control.

The primary causes of the pollution problems of the Ocmulgee River for the first several river miles downstream from Macon are a result of domestic wastes from the City of Macon and industrial wastes from Armstrong Cork Company and Georgia Kraft Company. This problem is well known, and a solution has been required by the State Water Quality Control Board. The waste outfalls for the City and the two industries are located in close proximity in a single drainage basin called Rocky Creek, shown in Figure 1. Therefore, in late 1966 the possibility of a joint solution to this problem was conceived. Arrangements were made with Dr. Robert S. Ingols, Research Professor at the Georgia Institute of Technology in Atlanta, who conducted bench scale treatability studies in late 1967 and reported on them in early 1968. Results of the bench scale studies are shown in Appendix I. The bench scale studies provided encouraging results. It was concluded that extended aeration type treatment with thirty hours detention of the waste would produce eighty-five to ninety percent (85-90%) reduction in biochemical oxygen demand. The bench scale studies did indicate, however, that large quantities of sludge would be produced and that further studies to define both the actual quantities and the means of sludge disposal were necessary. The high concentration of the waste also suggested that a plastic media biofilter would achieve a significant reduction in power costs for aeration.

To answer questions raised in the bench scale studies, a pilot plant study was planned by the three parties in mid 1968. It was felt that this study was of such significance, in several respects, that the City of Macon made application in May 1968 for a Federal Water Quality Administration Research and Development Grant. Such grants are provided for under the "Clean Water Restoration Act of 1966." On February 19, 1969, the City of Macon accepted an FWQA Research and Development Grant (11060DPD) in the amount of either $128,883.75, or seventy-five percent (75%) of the eligible project costs, whichever was less. Costs were retroactive to August 21, 1968.

At the request of the State Water Quality Control Board staff, construction on the pilot plant was initiated in August 1968, prior to the federal grant offer, so that a solution to the overall problem would be achieved as early as possible.

The pilot plant was constructed by the City of Macon, under the direction of Mr. Randolph Goulding of the engineering firm Jordan, Jones and Goulding, Inc. Pilot plant operation was begun in January 1969; however, due to difficulties with the secondary clarifiers, modifications were required. The units were modified and were placed in operation in mid April 1969 and remained under continuous study until December 5, 1969. This is approximately one and one-half months longer than was anticipated for pilot studies. This extra period is approximately the length of time lost in the studies due to aerator failures and Armstrong Cork Company pump outages.

The pilot plant provided facilities for studies of primary sedimentation and parallel secondary treatment systems consisting of (a) plastic media bio-filter in series with extended aeration, and (b) conventional extended aeration. Facilities for secondary clarification of the mixed liquor were also provided. Sludge dewatering studies were conducted on site by equipment manufacturers. Disinfection studies and all auxiliary analytical studies were conducted by either the Macon Board of Water Commissioners or the Georgia Institute of Technology.

The engineering firm, Jordan, Jones and Goulding, Inc. of Atlanta, Georgia, served as consultant on all engineering design and mechanical phases of the pilot project. Dr. Robert S. Ingols directed the pilot plant operation and served as consultant on the analytical phases of the project.

All engineering and economic data for the full-scale combined treatment plant were prepared by Jordan, Jones and Goulding, Inc. Similar data for the separate projects were prepared by the individual companies through their engineering staffs or arrangements with consultants.

This report has been prepared to make the findings of the pilot plant studies and the full-scale plant design data available as defined under the requirements for the EPA Research and Development Grant.

SECTION IV

BACKGROUND

The southern area of Macon, Georgia, has several large water-using industries and is experiencing rapid population growth. The industries do not provide adequate treatment for their wastewaters, and the population area served by a large trunk sewer is not provided with treatment facilities. The combined effects of these waste discharges on Rocky Creek, Tobesofkee Creek and the Ocmulgee River is an excessive pollutional load during low flow periods. The condition of the river is indicated in a 1967 report by EPA and State Water Quality Control experts (1). Therefore, the City of Macon and the two major water-using industries in the area, Georgia Kraft Company and Armstrong Cork Company, are confronted with the necessity of developing facilities to treat their respective wastes.

In discussions concerning methods for the treatment of these wastes, Mr. R. S. Howard, Jr., Executive Secretary, and Mr. Charles Starling, Chief of the Industrial Waste Service of the State Water Quality Control Board, have indicated that combined treatment would be a good solution to this water quality problem.

The treatment of wastes in combined facilities is, of course, not new. Information on other similar studies (2,3,4,5,6,7) were reviewed prior to undertaking this project. Several combined waste treatment investigations (8,9,10,11,12) were only slightly ahead or proceeding simultaneously with this project. While review of these and other (13) studies provides some insight into the combined treatment of municipal and industrial wastes, no situation studied to date is comparable in ratio and types of wastes to the one considered here. In order to demonstrate the feasibility of the design concept and provide design information for a successful full-scale unit, the pilot plant study described here was essential.

City of Macon:

The Macon Board of Water Commissioners currently operates a secondary treatment facility which serves about sixty-five percent (65%) of the populated area inside the City Limits. This plant was placed in operation in 1959 and discharges a treated effluent into the Ocmulgee River upstream from the area identified in this report as the Rocky Creek Drainage Basin.

The area lying within the basin outlined in Figure 1 includes portions of both the Rocky Creek and the Tobesofkee Creek drainage areas. Of the outlined area, approximately thirty-one square miles lie within the Rocky Creek Drainage Basin, and the remainder lies within the Tobesofkee Creek Drainage Basin. Of this total area, approximately 13,440 acres lie within the City Limits of Macon.

The City of Macon has an existing sewage collection system in the Rocky Creek and Tobesofkee Creek Drainage Basins (called the Rocky Creek Basin) which discharges untreated waste into the Ocmulgee River. The present average flow in the Rocky Creek Outfall is three million gallons per day, which is the City's domestic waste in the Rocky Creek Basin, plus any small industrial waste discharges connected to the system. This average flow is based on data obtained by the City's recording flow meter at an existing pumping station near the point of discharge into the Ocmulgee River. This is a population equivalent of 30,000 people. The estimated 1970 population of Macon is approximately 138,000 people. The projected population of Macon in the year 1985 is 148,500 people, which is an increase of seven percent (7%). Applying this average City-wide increase to the present flow in the Rocky Creek Basin, the anticipated Rocky Creek flow in 1985 would be 3.21 MGD; however, since the Rocky Creek Basin has a large, undeveloped area in Bibb County, which has a program of extending water and sewer facilities, a higher rate of growth has been applied to the Rocky Creek Basin. A fifty percent (50%) increase in the present flow has been provided for the City's domestic waste in these studies. The City of Macon's capacity requirements in the pilot plant studies to serve the Rocky Creek Basin until 1985 were planned on the basis of 4.5 MGD.

TABLE I

Characteristics of City of Macon Discharge for Rocky Creek Drainage Basin

	Design Conditions for Waste Treatment
Flow	4.5 MGD
BOD	7,515 lbs/day
pH	7.3
Total Suspended Solids	7,515 lbs/day
Volatile Suspended Solids	5,336 lbs/day

Armstrong Cork Company:

The Armstrong Cork Company's principal product at the Macon Division Mill is structural insulation board. This is converted into a wide range of decorative ceiling tiles, plank and boards, both of the acoustical and non-acoustical types. The principal raw material used in the manufacture of these products is pine fiber prepared by mechanical grinding of pine wood in the presence of process water. These products utilize approximately seventy-five percent (75%) of all the pulpwood used at the plant. The remaining twenty-five percent (25%) of purchased pulpwood is used in the production of insulating sheathing, roofing, certain board items and medium-density hardboard line including exterior siding and interior wall panels. In this smaller part of the production at the Macon plant, a cold caustic process is used in producing chemical pulp. The wood species used include all hardwoods found in the southeastern United States. Total production is in excess of six hundred tons per day.

The plant is located on the west side of the Central of Georgia Railroad south of Guy Paine Road as shown in Figure 1. The Company purchases some of its water from the City, but also has a private supply which consists of wells located on their property. Sanitary sewers are connected to the Rocky Creek outfall, and all industrial waste is presently discharged into Rocky Creek.

Based on separate studies by the Company and data from the operation of the primary sedimentation unit of the pilot plant, a decision was made to provide separate primary treatment of the wastes. Primary treatment facilities are presently under construction at the Armstrong plant. Their management estimates that the volume of their waste is 3.5 MGD, which is approximately the capacity assumed in conducting the pilot plant studies.

TABLE II

Characteristics of Armstrong Cork Company Wastewater

	Design Conditions for Waste Treatment
Flow	3.5 MGD
BOD	46,760 lbs/day
pH	6.6
Total Suspended Solids	5,845 lbs/day
Volatile Suspended Solids	3,098 lbs/day

Georgia Kraft Company:

Georgia Kraft Company, jointly owned by Inland Container Corporation of Indianapolis, Indiana, and the Mead Corporation of Dayton, Ohio, began operation at its first mill in Macon, Georgia, in April 1948. Since that time, Georgia Kraft Company has added divisions at Rome, Georgia, and at Mahrt, Alabama. The Company's employees have tripled in number and production is more than 3,200 tons of containerboard per day.

The Mead Division of Georgia Kraft Company, located within the southeastern perimeter of the City Limits of Macon, at the end of Mead Road, produces about 880 tons of unbleached containerboard per day. Wood, consisting of southern pine and mixed hardwoods, is subjected to a "kraft" pulping process and utilized to produce this product. The finished product is then shipped to container manufacturers throughout the United States and to foreign countries to be converted into a wide array of packages.

Process water for mill use is obtained from the Ocmulgee River. Two deep wells located on mill property provide water for domestic use. Sanitary sewage from the plant is discharged into the Rocky Creek outfall. The mill's effluent is discharged back into the Ocmulgee, approximately one hundred yards downstream of the intake.

A separate FWQA-sponsored Research and Development Grant investigation at the Mead Division ran simultaneously with the combined waste treatment pilot plant study. This separate investigation involved the use of a full-scale cooling tower to reduce the volume and BOD concentration of selected internal waste streams. The effectiveness of this unit at the Mead Division was indicated early in the pilot study, and appropriate adjustments were made in the waste flow to the pilot plant. The tower reduced the average BOD discharged from the mill by about 10,000 pounds per day, or approximately one-third of the normal waste load.

Holding ponds at Mead Division are utilized to collect and regulate the release of strong wastes into the normal waste flow from the plant. Continuous measurement of receiving stream flow and dissolved oxygen concentration are also utilized in regulating mill discharges.

TABLE III

Characteristics of Georgia Kraft Co., Mead Division Wastewater

	Design Conditions for Waste Treatment
Flow	9.0 MGD
BOD	30,060 lbs/day
pH	9.8
Total Suspended Solids	20,000 lbs/day
Volatile Suspended Solids	9,600 lbs/day

Stream Flow:

The U.S. Geological Survey has data available on the minimum flows of the Ocmulgee River at the Fifth Street Bridge in Macon and Tobesofkee Creek at U.S. Highway 80. The recorded flows at these two stations have been adjusted to predict the minimum flow in the Ocmulgee River at the confluence with the Tobesofkee Creek. The adjustments were made by determining the minimum flows in MGD per square mile of drainage area, and applying this factor to the additional drainage area between the gauging station and the intersection of the Ocmulgee River and the Tobesofkee Creek. The Ocmulgee River has 2,240 square miles of drainage area above the Fifth Street Bridge and an additional 119 square miles between Fifth Street Bridge and Tobesofkee Creek. Tobesofkee Creek has 182 square miles of drainage area above U.S. Highway 80 and an additional 44 square miles between U.S. Highway 80 and the Ocmulgee River, plus 48 square miles in the Rocky Creek drainage area. This stream flow information is summarized in Tables IV, V and VI.

TABLE IV

Ocmulgee River Flows

Recurrence Interval (Minimum)	At Fifth Street Bridge (MGD/Sq. Mi.)	Flow (MGD)	At Tobesofkee Creek Calculated Flow (MGD)
1-Day			
20 Year	0.037	83	87
10 Year	0.095	213	224
2 Year	0.176	394	415
7-Day			
20 Year	0.040	90	94
10 Year	0.127	284	300
2 Year	0.189	423	446
Month			
20 Year	0.048	107	113
10 Year	0.142	317	335
2 Year	0.239	535	564

* * * * * * *

TABLE V

Tobesofkee Creek Flows

Recurrence Interval (Minimum)	At U.S. Highway 80 (MGD/Sq. Mi.)	Flow (MGD)		At Ocmulgee Creek (Includes Rocky Creek) Flow (MGD)	
		#1	#2	#1	#2
1-Day					
20 Year	0.008	1.4	0.0	2.2	0.7
10 Year	0.018	3.3	0.0	4.9	1.7
2 Year	0.088	16.0	11.0	24.0	19.0
7-Day					
20 Year	0.010	1.8	0.0	2.7	0.9
10 Year	0.020	3.7	0.0	5.5	1.8
2 Year	0.093	17.0	12.0	25.5	20.0
Month					
20 Year	0.020	3.6	0.0	5.5	1.8
10 Year	0.043	7.8	2.8	11.8	6.8
2 Year	0.120	22.0	17.0	33.0	28.0

NOTE: Column #1 does not include any change which may occur through Tobesofkee Reservoir; Column #2 assumes a loss of 5.0 MGD due to evaporation from Tobesofkee Reservoir.

TABLE VI

Total Flow - Ocmulgee River and Tobesofkee Creek

Recurrence Interval (Minimum)	At the Junction of Tobesofkee Creek and Ocmulgee River Flow (MGD)		Dilution (17 MGD)
1-Day	#1	#2	
20 Year	89.2	87.8	5:1
10 Year	228.9	225.7	13:1
2 Year	439.0	434.0	25:1
7-Day			
20 Year	96.7	94.9	6:1
10 Year	305.5	301.8	18:1
2 Year	471.5	466.5	27:1
Month			
20 Year	118.5	114.8	7:1
10 Year	346.8	341.8	20:1
2 Year	597.0	592.0	35:1

SECTION V

DESCRIPTION OF PILOT PLANT AND STUDIES

General Process:

The pilot plant was designed with two parallel treatment systems (as shown in Figure 2) based on the extended aeration biological process. The total design flow of 120 gallons per minute was obtained from three sources in the following amounts: Armstrong Cork Company, 24 gallons per minute; City of Macon, 24 gallons per minute; and Georgia Kraft Company, 72 gallons per minute.

The wastes from the three sources entered a control weir box, as shown in Figure 3, where each was individually regulated and measured. From the control weir box, the wastes could be totally mixed and settled, mixed and settled in various combinations, settled individually or primary treatment could be bypassed. The steel settling tanks were provided with continuous sludge removal equipment. Each had a capacity to provide two hours detention of the total design flow. The effluent from the settling tanks and any flow bypassing the primary clarifiers were mixed and then split, with equal parts flowing to the two parallel treatment systems.

The No. 1 secondary system consisted of a sealed, excavated pond with a variable detention time of twenty-four to thirty hours, shown in Figure 2, and schematically in Figure 4. Aeration was provided by two five horsepower floating surface aerators. Sedimentation was accomplished in a settling area built into the effluent end of the pond, shown schematically in Figure 4. Pumps were provided for continuous sludge recirculation.

The No. 2 secondary system consisted of a plastic media bio-filter followed by a sealed, excavated pond with twelve to fifteen hours detention time, shown in Figures 2 and 5. The effluent from the filter entered the pond which used one five horsepower floating surface aerator. Sludge from the settling area could be recirculated to the pond influent and provisions were made to recirculate mixed liquor to the bio-filter influent.

Sludge drawn from either of the secondary clarifiers emptied into a 1500 gallon storage tank. Sludge from this tank could be recirculated or used for sludge disposal studies. Facilities for studying sludge disposal were provided by various equipment manufacturers.

Specific Units:

Control Weir Box and Mixing Chamber: The control weir box and mixing chamber was a common facility, constructed of steel plate with a bitumastic coating. Each of the individual wastes was discharged into separate weir chambers with the flow measured by means of "V"-notched weirs. Bleed valves ahead of the weir chambers provided the means of regulating the quantity of flow.

Flow from the weir chamber for each waste was sent either into the mixing chamber or bypassed for individual settling study. The mixing chamber provided two minutes mixing at a rate of flow of 120 gallons per minute. The overall dimension of this structure was nine feet wide, five feet long and two and one-half feet deep.

Primary Settling Tank: The primary settling tank provided two hours detention at the design flow of 120 gallons per minute. At other rates of flow, the side water depths could be varied to provide other detention times. The tank was designed of steel with a bitumastic coating and was eighteen feet (18') in diameter with a side water depth of eight feet (8') at 120 gallons per minute. Discharge was over a weir.

Auxiliary Settling Tank: The auxiliary settling tank provided two hours detention for the various flows of the individual wastes. Detention could be controlled by adjusting the water depth. The tank was steel, five feet (5') in diameter with a water depth of six feet (6') for a flow of 72 gallons per minute.

Mixing Chamber and Splitter Box: The mixing chamber and splitter box was of steel construction with a bitumastic coating. The mixing chamber provided two-minute mixing at a flow of 120 gallons per minute. The mixing chamber was eight feet by four feet by two feet deep.

Plastic Media Bio-Filter: The size was six feet by six feet by eight feet high. The structural frame was of wood. The plastic media was polyvinyl chloride, as manufactured by B. F. Goodrich Company. The means of distributing the flow at the top of the tower was through an open pan, fabricated from plywood with holes to provide reasonably uniform application of flow over the entire media area.

Aeration Basins: Aeration basins were earth dyke construction, sealed with soil cement on the bottom and asphalt on the sides. A concrete apron was provided at the water surface to prevent erosion. The detention time was controlled by varying the depth. The capability for continuous return of sludge was provided in each basin.

Aeration Pond #1 Without Bio-Filter - Excavated and Sealed

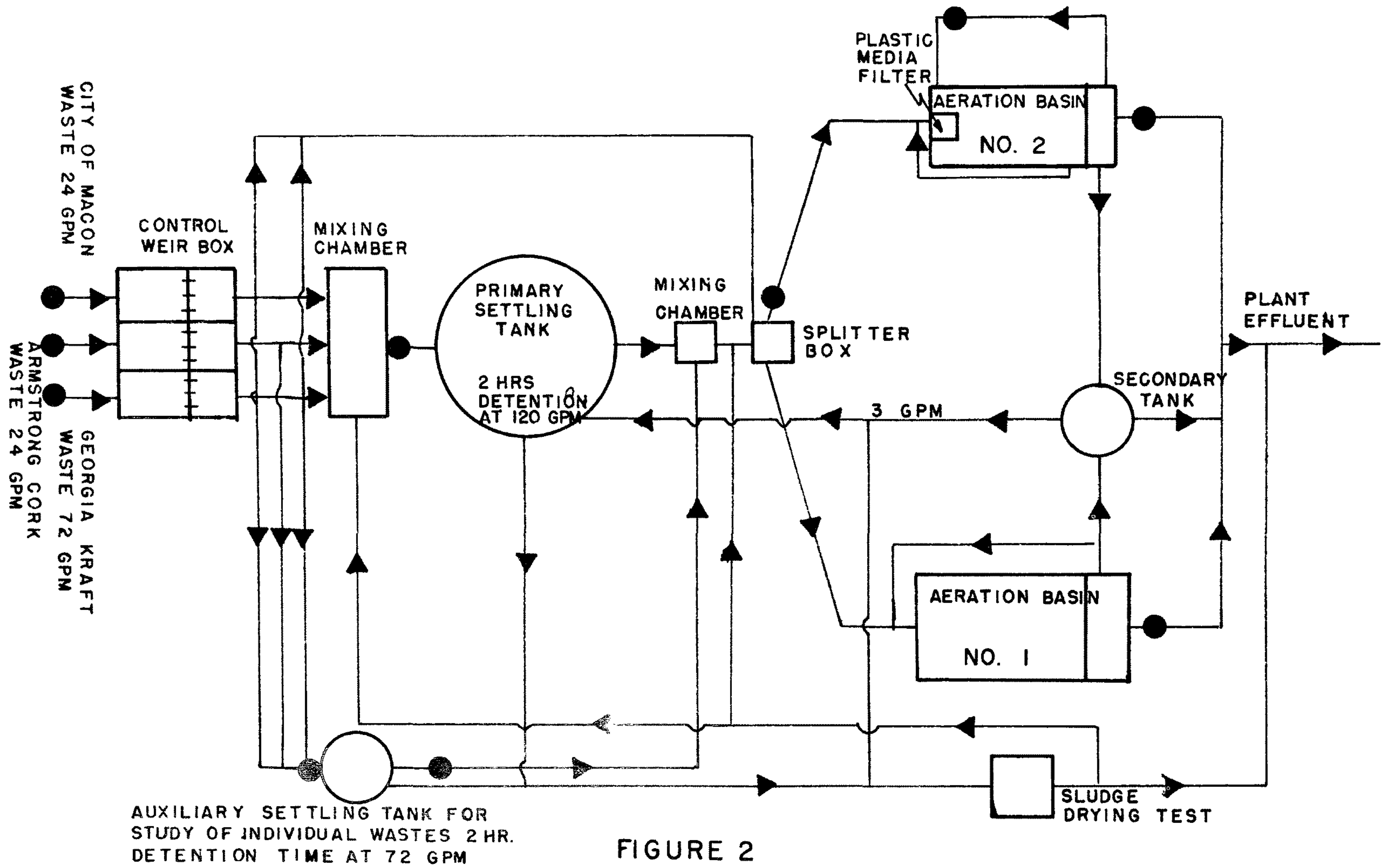
Twenty-four hour detention dimensions:
Surface 42 feet by 70 feet, Bottom 18 feet by 46 feet, Depth 6 feet.

Thirty hour detention dimensions:
Surface 42 feet by 74 feet, Bottom 18 feet by 46 feet, Depth 7 feet.

Aeration Pond #2 With Plastic Media Bio-Filter - Excavated and Sealed

Twelve hour detention dimensions:
Surface 42 feet by 47 feet, Bottom 18 feet by 23 feet, Depth 6 feet.

Fifteen hour detention dimensions:
Surface 46 feet by 51 feet, Bottom 18 feet by 23 feet, Depth 7 feet.



● SAMPLING POINTS

FIGURE 2

FLOW DIAGRAM

PILOT PLANT

ROCKY CREEK WATER POLLUTION CONTROL PLANT

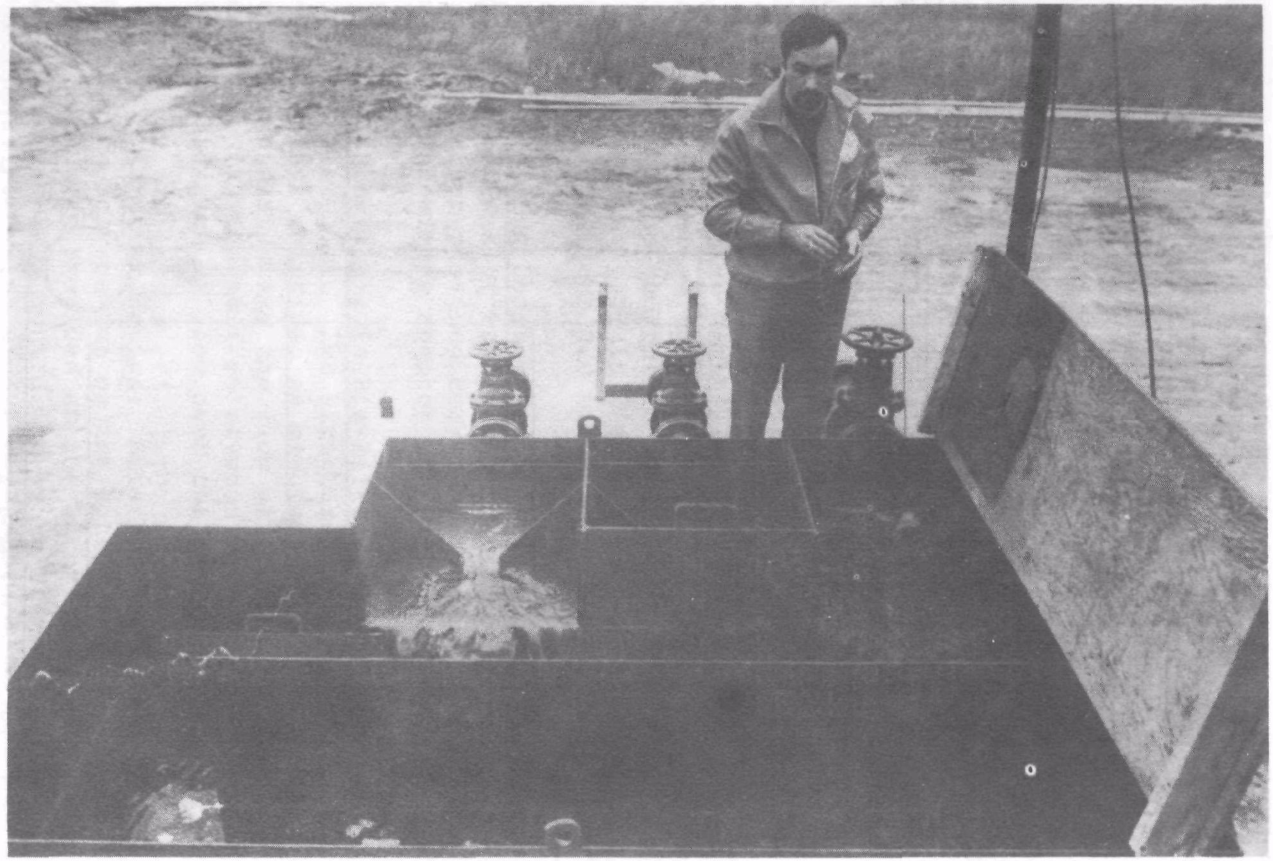


FIGURE 3

PLANT INFLUENT-WEIR BOX

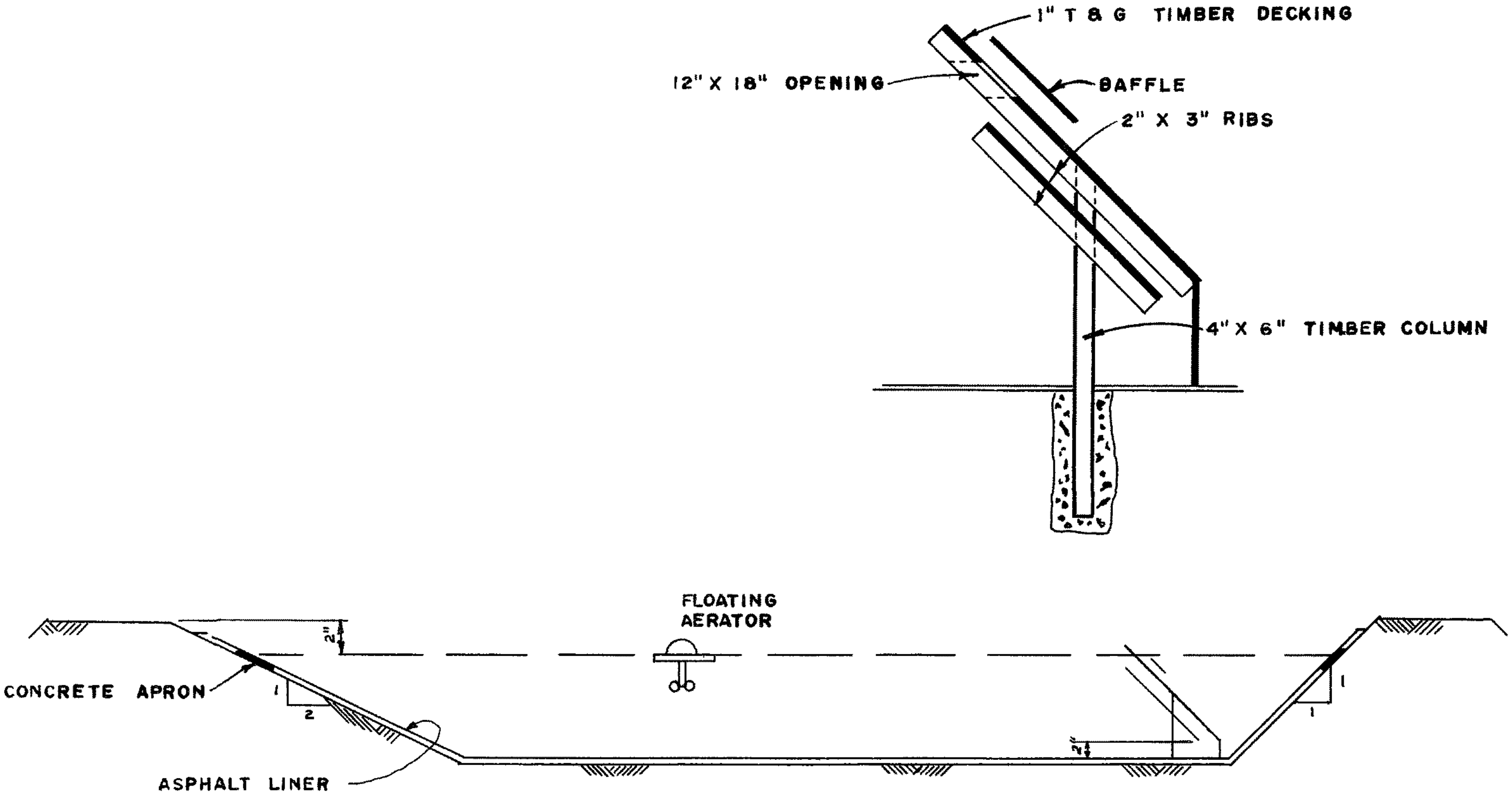


FIGURE 4
TYPICAL SECTION AERATION BASIN
PILOT PLANT
ROCKY CREEK WATER POLLUTION CONTROL PLANT

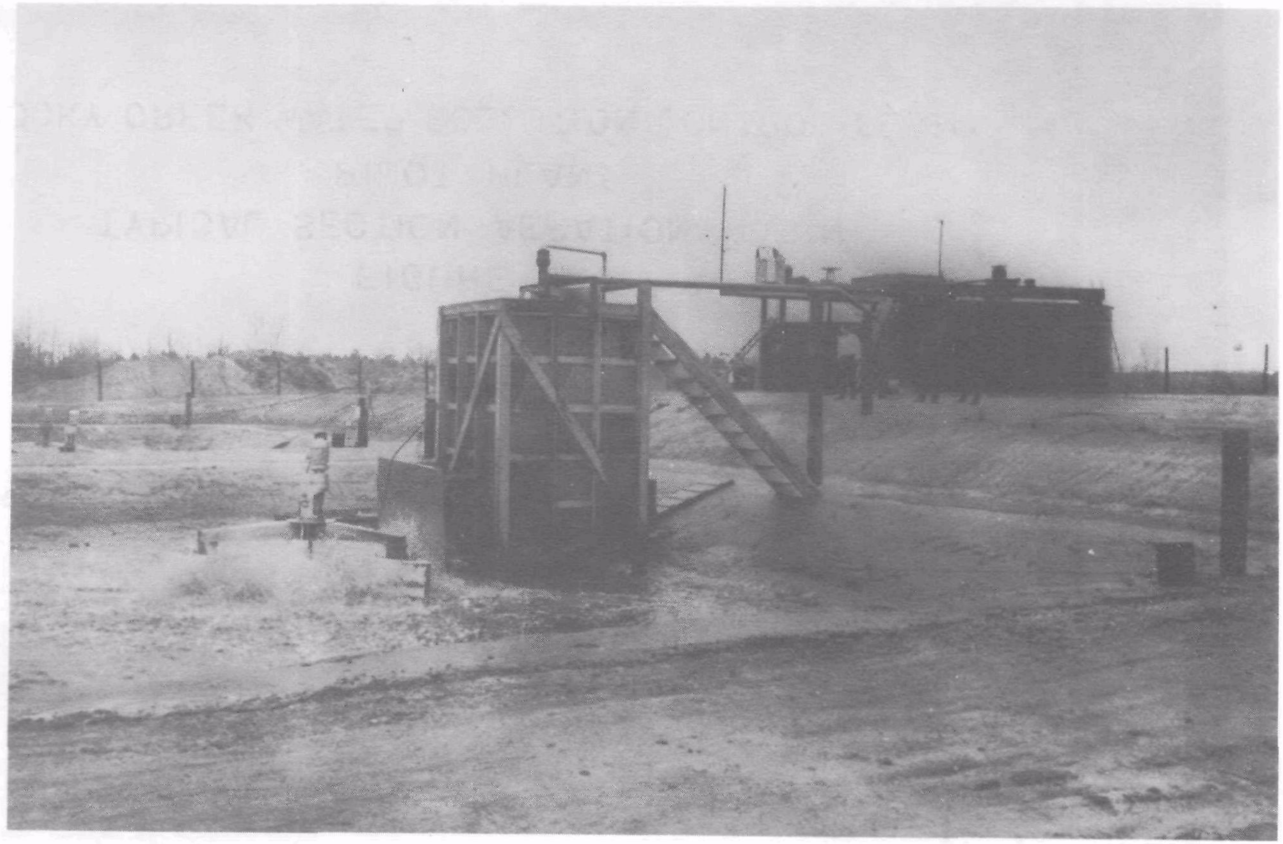


FIGURE 5
PLANT NO. 2

Secondary Clarifiers: This clarifier unit was constructed at the effluent end of the aeration basin as shown schematically in Figure 4. Flow from the aeration basin entered through a baffle arrangement designed to reduce the turbulence. The chamber had a triangular cross-section with a maximum depth of seven feet, five inches, with surface dimensions of fourteen feet by thirty-three feet. The side wall slope was 1 to 1. Sludge was removed by air-lift pumps from the bottom of each clarifier.

Secondary Tank: The secondary tank had a 1500 gallon capacity and was constructed of steel with a bitumastic coating. The tank was approximately eight feet in diameter and six feet high.

Sampling and Analysis:

Except for mechanical interruptions, the pilot plant was operated twenty-four hours per day, seven days per week, from April 15 to December 5, 1969.

Tests were run on twenty-four-hour composite samples throughout the project, except for a period from April 28 through May 26, when tests were run on eight-hour composites. During the period from April 15 through May 26, sampling was automatic, once per hour, using electrically operated solinoid valves. During this period, samples were not refrigerated. Starting on May 26, and continuing for the duration of the project, samples were collected manually at one-hour intervals, and refrigerated. Samples were not collected every day, but a representative number of samples were taken during each new study phase. Composite samples as shown in Figure 2 were collected at the following points:

1. Raw waste from each party.
2. Primary sedimentation effluent (including non-settled raw wastes, when scheduled).
3. Mixed Liquor, Plant #1.
4. Mixed Liquor, Plant #2.
5. Final settling tank effluent, Plant #1.
6. Final settling tank effluent, Plant #2.
7. Secondary sludge, tank effluent, Plant #1.
8. Secondary sludge, tank effluent, Plant #2.

The pilot plant operators made dissolved oxygen and settleability determinations on the mixed liquor each hour. Other duties included pumping out primary sludge, skimming off floating surface solids, adding defoamer, and a number of mechanical tasks necessary for the maintenance and operation of the plant.

A daily log of pilot plant operations was maintained. The daily analyses made on the composite samples and other pertinent information have been summarized and included in Appendix II. All of the analyses were made in accordance with the thirteenth edition of "Standard Methods for the Examination of Water and Wastewater."

Schedule of Operations:

A schedule of operation was set forth at the beginning of the pilot plant study to investigate the various objectives defined. Certain modifications to the original schedule were made based on the findings as the project moved forward, and to accommodate certain malfunctions in equipment.

The schedule of operations followed in the pilot plant studies from the beginning of stable operations on April 15 is shown in Table VII.

TABLE VII

Schedule of Operations

Period 1969	Flow Rates - GPM Armstrong	Ga.Kraft	City	Primary Sedimentation Armstrong	Ga.Kraft	City	Detention Time - Hrs. Plant #1	Plant #2	Nutrients Added	Remarks
April 15 - May 5	50	72	24	Yes	Yes	Yes	24	12	No	
May 6 - May 12	--	--	--	--	--	--	--	--	--	Data not used due to several operational and sampling changes.
May 13 - May 18	50	72	24	Yes	Yes	Yes	24	12	No	
Mar. 19 - June 15	24	72	24	Yes	Yes	Yes	30	15	No	
June 16 - June 26	24	72	24	Yes	Yes	Yes	30	15	Yes	Supplemental Nutrients added.
June 27 - July 7	--	--	--	--	--	--	--	--	--	Data not used due to industrial flow interruption
July 8 - July 25	24	72	24	Yes	Yes	Yes	24	12	No	
July 26 - July 30	--	--	--	--	--	--	--	--	--	Detention time change, restabilization period
July 31 - Aug. 7	--	--	--	--	--	--	--	--	--	No flow from city
Aug. 8 - Aug. 18	--	--	--	--	--	--	--	--	--	No. 1 plant aerators down for repairs and no flow from Armstrong
Aug. 19 - Aug. 28	NONE	72	24	--	Yes	No	--	18.8	No	No. 1 plant aerates inoperative, no flow from Armstrong
Aug. 29 - Sept. 12	NONE	72	24	--	Yes	No	30	18.8	No	No flow from Armstrong
Sept.13 - Oct. 16	--	--	--	--	--	--	--	--	--	Numerous interruptions from plant #1 aerators and Armstrong Cork flow
Oct. 17 - Oct. 31	54	72	24	Yes	No	No	19.2	12	No	
Nov. 1 - Nov. 5	30	72	NONE	Yes	No	--	30	18.8	No	No flow from city
Nov. 6 - Nov. 21	30	72	24	Yes	No	No	24	15	No	
Nov. 22 - Dec. 5	24	NONE	24	Yes	--	No	--	18.8	No	No flow from Ga. Kraft, insufficient flow for #1 plant operation

SECTION VI

OBJECTIVES

The overall objective of this project was to compare and evaluate the technical and economic feasibility of selected conventional primary, and biological secondary systems in the treatment of waste waters of certain manufacturing processes in combination with municipal wastes.

Specific objectives were:

1. To determine the efficiencies of selected conventional primary and biological secondary waste treatment systems, and devices in the treatment of combined industrial and municipal waste waters.

2. To determine if preconditioning of industrial wastes will be required prior to combined treatment.

3. To determine the need for and/or the technical problems, and economic aspects of disinfecting the wastes handled in this combined waste treatment process.

4. To determine how sensitive the selected systems will be to shock loadings, and other upsets of the contributing industries.

5. To determine the overall reliability of the selected systems.

6. To determine what operational problems are involved in continuous operation of the selected systems.

7. To collect engineering data which can be used for design purposes for Macon and other projects.

8. To compare the economics of construction of various systems for combined treatment.

9. To compare the operational economics of various systems for treating the combined wastes.

10. To determine how the economic construction of the systems selected for combined treatment compare with the construction of facilities to treat the separate wastes individually.

11. To determine how the economics of operating the selected systems of combined treatment compare with the costs of operating separate facilities for treating the individual wastes.

12. To determine a means of equitably allocating the costs of construction and operation to the individual waste discharges.

13. To determine parameters of treatment on which to base the development of equitable rate structures for municipal waste treatment.

14. To observe the reliability of various instruments for providing the necessary data outputs for input to computer controls for the pilot plant, and the full-scale facilities.

The investigation of these objectives necessitated the design, construction, and operation of a pilot plant to treat the waste in various combinations. Analysis of the waste before and after treatment in the various units of the pilot plant provide the basis for conclusions reached concerning combined treatment. Data provided by the individual parties establishes the basis for conclusions covering the economics of joint vs. separate treatment.

SECTION VII

PRIMARY TREATMENT

The bench scale biological treatment experiments were all carried out on settled waste mixtures. It was assumed that primary treatment would be necessary in the pilot plant, and provisions were made for settling individually or combined the influent from the three contributors.

The main primary clarifier was in operation throughout the period of pilot studies. Initially all three contributors' wastes were settled prior to secondary treatment. During various phases of the project, the overall system was operated with and without primary clarification of several combinations of the three flows. The schedule followed is shown below.

Period	Mode of Operation
April 15 - May 5	All waste receiving primary clarification
May 13 - May 18	All waste receiving primary clarification
June 1 - June 29	All waste receiving primary clarification
July 8 - July 25	All waste receiving primary clarification
Aug. 19 - Aug. 28	Only Ga. Kraft receiving primary clarification*
Aug. 29 - Sept. 12	Only Ga. Kraft receiving primary clarification*
Oct. 17 - Oct. 31	Only Armstrong receiving primary clarification
Nov. 1 - Nov. 21	Only Armstrong receiving primary clarification
Nov. 23 - Dec. 5	Only Armstrong receiving primary clarification**

*No flow from Armstrong Cork Company
**No flow from Georgia Kraft Company

A study of the effect of primary clarification on BOD removed when all wastes were settled with two hours detention indicates the following:

TABLE VIII

Primary Clarification of Combined Wastes

Period	-Average BOD- Influent(mg/l)	Effluent(mg/l)	BOD Removal(%)
April 15 - May 5	612	540	12
May 13 - May 18	650	600	8
May 19 - June 15	625	550	12
June 16 - June 26	635	648	-2
July 8 - July 25	508	480	5

A study of the effect of primary clarification on BOD removal from the industrial wastes in the pilot plant indicated the following:

TABLE IX

Separate Primary Clarification of Industrial Wastes

Partie's Waste Clarified	Period	-Average BOD- Influent(mg/l)	Effluent(mg/l)	BOD Removal(%)
Ga. Kraft	Aug. 19 - Aug. 28	450	353	22
Ga. Kraft	Aug. 29 - Sept. 12	416	360	13
Armstrong	Nov. 6 - Nov. 21	1180	1070	9.3
Armstrong	Nov. 23 - Dec. 5	1280	1170	8.6

No specific studies were made to determine BOD removal by separate primary clarification of the municipal wastes; however, it has been established that the removal of BOD from domestic wastes by sedimentation is usually twenty-five to thirty-five percent (25-35%). (14)

From these and other studies, it was concluded that the provision of primary sedimentation ahead of the secondary treatment systems showed no significant advantage from a BOD removal standpoint.

A review of the suspended solids data in the raw wastes indicated the following:

TABLE X

Average Suspended Solids in Raw Wastes

	City of Macon (mg/l)	Ga. Kraft (mg/l)	Armstrong Cork (mg/l)
AVERAGE	193	130	2602
MAXIMUM	290	265	3620
MINIMUM	120	85	1350

The above figures are for the raw wastes entering the pilot plant during the pilot study. These figures have not been used in the design of the full-scale plant since they do not indicate maximum loadings from Georgia Kraft, or subsequent primary settling by Armstrong Cork. See Tables I, II, and III for design conditions.

The above data shows that the Armstrong Cork raw waste contains a very high concentration of suspended solids which was as expected.

Based on data from the pilot plant and on separate studies conducted by the Company, a decision was made by Armstrong Cork to provide primary treatment and sludge dewatering on its own property. This facility consists of two 60-foot diameter clarifiers, a 60-foot diameter sludge thickener and a coil filter.

Based on studies to be presented in the following section, the biological treatment system functions equally well without primary treatment of the wastes from Georgia Kraft and Macon. Therefore, plans for the full-scale plant call for secondary treatment without primary clarification of these wastes.

SECTION VIII

SECONDARY TREATMENT

Two systems of aerobic secondary biological treatment have been studied in the pilot plant for the treatment of the mixed industrial-domestic wastewater. The first system (Plant #1) used a completely mixed, extended aeration system with a final settling tank, and return sludge to the aeration basin inlet. In Plant #1 two aeration periods were studied; the bench scale tests had indicated that thirty hours detention was required, but provisions were included to study twenty-four hours detention in the hope that this would prove adequate. The second system (Plant #2) included a plastic media bio-filter and a shorter detention time extended aeration system with direct flow from the filter to the aeration basin. Recirculation of the aeration tank mixed liquor to the top of the filter (six volumes of raw to one volume of aeration tank mixed liquor) was included in the design. Plant #2 also had a final settling tank and return sludge, and arrangements for studying different detention times. Both aeration tanks had float-mounted aerators. These were three identical five-horsepower aerator units; two were bolted together in Plant #1 aeration system. Each secondary system received sixty gallons of mixed wastewater per minute continuously.

Air lift pumps were used to recirculate large volumes of sludge (thirty to forty gallons per minute) from each final settling tank to the head end of each aeration basin. Plant #2 was expected to need only half of the aerator capacity of Plant #1 because of the anticipated BOD reduction through the bio-filter. Thus, the original detention in the small aerator was fifteen hours with only one aerator instead of two identical aerators in the large thirty-hour detention unit.

About two weeks, from April 15 through May 1, were required for the development of an operating level of suspended solids in each unit. The suspended solids had developed to 3000 to 4000 mg/l when appreciable quantities of sludge appeared in the effluent.

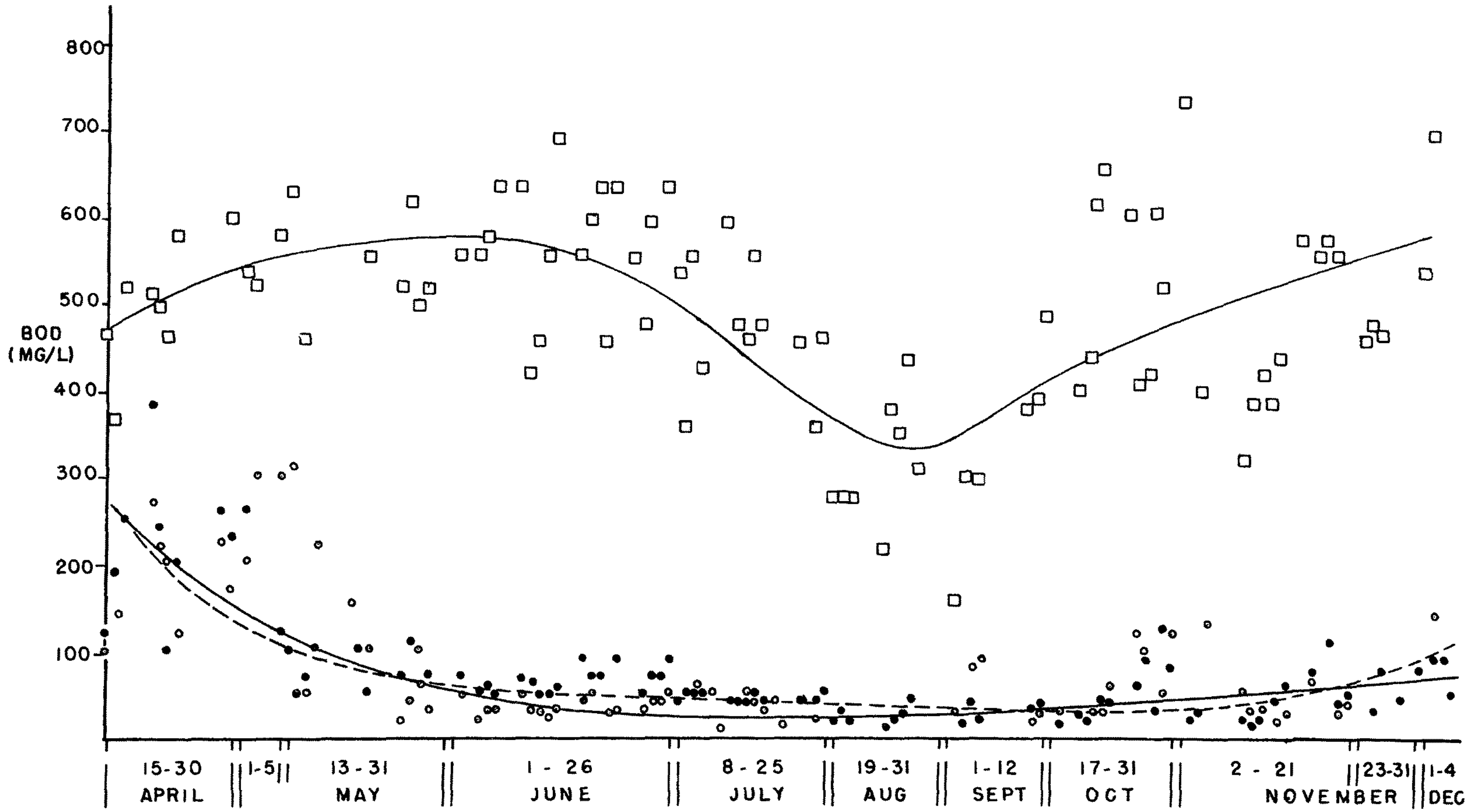
Figure 6 shows individual day BOD's before and after biological treatment in Plants #1 and #2.

Figure 7 shows period average raw influent and effluent BOD's from Plants #1 and #2.

Plant #1 Performance: With thirty hours detention in the aeration basin, the system was operating very stably by mid May. Several parameters were monitored in order to define operating controls. Dissolved oxygen concentration measured hourly remained at 3.5 mg/l or above. Therefore, DO was not the limiting factor in this system. It was decided for Plant #1 that the volume of sludge in the effluent, as measured in an Imhoff cone after sixty minutes settling, would determine when it was necessary to waste sludge. When the volume of sludge in the effluent

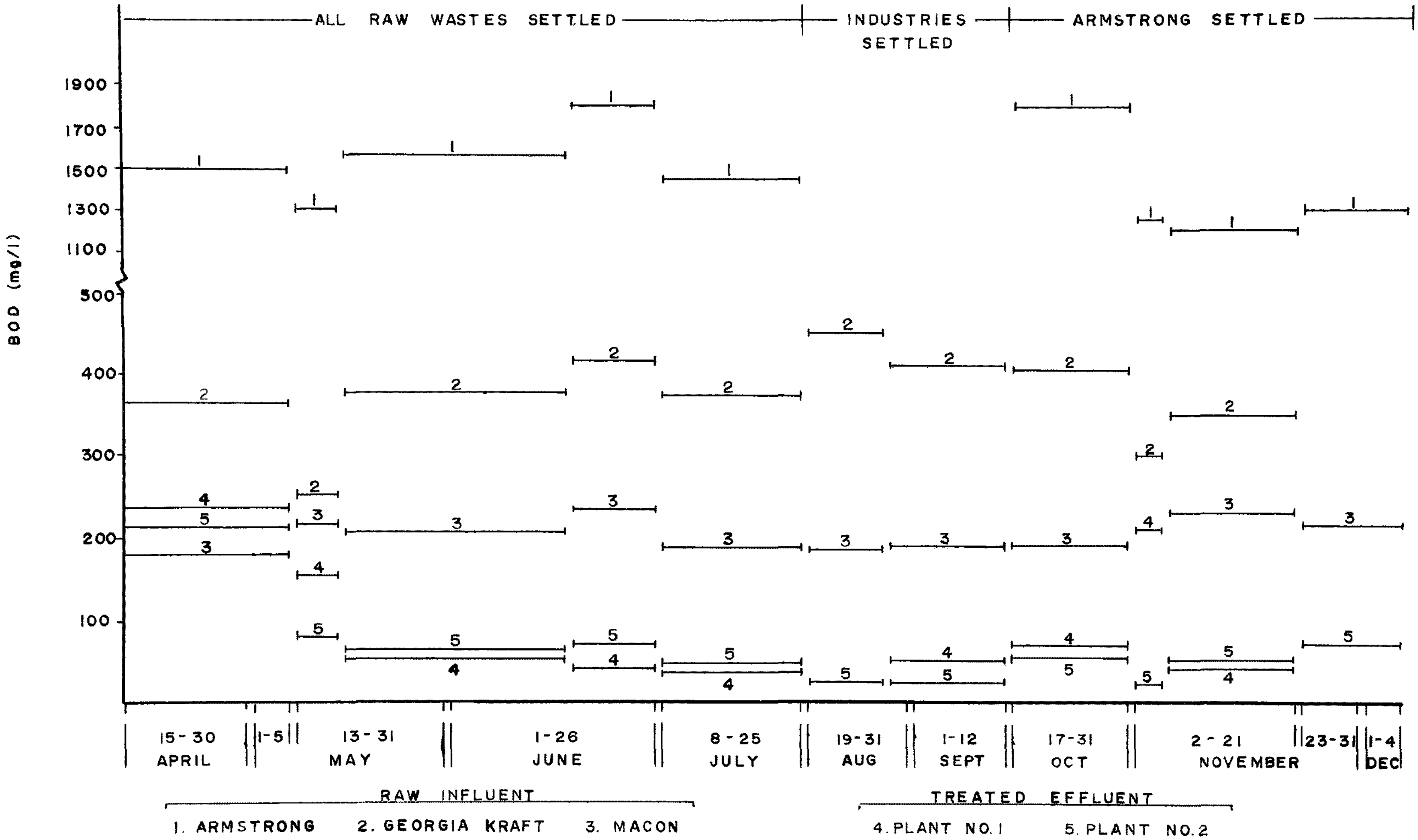
FIGURE 6

BOD CONCENTRATION BEFORE AND AFTER BIOLOGICAL TREATMENT



INFLUENT TO SECONDARY TREATMENT □
EFFLUENT PLANT NO. 1 ∘
EFFLUENT PLANT NO. 2 •

FIGURE 7
PERIOD AVERAGE BOD CONCENTRATIONS



sample (taken hourly) exceeded 1.0 ml/l/hr, then some sludge was wasted. This limiting operating factor proved to be a reasonable criterion as a good quality effluent could be maintained.

Except for the startup period, the system was maintained at thirty hours detention until the end of June. Detention time was then changed to twenty-four hours. Comparison of data in Figures 6 and 7 from the period May 22 through June 15 with the period of July 8 through July 25 shows no significant change in performance. BOD removal for each period exceeded ninety percent (90%), and sludge appearance and condition remained good. The normal operation of the system was therefore defined at twenty-four hours detention.

Plant #1 was operated without Armstrong's waste during the period from August 19 to September 12. This was during a period of mechanical operating problems with this unit and a high level of mixed liquor suspended solids was not maintained. Even so, efficiencies in excess of eighty percent (80%) were consistently maintained.

Plant #1 was not operated without Georgia Kraft's waste.

During a four-day period from November 2 through November 5, shown in Figure 7, waste flow from the City was interrupted. The BOD removal efficiency of this unit dropped rapidly.

Plant #2 Performance: Attempts were made to determine the amount of BOD reduction through the bio-filter. Composite samples became septic too quickly when taken with sampling pumps. Manual sampling for preparing composites did little better. Since only the total performance of the system would determine the choice for the full-scale plant, the direct determination of the filter performance was discontinued.

As in the case of Plant #1, various parameters were monitored to determine routine operating controls. As the mixed liquor suspended solids climbed to the 3000-4000 mg/l range in this plant, the DO dropped below 1.0 mg/l. Because it was considered important to maintain 1.0 mg/l DO, it was decided that sludge should be wasted at a rate required to maintain this level of dissolved oxygen in the unit.

Plant #2 was operated with fifteen hours detention in the aeration basin upon startup and continued in this mode until the first of July. The detention time was then changed to twelve hours. Comparison of data for the periods May 19 to June 15 and July 8-25 shows only a small reduction in BOD removal; however, the sludge condition rapidly deteriorated, which indicated the system could not operate in this mode.

The detention period was increased back to its original value of fifteen hours, and the system performance improved greatly. The shorter detention period in the aeration basin did not decrease the mechanical effectiveness of the aerator for the blade had the same depth at either detention period; the aerator was suspended from floats. The shorter detention period did place a greater demand on the oxygen capacity of the aerator which was apparently already at its limit (sludge was wasted to maintain a 1.0 mg/l dissolved oxygen). Had more oxygen capacity been available, one would expect that a lower BOD might have developed in the effluent, but the complete breakdown in the sludge indicated that the shorter period could not be studied with present equipment and still produce an acceptable effluent. The normal system operation was therefore defined as fifteen hours detention.

Plant #2 was operated without Armstrong's waste during the periods of August 19-28 and August 29-September 12. Plant operation and efficiency was good during both periods, as shown in Figures 6 and 7.

The plant was also operated without Georgia Kraft's waste during November 23-December 5 and operated satisfactorily, as shown in Figure 6.

Comparison of Two Units: With the systems under normal operating modes (fifteen hours detention in Plant #1 and twenty-four hours detention in Plant #2) the performance of the two systems was substantially the same, as shown in Figures 6 and 7. During the colder months of October and November the dissolved oxygen concentrations in each unit increased, and with the higher DO values in Plant #2, the units were fully comparable in performance.

The changes which occured in influent waste strength, primary sedimentation and detention times during the pilot plant study resulted in many different BOD loadings on the aeration basins. Figure 8 shows the relationship between the rate of BOD removal per pound of mixed liquor volatile suspended solids and the BOD loadings on the aerated basins. The BOD removal includes that removed in secondary sedimentation. The BOD loading is from influent BOD to each basin and does not consider the BOD in the recirculated sludge. Figure 9 shows the amount of sludge wasted per day compared to the BOD loading on the aeration basins.

Figure 8 indicates that the rate of BOD removal was more efficient at the higher BOD loadings; that is, doubling the BOD loading more than doubled the removal rate. Figure 9 shows that at the higher BOD loadings, the volume of sludge wasted increased rapidly. This is probably the primary source of the greater BOD removal rate.

In Figures 8 and 9, it has been assumed that BOD removal by the bio-filter is 37.5 percent of the total BOD removal in Plant #2. This assumption is based on the fact that the two plants produced essentially the same quality effluents and Plant #2 had only 15/24 (fifteen hours compared to twenty-four hours) of the aeration basin detention time. Therefore, the bio-filter must have produced the other 9/24 of the BOD removal.

In designing a system using this data, the BOD removal rate must be balanced against sludge production and aeration costs.

Nutrients: Early in the pilot plant operation it was found that a satisfactory effluent could be produced without the use of supplemental nutrients; however, to determine if supplemental nutrients would improve BOD removal, mineral nutrients (ammonium sulfate and sodium phosphate) were added to the influent of each plant during the period of June 16-26. Review of Figure 10 shows no improvement in BOD removal during this period as compared to a similar period from June 2 through June 15, when no nutrients were added. Nutrients were added to provide a BOD:N:P ratio of 100:5:1.

Qualitative checks of the systems' effluent for ammonia were made, and all samples were positive without adding nutrients. The tests for phosphates in the effluent were positive, but were not carried out quantitatively. These results led to the conclusion that the domestic wastewater provided an adequate amount of nutrients, and no further nutrient studies were made.

Shock Loading Studies: Studies of shock loads from Georgia Kraft Company were made. The waste strength was approximately doubled for twenty-four hours on October 22 without causing any significant change in the effluent character, as indicated in Figure 11. Armstrong Cork Company's wastewater varied so greatly from day to day due to mill production changes that no special studies were conducted. There was no obvious correlation between Armstrong Cork Company's wastewater characteristics and pilot plant effluent quality. Sudden changes in strength of domestic wastewater are not anticipated.

The effluent quality of each biological treatment system was consistently good. No evidence of biological failure developed from biochemical causes with all three wastewater streams.

FIGURE 8
BOD REMOVAL-VS-BOD LOADING

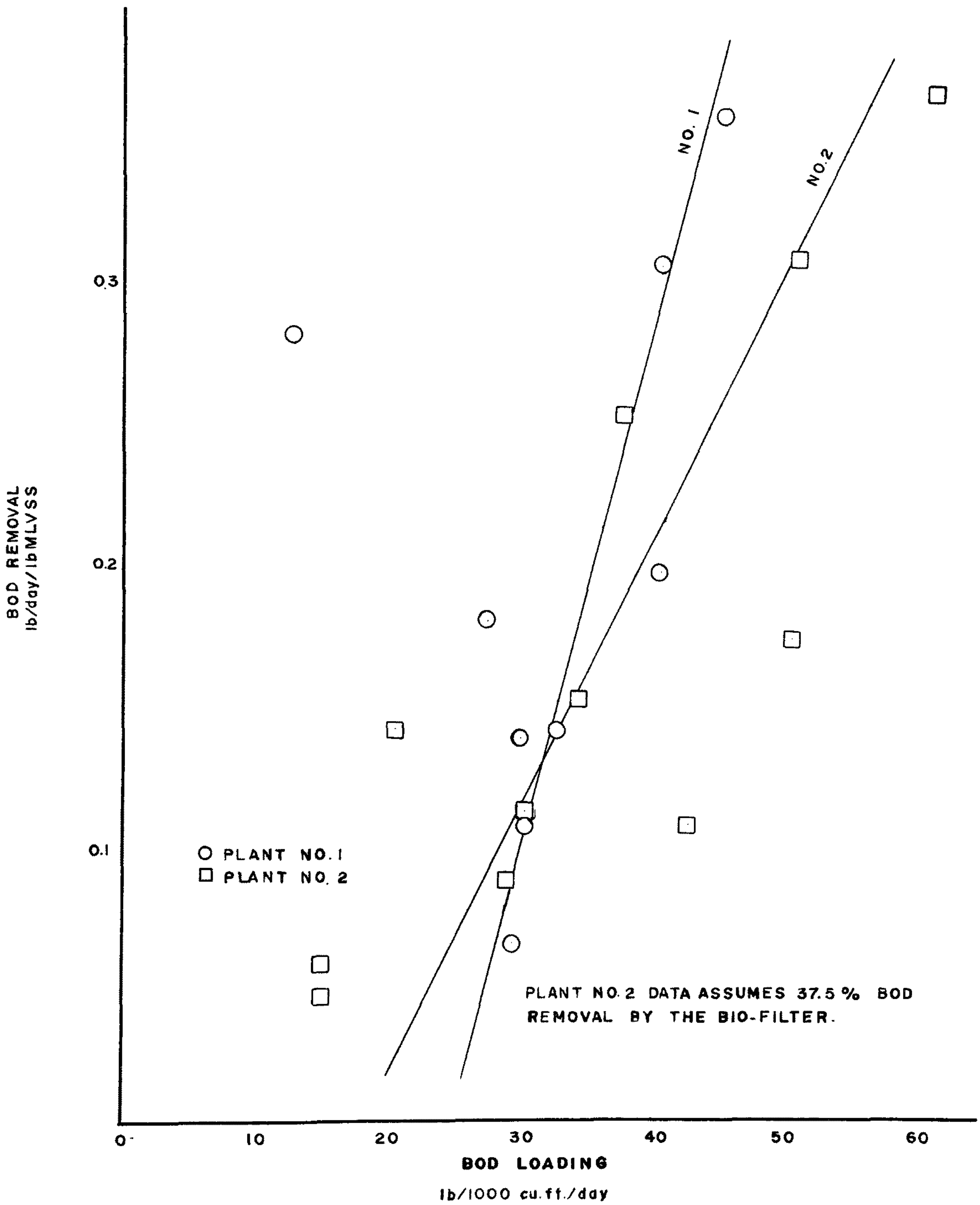


FIGURE 9
SLUDGE PRODUCTION-VS-BOD LOADING

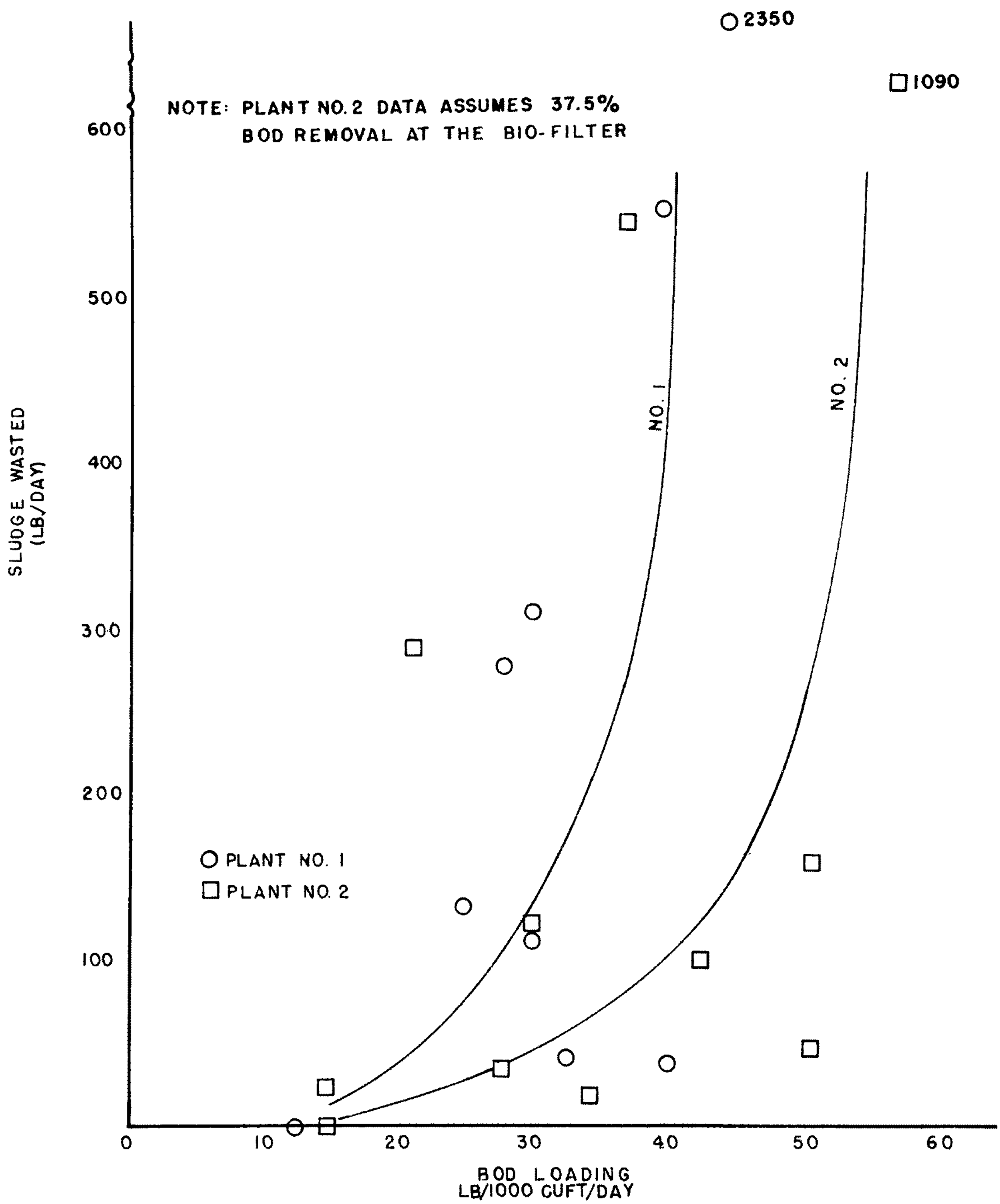


FIGURE 10
EFFECT OF NUTRIENTS

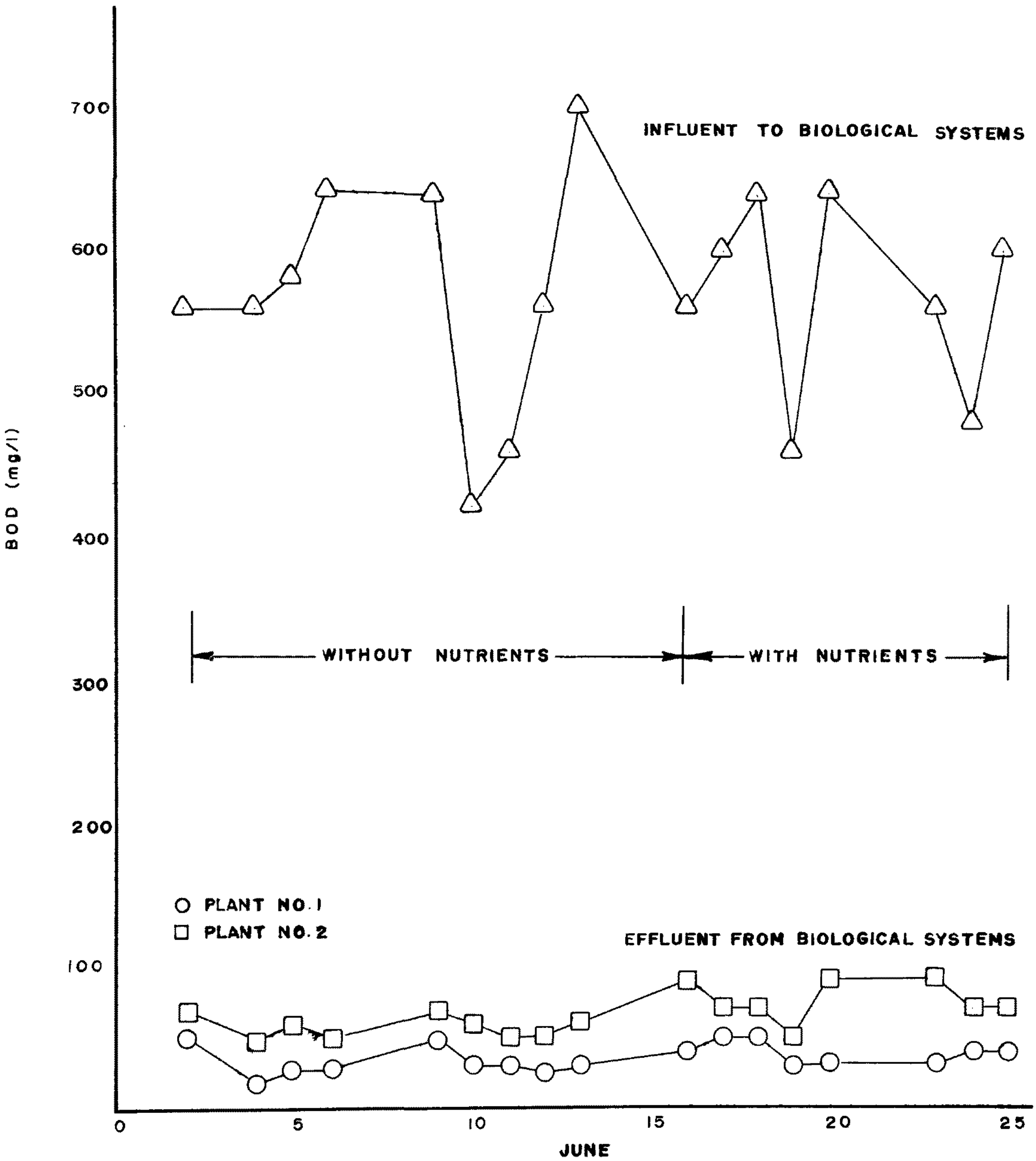
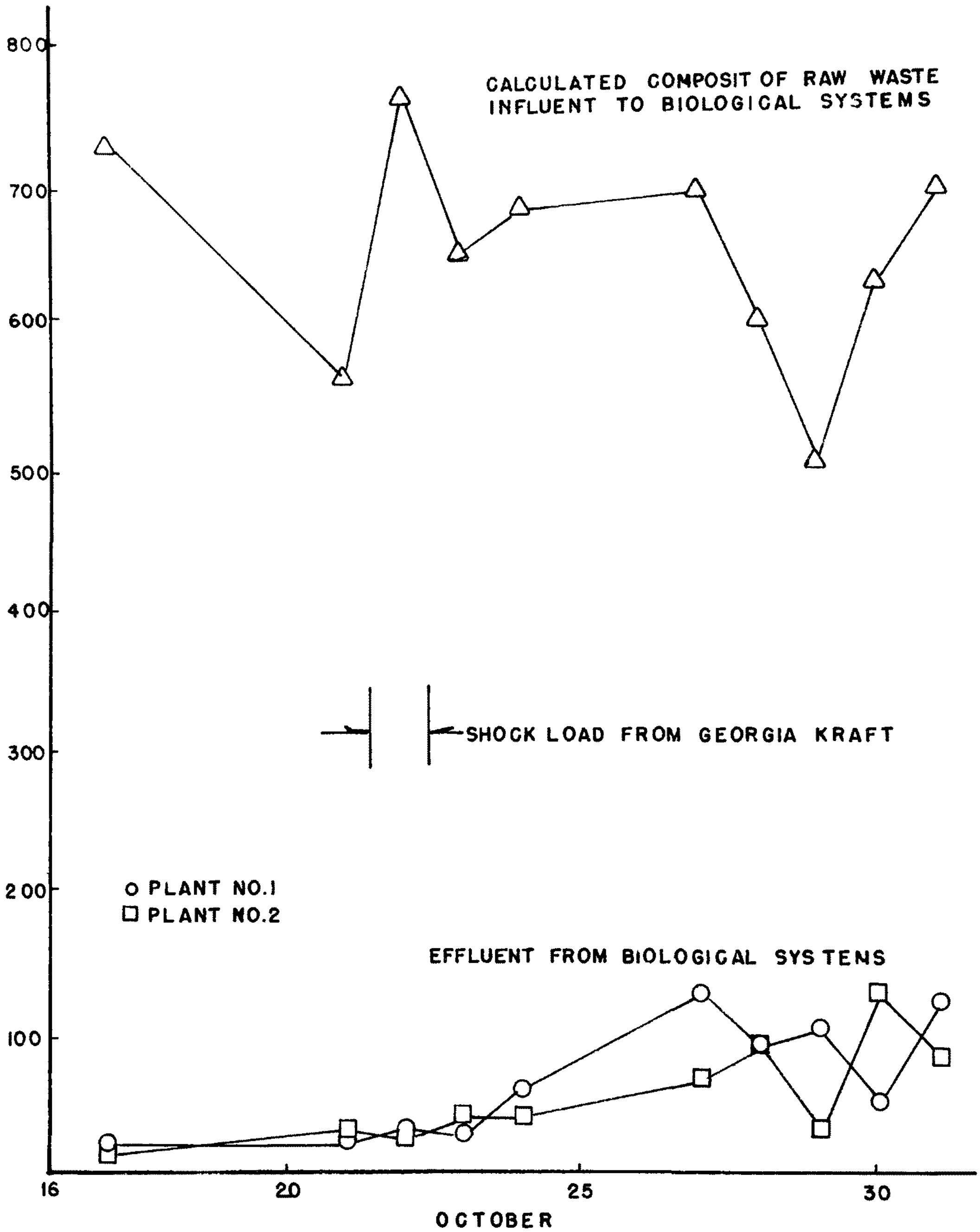


FIGURE 11
EFFECT OF SHOCK LOADINGS



SECTION IX

SLUDGE DISPOSAL

No specific facilities were provided in the pilot plant for sludge dewatering. Equipment manufacturers were requested to provide pilot facilities, and two types of pilot-scale sludge dewatering facilities were actually operated with sludge from the secondary clarifiers of the pilot plant. The following is a summary of the results of these two studies:

Centrifuge: A study was conducted to evaluate the effectiveness of a Sharples-Stokes Super-D-Canter Centrifuge. The sludge from the pilot plant had a consistency of approximately one percent (1%) W/W solids. A slury of this sludge and a polyelectrolyte was applied to the centrifuge. Various concentrations of polyelectrolyte ranging from below five pounds/ton up to twenty to twenty-five pounds/ton were tried to improve the recovery level. These tests indicated that the amount of polymer required would have unacceptable cost. The supplier has proposed a different centrifuge system that could produce acceptable results at a lower polyelectrolyte loading.

Filter Process: The Beloit-Passavant Corporation conducted tests at the pilot plant to determine the required capacity of a full-scale plant using the Beloit-Passavant Sludge-All System. This system, which consists of a hydraulic filter press with auxiliary equipment, was able to deliver filter cakes with solids ranging from 40 to 50 percent solids when using a waste ash for conditioning of the incoming waste activated sludge. The sludge was conditioned at approximately 1.7 to 2 percent solids and admixed in ratios ranging from 2½ parts of ash per part of dry sludge solids down to approximately one part of ash per part of dry sludge solids. The filtrate from the system contained less than twenty ppm suspended solids.

Included in this system would be a multiple hearth incinerator to burn the filter cake.

Operating costs would include labor, electrical power and some fuel for incineration and maintenance.

Information from the pilot studies provides the following information:

1. The sludge is bulky and can only be concentrated by gravity settling to the one to three percent (1-3%) range.

2. Destruction of sludge in the mixed liquor via endogenous respiration is at a rate of 3.9 percent of the volatile suspended solids present. The basis for this conclusion is discussed under Section X.

SECTION X

DISINFECTION

Indicator Organisms Present: The State Water Quality Control Board requires that a maximum fecal coliform concentration of 5000 per 100 ml not be exceeded in rivers classified for use as fishing streams. The lack of use of the Ocmulgee River for a public water supply below Macon and its limited use for contact sports would justify this assignment.

Of the three wastes entering the plant, only that from the City of Macon contains sanitary wastes and true fecal coliform organisms. An organism of the *Klebsiella* genus is found in the waste from the Armstrong Cork Company (see Appendix III for separate study on this subject). These organisms will indicate a false positive fecal coliform count using the test procedure from Standard Methods. The presence of these organisms in the plant effluent made the evaluation of the actual concentration of fecal coliform organisms present and their removal in the plant impossible.

The waste from the City of Macon entering the plant contained an average MPN (Most Probable Number) of 7.6×10^6 fecal coliform per 100 ml. At the design flow of 4.5 MGD from the City and 17 MGD total flow, a dilution of 3.8:1 will result in a concentration of fecal coliform in the combined plant effluent of 2×10^6 per 100 ml. Other studies have shown (15) that sedimentation and die-off will result in ninety-five percent (95%) removal of the organisms through the plant, then 0.1×10^6 per ml should be the approximate effluent concentration.

The minimum day, twenty-year recurrence, low flow for the Ocmulgee River just below the junction with the Tobesofkee Creek is an estimated 88 MGD. The addition of the effluent of the proposed treatment plant, without chlorination, would increase the fecal coliform count at this low flow by 16,300 per 100 ml. The minimum day, two-year recurrence, low flow of 434 MGD would result in an increase of 3800 per 100 ml. Additional die-off of organisms as the waste flows through the swamp adjacent to Tobesofkee Creek prior to entering the River should result in these counts being lower.

As shown later, the chlorine required to produce a ninety-five percent (95%) kill of apparent fecal *E. coli* averaged 35 mg/l, which would be approximately two and one-half tons per day. The addition of this amount of chlorine could, in itself, be harmful to the river.

Based on the above information, it was recommended and concurred in by the State Water Quality Control Board that chlorination of the plant's effluent not be required.

Chlorine Demand: Chlorine demand studies were carried out separately from the chlorine requirement studies. The chlorine demand studies were carried out at the pilot plant on freshly collected samples. The chlorine was added to ten aliquots. The lowest dose of 10 mg/l was increased in increments of 10 mg/l to 100 mg/l. After fifteen minutes contact, an excess of thiosulfate was added to each flask. The excess of reducing agent was titrated with a standard iodine solution according to the procedure in "Standard Methods for the Examinations of Water & Wastewater". The chlorine demand varied from 20 mg/l to more than 100 mg/l when the chlorine demand is defined as the amount needed to provide a residual beyond which an increment in dose produced a similar increment in the residual. Thus, a 20 mg/l demand was recorded when a dose of 30 mg/l showed a residual of 10 mg/l. A summary of the chlorine demand studies is given in Table XI. There is very little correlation between the chlorine demand the BOD or COD values recorded for the composite samples on those days. The chlorine demand analyses were run on grab samples, however, rather than on composite samples.

Chlorine Requirements: Chlorine requirement studies were performed on samples less than two hours after sampling. Chlorine requirement is defined here as the dosage needed to produce ninety-five percent (95%) kill of indicator organisms. The number of analyses run was less than the chlorine demand tests because of the time, space and equipment required for the bacterial counts. The chlorine requirement for most samples is much less than the complete chlorine demand. The results of several runs are shown in Table XII.

Other Disinfecting Studies: A study of several disinfecting agents as suggested by the literature and various individuals was conducted to determine the best method of further reducing the organism count in the effluent.

No reduction in chlorine requirements was observed by performing disinfection through chemical addition of mono-chloramine (NH_2Cl) or chloro sulfamic acid (NSO_3NHCl).

Free ammonia is present in the effluent from the aeration basin and must, therefore, enter into the chlorination mechanism.

Tests were also run with acrolein. Long contact times and a much higher chemical cost would be required to gain comparable reduction in bacterial numbers.

Other disinfectants such as ozone would produce no toxic by-products such as chlorinated organics, but no observations have been made. If disinfection should be required at some time in the future, ozone should be considered.

TABLE XI

Chlorine Demand

Date	mg/1 Cl	Daily Requirement
11 Nov.	23	1.5 Tons
11 Nov.	43	2.8 Tons
12 Nov.	62	4.0 Tons
13 Nov.	41	2.7 Tons
14 Nov.	65	4.2 Tons
19 Nov.	43	2.8 Tons
20 Nov.	100	6.5 Tons
20 Nov.	100	6.5 Tons
25 Nov.	70	4.6 Tons
25 Nov.	70	4.6 Tons

The demand is defined as the maximum difference between dose and residual at two successive doses with 10 mg/1 increment.

TABLE XII

Chlorine Requirement Studies

Bacterial Numbers MPN per 100 ml

(All counts as faecal *Eschericia coli* by SM Boric acid media)

Kraft	Domestic	Armstrong	Effluent	Chlorine Dose									
				Dose →	20 mg/l			30 mg/l			40 mg/l		
				Minutes Contact →	15	60	120	15	60	120	15	60	120
—	—	—	$3.3x10^5$		$3x10^3$	$4x10^3$	230	330	170	—	—	—	—
—	$2.2x10^6$	$< 1x10^3$	$2.4x10^5$		—	>	>		>	>		>	$>1.6x10^4$
$< 2x10^3$	$1.3x10^7$	$5.4x10^7$	$5x10^5$		—						< 20		
Combined - $4x10^6$			$8x10^5$		> 17,000			800			5400		
		$2.3x10^4$	$1.3x10^4$		540			1500			35		

Chloramine and chlorosulfamic acid showed no improvement over chlorine in reducing bacterial numbers. Ammonia is present in the effluent and therefore, monchloramine is probably formed even though the chlorine is added as hypochlorous acid.

SECTION XI

SUPPORTING STUDIES

Effect of pH: It was originally thought that fluctuation of pH might upset the biological conditions in the waste treatment system. While there was some variations in pH of the Armstrong and Georgia Kraft wastes, no related effects could be defined on the treatment plant. At no time did the mixed liquor pH vary outside the range of 6.0 - 8.5.

Instrumentation: The proposal to FWPCA included a notation of intent to instrument the pilot plant for automatic control. Local representatives of two major companies had indicated their desire to aid in loaning instruments for the pilot plant. The national headquarters felt that there would be too many pilot plants where they would be obligated to loan instruments if a loan was made to the pilot study at Macon. Therefore, no instrument control studies were done.

Because the character of the industrial wastewater from Armstrong varies widely on an hourly basis (each day that hourly samples were taken and preserved individually) an on-line analysis of the food or organic matter load would be a valuable addition to the data included in this report.

For purposes of efficient operations, a variable speed aerator in the aeration tanks would be highly desirable, especially if it is controlled by the output of a dissolved oxygen sensor with automatic controls. While this full-scale plant must produce a high quality effluent, it is necessary to control the activated sludge concentration in the aerators. On-line sensors are needed to provide information that will allow an analysis of the cost comparative of aerobic digestion in the aeration basins against the cost of disposing of a larger amount of excess sludge.

Because the Ocmulgee River has a very limited quantity of water at times which carries a moderate waste load from up river, monitoring of the effluent of this plant for oxygen uptake (short term BOD) and/or organic carbon would be highly desirable. The river is currently monitored at a point approximately six miles below the entrance of Tobesofkee Creek, which would carry the wastes from the full-scale plant. This information from the river monitoring station would be telemetered back to the full-scale treatment plant site for possible correlations with plant data.

Sludge Concentration: Each of the aeration basins was studied hourly for the volume of sludge after sixty minutes settling. The commonly used shorter period of thirty minutes was not used because very little settling took place in that period. Even after sixty minutes, the sludge layer occupied eighty to ninety percent (80-90%) of the original volume. With this very poorly settling sludge, the final settling tanks were much more successful than expected. There was generally an increase of three to five times the suspended solids concentration in the return sludge flow over the mixed liquor values.

Attempts to have the operators waste sludge on the basis of the sludge volume in the aeration basins developed some very unexpected information. The sludge volume during the day with the cylinders on the apron of the aeration tanks was approximately one-half the values from the sludge settling tests run at night on most days. When the cylinders for the sludge settling tests were placed inside of the control room, the day and night differences in settled sludge volume disappeared. The reduction in volume occurred in plastic or glass cylinders and even on cloudy days, but not on rainy days. Studies in the laboratory indicated that UV and fluorescent light were ineffective in changing the sludge floc. Infra-red radiation made rapid changes in the appearance of the sludge floc.

When domestic wastewater sludge from one of Atlanta's activated sludge plants was irradiated with infra-red, no changes were observed in the appearance of the floc and no ultimate change in the settled sludge volume occurred. A sludge sample from the pilot plant was aerated and fed in the laboratory with glucose and peptone. After several aeration periods, the sentitivity to infra-red radiation disappeared. Conversely, the sample of Atlanta sludge developed sensitivity to the infra-red radiation after feeding with Kraft mill effluent.

Because of the press of other problems, no further observations on this phenomenon were made. Due to the high cost of sludge handling by filter press, vacuum filter or centrifuge, some quantitative studies of the requirements of equipment for effecting reductions in sludge volume should be undertaken.

SECTION XII

CONCEPTION OF FULL-SCALE DESIGN

Regulatory Requirements: The Ocmulgee River has not been specifically assigned a Water Use Classification by the State of Georgia. Below the City of Macon, the river is not used as a public water supply, and its limited accessibility results in its primary use being a fishing stream. Based on this information, the Ocmulgee River will be assumed to have a Water Use Classification of Fishing, Propagation of Fish, Shellfish, Game and other Aquatic Life, as defined by the State Water Quality Control Board.

Based on this classification and specific guidelines for the treatment facility established by the State Water Quality Control Board, the following criteria are established:

1. BOD Removal - Maximum 50 mg/l in the effluent for the combined plant or a high degree of secondary treatment for separate plants.

2. Dissolved Oxygen - Minimum 4.0 mg/l.

3. pH - 6.0 to 8.5.

4. Temperature - Not to exceed 93.2° F at any time and not to be increased more than 10° F above intake temperature.

5. Bacteria - Fecal coliform, maximum average MPN 5000 per 100 ml over a thirty-day period; not to exceed 20,000 per 100 ml in more than five percent (5%) of the samples in any ninety-day period.

6. Toxic Wastes - None in concentrations that would harm man, fish and game, or other beneficial aquatic life.

The design of the combined treatment facility is based on compliance with these criteria. The pilot plant data indicates that sufficient BOD removal can be accomplished in either of the systems used.

The pH of the pilot plant effluent ranged between a low of 6.4 and a high of 8.2. These figures are within the limitations established. Temperature data on the mixed liquor of the pilot plant showed a low of 40° F in November and December and a high of 87° F in June. When the full-scale plant is in operation, it is anticipated that the final effluent will approach ambient temperatures. Therefore, no problem is expected in meeting the stated stream requirements.

The difficulty of properly measuring the fecal coliform content of the pilot plant effluent due to the interfering Klebsiella organisms in the Armstrong Cork waste does not allow proper evaluation of bacterial pollution. This has been discussed in some detail under the section on disinfection. For various reasons, some of which are also discussed under the section on disinfection, chlorination has not been required by the State Water Quality Control Board.

Probability of toxic wastes in a concentration which would be harmful to man, game and fish, or other beneficial aquatic life in the plant effluent is quite remote.

Comparison of Combined Alternatives: The two types of treatment systems which were studied in the pilot plant for expansion to full-scale design were extended aeration plant with 24 to 30 hours contact time, and a combined high rate plastic media bio-filter followed with a shorter term extended aeration plant using twelve to fifteen hours contact time.

The full-scale plant using the twenty-four hour extended aeration system would use three parallel aeration basins, each having a volume of 5.7 million gallons and a surface area of approximately 76,000 square feet. Pilot plant data indicated a BOD reduction averaging 1.26 pounds BOD per hour per horsepower; therefore, a BOD removal requirement of 77,335 pounds in the full-scale plant necessitates a horsepower requirement of 2,556 (for design purposes - 2,600). This could be obtained by using five 175-horsepower aerators in each basin.

The plant using the plastic media bio-filter and fifteen hours detention time would also be designed using three parallel systems. Pilot plant data showed that a total BOD removal averaging 343 pounds per day occurred using this combination. Loading to the plant averaged 373 pounds BOD per day. With the 288 cubic feet of plastic media in the tower, this provides a loading rate of 1.3 pounds BOD per cubic foot. Since the distribution system for the filter was somewhat inefficient, the more conventional loading rate of 1.58 pounds BOD per cubic foot, or approximately twenty percent (20%) in excess of that used in the pilot unit, was used for the full-scale design.

As discussed under the biological treatment section, Plant #2 was somewhat under aerated in that sludge had to be wasted so that dissolved oxygen could be maintained. Therefore the five horsepower for Plant #2 was increased by twenty percent (20%). This gives a gross plant loading rate of 4.1 pounds BOD per horsepower per hour. In the full-scale plant 53,800 cubic feet of plastic media and 1,420-horsepower is needed based on the pilot plant studies. For design purposes, 1500-horsepower was used with four 125-horsepower aerators in each of three basins. The basins would have a volume of 3.55 million gallons and a surface area of approximately 48,000 square feet.

Clarifiers for both systems will be based on a net surface settling rate of 600 gallons per square foot per day with a detention time of three hours. With a flow rate of 17 MGD, three clarifiers having a surface area of 950 square feet each would be required. Similar type units would be used for both type plants.

Waste sludge production by both treatment systems was similar. Use was made of the following data for BOD and solids in the calculation of actual sludge production in the full-scale plant:

	Influent (lbs/day)	Effluent (lbs/day)	Removed (lbs/day)
BOD:			
Armstrong Cork Company	46,760	3,878	42,882
City of Macon	7,515	623	6,892
Georgia Kraft Company	30,060	2,499	27,561
Total	84,335	7,000	77,335
Total Suspended Solids:			
Armstrong Cork Company	5,845	1,253	4,592
City of Macon	7,515	1,540	5,975
Georgia Kraft Company	20,000	4,207	15,793
Total	33,360	7,000	26,360
Volatile Suspended Solids:			
Armstrong Cork Company	3,098	518	2,580
City of Macon	5,336	891	4,445
Georgia Kraft Company	9,600	1,601	7,999
Total	18,034	3,010	15,024
Non-Volatile Suspended Solids (Total Suspended less Volatile Suspended)			
Armstrong Cork Company	2,747	735	2,012
City of Macon	2,179	649	1,530
Georgia Kraft Company	10,400	2,606	7,794
Total	15,326	3,990	11,336

Mixed liquor volatile suspended solids will be maintained at 3,800 mg/l in the basins.

Data from the pilot plant study was used to determine the constant b in the following solids balance equation:

lbVSS(produced) + lbVSS(removed) =

0.55(lbs BOD removed) + b(lbs MLVSS)

The value of b for Plant #2 was determined to range between -0.034 and -0.044, with an average of -0.039. Using this constant and the above equation, the quantity of waste sludge was determined to be 41,106 pounds per day from the combined plant. The amount produced by each participant is as follows:

Armstrong Cork Company	23,098 pounds per day
City of Macon	1,875 pounds per day
Georgia Kraft Company	16,133 pounds per day
Total	41,106 pounds per day

The capacity of the sludge drying and incineration facility will be designed to handle 20.5 tons of waste sludge in a sixteen-hour period, seven days per week.

Chlorination: Based on information provided under the disinfection section, an average demand of 35 mg/l will be required with a two-hour detention period, if chlorination is deemed necessary. To meet this demand, facilities to handle 5,000 pounds per day will be necessary for either plant.

Recycling Pumping Equipment: Pumping equipment for either plant will be provided with a capacity to return sludge at a rate of up to one hundred per cent (100%) of the design flow to the head of the plant. In addition to the above, a plant utilizing plastic media biofilters will have pumping equipment with a capacity of returning mixed liquor at a rate of up to one hundred percent (100%) of the design flow to the top of the filter.

Miscellaneous Facilities: An administration building will be provided at either plant, containing a plant superintendent's office, an adequate laboratory and employees' locker and shower facilities. Also provided will be a maintenance facility for plant equipment.

In addition to the waste treatment plant, the following will have to be provided at either plant by the participants:

Armstrong Cork Company: A twenty-four inch outfall sewer from their primary treatment facility to the existing Rocky Creek Outfall Sewer; also share with the City in providing both additional pumping capacity at the City's existing Rocky Creek Pumping

Station and a force main from the pumping station to the proposed treatment plant.

City of Macon: Provide screening, metering and grit removal at the existing Rocky Creek Pumping Station; also share with Armstrong Cork Company in providing additional pumping capacity at the existing Rocky Creek Pumping Station and a force main to the proposed waste treatment plant.

Georgia Kraft Company: Provide a pumping station and a twenty-four inch force main to the proposed waste treatment plant.

Plant Layout: In order to provide flexibility of operation, especially during shutdown of one of the industries, the plant will be constructed in three equal parallel treatment units, with the exception of sludge disposal and drying, pumping and chlorination.

Flow Diagram and Site Plan: A flow diagram and site plan are made a part of this report as Appendix IV.

Participants' Plans for Separate Waste Treatment:

Armstrong Cork Company - Macon Division: The proposed separate treatment facility for Armstrong Cork Company is shown schematically in Figure 12. As indicated earlier, a primary treatment system is already under construction and will include vacuum filters for sludge dewatering.

The secondary plant will be of the extended aeration type with thirty-six hours detention. Facilities would be provided to operate the system as either a contact stabilization or conventional activated sludge unit. Ten 100-horsepower aerators will provide oxygen and mixing for the mixed liquor. A secondary clarifier with rapid sludge return to the aeration basin would be provided.

Waste sludge will be returned to the thickener in the primary system for dewatering on the vacuum filter. Final disposal of sludge will be in a land fill initially.

Georgia Kraft Company - Mead Division: The proposed separate waste treatment facility for Mead Division, Georgia Kraft Company, is shown schematically in Figure 13. As previously described, preliminary treatment for selected pulp mill streams is provided by the cooling tower. Strong wastes are impounded in a heavy liquor pond and metered into a collection tank.

In the proposed treatment plant the mill effluent would be collected in the existing one million gallon tank and discharged by gravity to a 180-foot diameter primary clarifier.

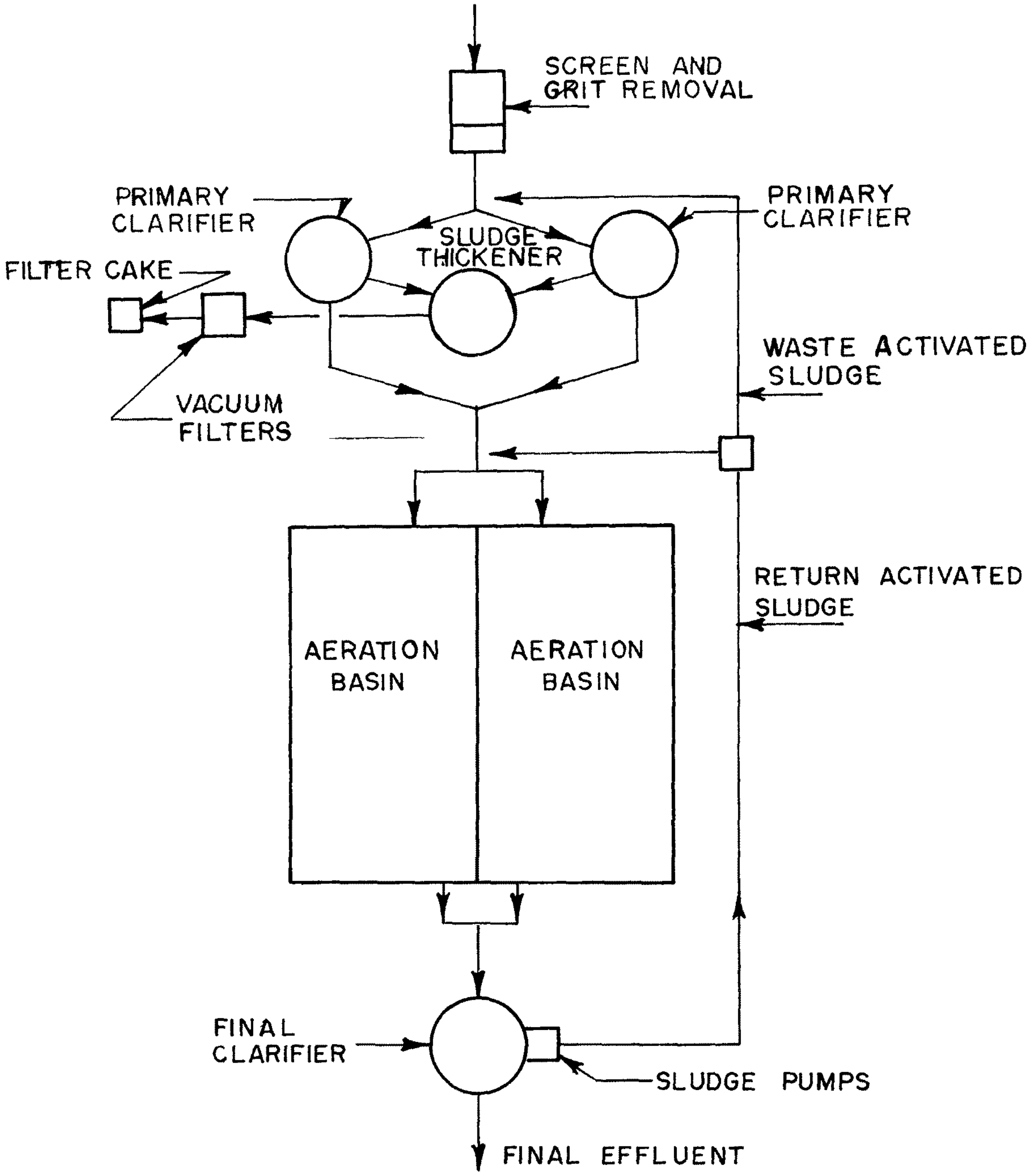


FIGURE 12
FLOW DIAGRAM
SEPARATE TREATMENT FACILITY
ARMSTRONG CORK CO, MACON, GA.

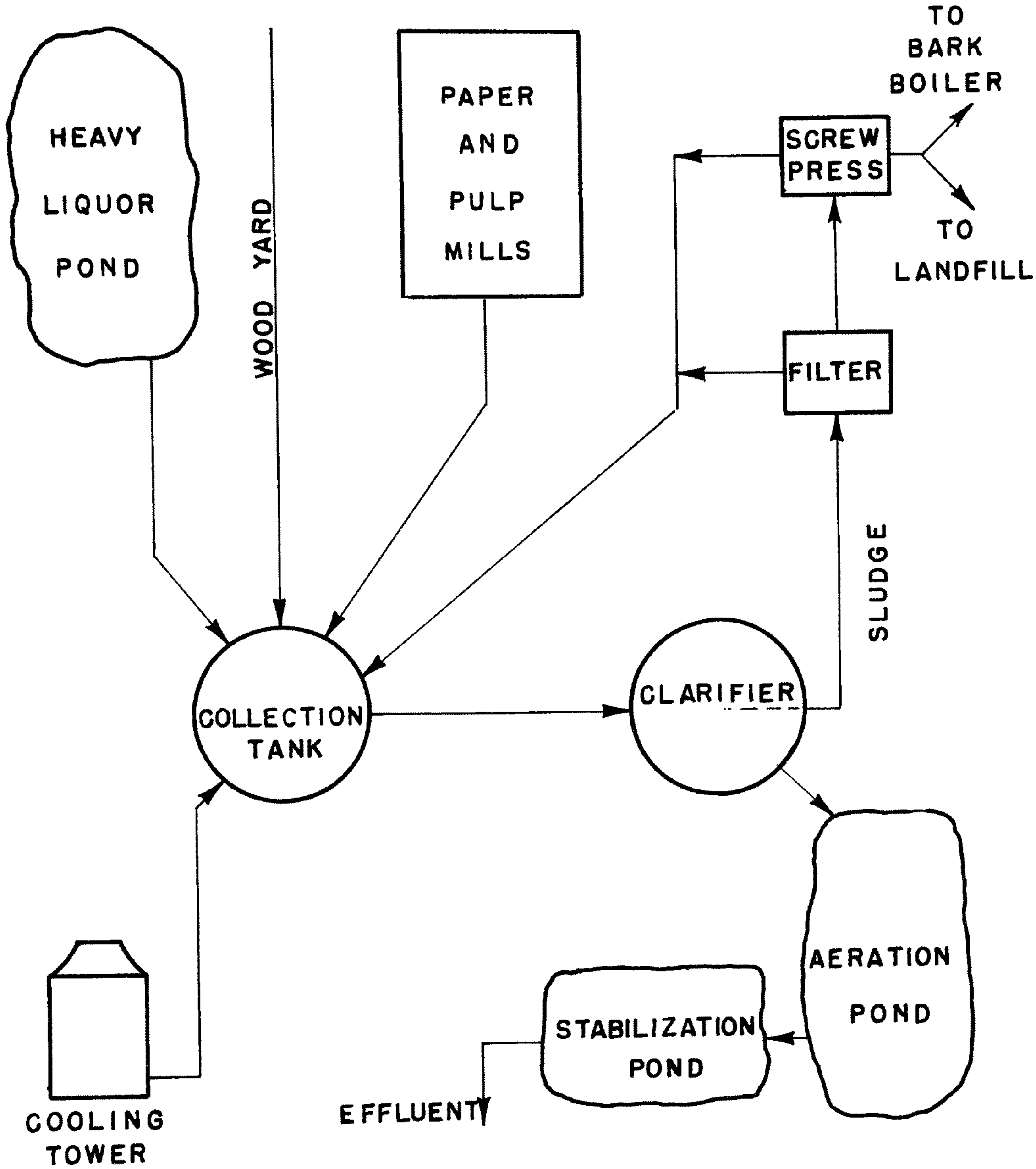


FIGURE 13

FLOW DIAGRAM
SEPARATE TREATMENT FACILITY
GEORGIA KRAFT CO., MEAD DIVISION

Overflow from the primary clarifier would undergo secondary treatment in a fifty-five-acre aeration pond and a fifteen-acre stabilization pond. The nominal depth of both ponds would be ten feet. These ponding volumes result in a detention time of twenty days aeration and five days stabilization at a design flow rate of 9 MGD. Freeboard on the dykes above the nominal depth could be used for regulation of discharge at times of low river flow.

Clarifier underflow is pumped to a belt or coil type filter and then to a V-press for final dewatering. The dewatered sludge is then burned in the existing bark boiler; filtrate from dewatering of the sludge is returned to the collection tank. A ten-acre sludge pond is provided in the event of an outage of any part of the sludge disposal system.

City of Macon: The recommended separate treatment facility for the City of Macon, Rocky Creek Water Pollution Control Plant, is shown schematically in Figure 14. The contact stabilization process is applicable to the treatment of wastes containing a high proportion of the BOD in suspended or colloidal form. The waste entering the contact tank has its BOD rapidly removed by biosorption and agglomeration of suspended solids. After the contact period, the activated sludge is separated from the liquid by sedimentation.

This sludge is pumped to a reaeration tank where the BOD and solids removed in the contact tank are stabilized. The detention time in the reaeration tank is sufficiently long to assimilate the waste removed without losing the activated sludge to endogenous respiration. This conditioned sludge is then returned to the contact tank to repeat the process.

The recommended 4.5 MGD plant will contain one contact tank and two reaeration tanks, and will be provided with one hundred percent (100%) return sludge capability. Clarifiers will follow the contact tank and sludge pumped from them will enter the reaeration tanks or digesters.

Waste sludge will be disposed of through an aerobic digester and sludge drying equipment. Underflow from sludge dewatering will be returned to the reaeration basin. Additional facilities will include screening and grit removal of the raw waste, chlorination of the effluent, recirculation pumps and administration and maintenance buildings.

Comparison of Combined and Separate Treatment Facilities: It should be noted that even though all the separate treatment plants would provide a high degree of secondary treatment, they will not produce the overall reduction in BOD expected of the combined plant, based on the pilot study.

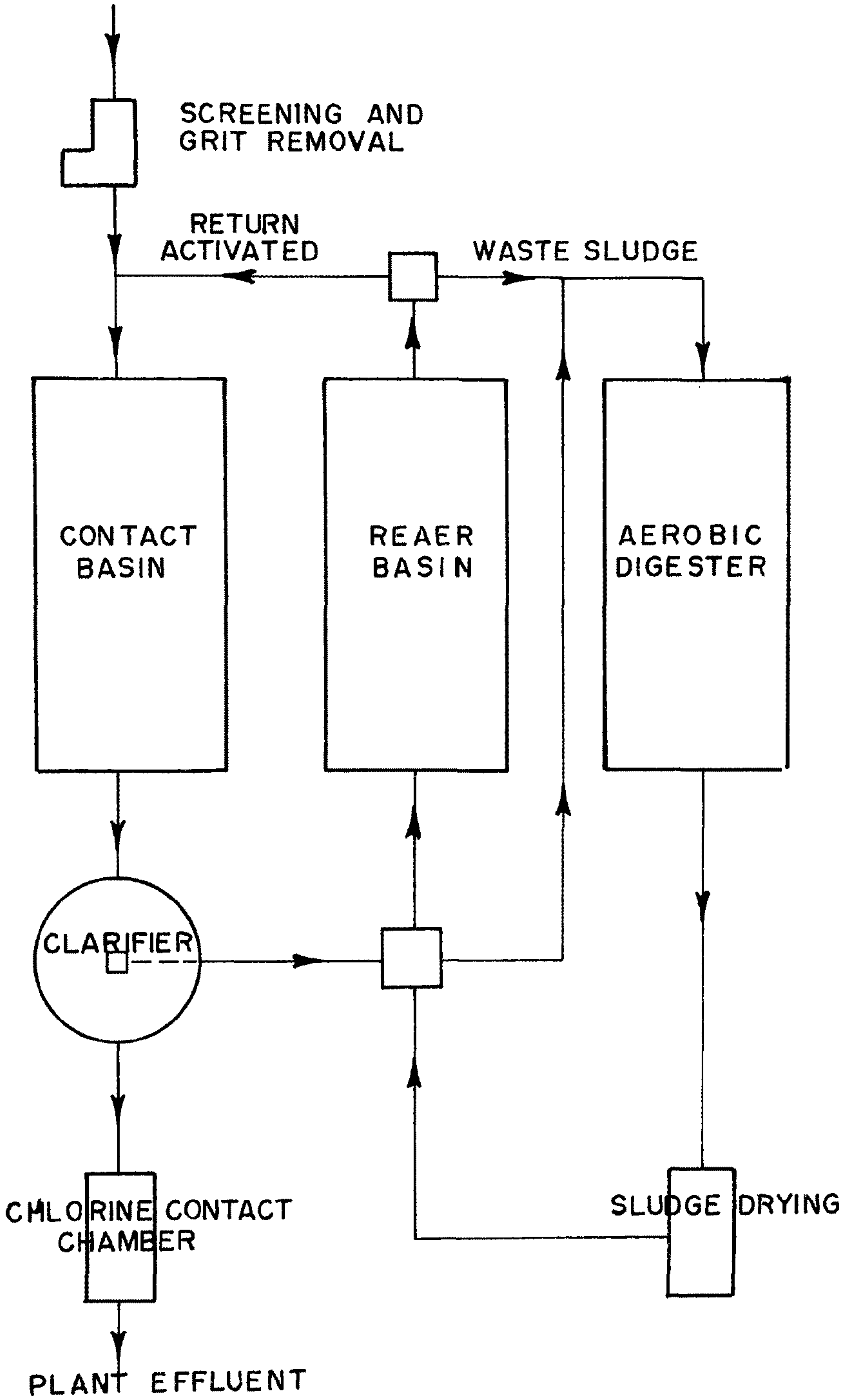


FIGURE 14
FLOW DIAGRAM
SEPARATE TREATMENT FACILITY
CITY OF MACON

Combined Treatment:	Influent lbs.	% Removal	Effluent
Armstrong Cork Company	46,760	91.7	3,878
City of Macon	7,515	91.7	623
Georgia Kraft Company	30,060	91.7	2,499
	84,335		7,000

Separate Treatment:	Influent lbs.	% Removal	Effluent
Armstrong Cork Company	46,760	90.0*	4,676
City of Macon	7,515	90.0	752
Georgia Kraft Company	30,060	85.0	4,509
			9,937

*Estimated

SECTION XIII

CONSTRUCTION AND OPERATING COSTS

Combined Treatment Facility:

Construction Costs - Estimated construction costs were compared between a facility with twenty-four-hour detention aeration basins and a facility with plastic media bio-filters and fifteen-hour detention aeration basins. These estimated project costs, including chlorination facilities, are as follows:

Plant with 24-Hour Detention:

Waste Treatment Plant	$4,561,900
Outfall Sewer - Armstrong Cork Company	65,000
Modifications to Existing Pumping Station and Force Main	156,800
Pumping Station and Force Main - Georgia Kraft Company	175,000
Contingency @ 15%	743,800
Total Construction	$5,702,500
Engineering	293,600
Resident Inspection and Soil Investigations	27,000
Legal and Administrative	15,000
Project Contingency @ 3%	181,100
Total Project Cost	$6,219,200
Federal Grant @ 33%	2,052,300
Participants' Cost	$4,166,900
Estimated Participants' Cost with Elimination of Chlorination	$4,038,600

Plant with Plastic Media Bio-Filter and 15-Hour Detention:

Waste Treatment Plant	$4,265,900
Outfall Sewer - Armstrong Cork Company	65,000
Modifications to Existing Pumping Station and Force Main	156,800
Pumping Station and Force Main - Georgia Kraft Company	175,000
Contingency @ 15%	699,400
Total Construction Cost	$5,362,100
Engineering	276,600
Resident Inspection and Soil Investigation	27,000
Legal and Administrative	15,000
Project Contingency @ 3%	170,100
Total Project Cost	$5,850,800
Federal Grant @ 33%	1,930,800
Participants' Cost	$3,920,000
Estimated Participants' Cost with Elimination of Chlorination	$3,791,900

A detailed breakdown of the estimated construction cost of the less expensive bio-filter plus aeration plant is shown in Table XIII.

Operating Costs - The estimated operating costs are based on requirements of personnel as recommended by the Board of Water Commissioners; the current power rates of the Georgia Power Company; and maintenance expense, general expense and administrative overhead from the Board's current audit. These estimated operating costs are as follows:

Plant with 24-Hour Detention Basins:

Labor	$ 94,260
Power	119,700
Vehicle Expense	12,730
Maintenance and Upkeep	20,000
Supplies and General Expense	15,000
Chlorination	73,000
Administrative Overhead @ 24%	80,310

Total Estimated Yearly Operating Cost	$415,000
Without Chlorination, reduce by 73,000 x 1.24	90,520
Estimated Yearly Operating Cost Without Chlorination	$324,480

Plant with 15-Hour Detention Basins:

Labor	$ 94,260
Power	82,600
Vehicle Expense	12,730
Maintenance and Upkeep	20,000
Supplies and General Expense	15,000
Chlorination	73,000
Administrative Overhead @ 24%	71,410
Total Estimated Yearly Operating Cost	$369,000
Without Chlorination, reduce by 73,000 x 1.24	90,520
Total Estimated Yearly Operating Cost Without Chlorination	$278,480

A detailed breakdown of the less expensive 15-hour plant operating costs are shown in Table XIV.

Participants' Separate Treatment Facilities: Cost data for the separate treatment facilities as shown in the following tables were provided by the participants through their engineers or engineering staffs.

Armstrong Cork Company, Macon Division - The capital and annual operating costs for the Armstrong Cork Company's separate waste treatment system, as shown in Figure 12, are provided in Tables XV and XVI.

TABLE XIII

Estimated Construction Cost
15-Hour Plant

A.	CONSTRUCTION COST	
1.	Excavation and Grading	$ 225,000
2.	Slope Treatment and Outlet Structures	180,000
3.	Clarifiers	415,800
4.	Plant Pumping	105,000
5.	Electrical and Controls	450,000
6.	Plant Piping	139,600
7.	Chlorination	154,000
8.	Paving	17,500
9.	Grassing	30,000
10.	Fencing	9,400
11.	Plastic Media Bio-Filter	242,100
12.	Aerators	480,000
13.	Sludge Drying and Disposal	1,697,500
14.	Administration Building	75,000
15.	Maintenance Building	45,000
16.	Modifications to Existing Pump Station	71,800
17.	Outfall Sewer - Armstrong Cork Company	65,000
18.	Screening, Grit Removal and Flow Measuring - City of Macon	85,000
19.	Pumping and Force Main - Georgia Kraft	175,000
20.	Construction Contingency @ 15%	699,400
	Total Estimated Construction Cost	$5,362,100
B.	ENGINEERING, ADMINISTRATION, LEGAL, ETC.	
1.	Engineering 5.158%	$276,000
2.	Resident Inspection & Soil Investigation	27,000
3.	Legal and Administrative	15,000
	Total Estimated Engineering Cost	$318,000
C.	PROJECT CONTINGENCY @ 3%	$170,000
	TOTAL PROJECT COST	$5,850,800
	Federal Grant (660 Program)	1,930,800
	Participants' Cost	$3,920,000

TABLE XIV

Detailed Breakdown of Yearly Operating Cost
15-Hour Plant

LABOR

Superintendent		$ 8,700	
Chemist		6,000	
Operators (10 required)			
4 @ $5,640	$22,560		
6 @ $5,100	30,600		
Total Operators		53,160	
Office Clerk		5,400	
Maintenance			
Foreman	$ 7,200		
Assistant Foreman	5,400		
Helpers - 2 @ $4,200	8,400		
Total Maintenance		21,000	
Total Labor			$94,260

POWER

Motor Horsepower		
Aerators	1500 HP	
Recirculation Pumps	300 HP	
Miscellaneous Pumps	200 HP	
Total Horsepower	2000 HP x .746 =	1,492 KW
Sludge Drying		200 KW
Miscellaneous Power		150 KW
Total Power Load		1,842 KW

Demand

Motor Horsepower	1,492 x .70 =	1,044.4 KW
Sludge Drying	200 x .67 =	134.0 KW
Miscellaneous	150 x .50 =	75.0 KW
Total Demand		1,253.4 KW

Monthly Use - Based on 720 Hours per Month
1,255 x 720 = 903,600 KWH

Monthly Cost - Based on Rate Outlined in Georgia Power Company Schedule C-7

1,000 KWH @ 3.00¢/KWH	$ 30.00	
4,000 KWH @ 2.00¢/KWH	80.00	
20,000 KWH @ 1.50¢/KWH	300.00	
100,500 KWH @ 1.20¢/KWH	1,206.00	
125,500 KWH @ 0.96¢/KWH	1,204.80	
652,600 KWH @ 0.60¢/KWH	3,915.60	
903,600 KWH	$6,736.40	
Plus 2.172%	146.31	
Monthly Power Cost	$6,882.71	
Yearly Power Cost		$82,600

TABLE XIV (Continued)

VEHICLE EXPENSE: 5 Vehicles Required		
Operating Cost	$7,730.00	
Depreciation $15,000 over 3 yrs.	5,000.00	
Total Vehicle Expense		$ 12,730
MAINTENANCE AND UPKEEP		
Based on Current Cost of City's Existing Plants		$ 20,000
SUPPLIES AND GENERAL EXPENSES		
Based on Current Cost of City's Existing Plants		$ 15,000
CHLORINATION		
Average Chlorine Demand 35 mg/l		
35 mg/l @ 17 MGD Discharge = 5000 lbs. Chlorine per Day		
5000 lbs. Chlorine per Day @ $0.04/lb. = $200.00 per Day		
Total Chlorination		$ 73,000
ADMINISTRATIVE AND OVERHEAD		
Based on Current Audit of City of Macon - 24%		$ 71,410
ESTIMATED ANNUAL OPERATING COST		$369,000

TABLE XV

Armstrong Cork Company
Estimated Construction Cost for
Separate Treatment Facility

1.	Aeration Basin	$ 749,000
2.	Clarifiers	95,800
3.	Activated Sludge Pumping Station	29,700
4.	Piping and Valves	21,450
5.	Electrical	192,500
6.	Site Work and Miscellaneous	59,550
		$1,148,000
	Construction Contingency @ 5%	57,400
		$1,205,400
	Engineering & Administrative @ 12%	144,600
	TOTAL PROJECT	$1,350,000

Note: The above table does not include cost of permanent sludge disposal facilities.

* * * * * *

TABLE XVI

Armstrong Cork Company
Estimated Annual Operating Cost
Separate Secondary Treatment Facility

1.	Power	$40,140
2.	Repair Materials	7,500
3.	Chemicals	10,000
4.	Labor	6,000
5.	Supplies	1,360
	Total Annual Operating Costs	$65,000

Manpower services for operation of the secondary plant are provided for in a primary facility presently under construction and are not included above.

Georgia Kraft Company, Mead Division - The construction and annual operating costs for the Mead Division's separate waste treatment system as shown in Figure 13 are provided in Tables XVII and XVIII.

TABLE XVII

Georgia Kraft Company
Estimated Construction Cost
Separate Treatment Facility

1.	Clarifier, 180-foot diameter	$ 281,282
2.	Sludge Disposal System	285,412
3.	Alterations to One Million Gallon Tank	14,060
4.	Instrumentation	34,550
5.	Electrical Wiring and Lighting	153,650
6.	Control Room Building	15,278
7.	Aerators	201,013
8.	Ponding	895,000
9.	Painting	10,000
10.	Pump	4,100
	Construction Subtotal	$1,894,345
	Miscellaneous and Contingencies	160,640
	Total Construction	$2,054,985
	Contractor's Overhead and Profit	332,388
	Engineering Fees and Services	41,346
	Project Subtotal	$2,428,719
	Purchase of Land	102,400
	TOTAL PROJECT	$2,531,119

* * * * * *

TABLE XVIII

Georgia Kraft Company
Estimated Annual Operating Costs
Separate Treatment Facility

1.	Electricity	$ 53,640
2.	Repair Materials	26,860
3.	Repair Labor	17,000
4.	Operating and Testing Labor	20,000
5.	Supplies	3,600
6.	Foam Control	60,000
	Total Annual Operating Costs	$181,100

City of Macon, Rocky Creek Plant - The construction and annual operating costs for the Rocky Creek separate treatment system, as shown in Figure 14, are provided in Tables XIX and XX.

TABLE XIX

City of Macon
Estimated Construction Costs
Separate Treatment Facility

1. Waste Treatment Facilities	$2,022,200
Screening, Metering and Grit Removal at Existing Pumping Station	130,000
Contingencies	322,800
Total Construction Cost	$2,475,200
Engineering	132,500
Resident Inspection and Soil Investigations	27,000
Legal and Administrative	10,000
Project Contingency	79,100
Total Project Cost	$2,723,600
Federal Grant @ 33%	898,800
City's Cost	$1,824,800

* * * * * *

TABLE XX

City of Macon
Estimated Annual Operating Costs

Labor	$ 88,860
Power	42,500
Vehicle Expense	12,730
Maintenance	12,000
Supplies	8,000
Chlorination	25,000
Administrative Overhead @ 24%	45,380
Total Estimated Annual Operating Cost	$234,470

SECTION XIV

ALLOCATION OF COSTS OF COMBINED PLANT AMONG PARTICIPANTS

Allocation of Construction Costs:

The recommended method of prorating the capital cost among the participants is to prorate those facilities related primarily to flow on a percentage-of-flow basis; those facilities related primarily to BOD on a percentage-of-BOD basis; those facilities related primarily to sludge drying and disposal on a percentage-of-sludge basis; share equally the cost of miscellaneous facilities; and one hundred percent (100%) those facilities required by individual participants.

The distribution of the participants' cost of the plant utilizing plastic media bio-filters and fifteen hours detention is as follows:

Armstrong Cork Company	$1,546,000
City of Macon	652,400
Georgia Kraft Company	1,721,600
TOTAL	$3,920,000

Table XXI shows the design flow, BOD, and sludge data used as a basis for distributing costs in this project.

Table XXII summarizes the distributed cost of the fifteen-hour plant for each party based on the distribution discussed above. Table XXIII shows how the individual items were prorated to flow, BOD, sludge, etc.

TABLE XXI

Basis for Cost Distribution

Flow		
Armstrong Cork Company	3.5 MGD	20.6%
City of Macon	4.5 MGD	26.5%
Georgia Kraft Company	9.0 MGD	52.9%
Total	17.0 MGD	100.0%
BOD		
Armstrong Cork Company	46,760 lbs.	55.4%
City of Macon	7,515 lbs.	8.9%
Georgia Kraft Company	30,060 lbs.	35.7%
Total	84,335 lbs.	100.0%
Sludge		
Armstrong Cork Company	23,098 lbs.	56.2%
City of Macon	1,875 lbs.	4.6%
Georgia Kraft Company	16,133 lbs.	39.2%
Total	41,106 lbs.	100.0%
Modifications to Existing Pumping Station		
Armstrong Cork Company		
Average Flow - 3.5 MGD x 1.5 =	5.25 MGD	36.8%
City of Macon		
Average Flow - 4.5 MGD x 2.0 =	9.00 MGD	63.2%
Total	14.25 MGD	100.0%

* * * * *

TABLE XXII

Summary of Construction Cost Distribution - 15 Hour Plant

Distribution of Cost	Armstrong Cork	City of Macon	Georgia Kraft Company
Based on Flow	$ 355,620	$457,470	$ 913,210
Based on BOD	400,045	64,265	257,790
Based on Sludge	953,995	78,085	665,420
Shared Equally	40,000	40,000	40,000
Prorated Between Armstrong Cork and City of Macon	26,420	45,380	
100% by Each Participant	65,000	85,000	175,000
Const. Contingency @ 15%	276,160	115,530	307,710
Total Construction Cost	$2,117,240	$885,730	$2,359,130
Engineering @ 5.158%	109,215	45,690	121,695
Technical & Administrative Cost	14,000	14,000	14,000
Project Contingency @ 3%	67,085	28,310	74,705
Total Project Cost	$2,307,540	$973,730	$2,569,530
Federal Grant 33%	761,540	321,330	847,930
Estimated Participants' Cost	$1,546,000	$652,400	$1,721,600

TABLE XXIII

Detailed Breakdown of Construction Costs Proration

A. CONSTRUCTION COST

1. Cost to be Pro-Rated Based on Flow

a. Excavation and Grading	$225,000	
b. Slope Treatment and Outlet Structures	180,000	
c. Clarifiers	415,800	
d. Plant Pumping	105,000	
e. Electrical and Controls	450,000	
f. Plant Piping	139,600	
g. Chlorination	154,000	
h. Paving	17,500	
i. Grassing	30,000	
j. Fencing	9,400	
Total to be pro-rated based on flow		$1,726,300

2. Cost to be Pro-Rated Based on BOD

a. Plastic Media Filter	$242,100	
b. Aerators	480,000	
Total to be pro-rated based on BOD		722,100

3. Cost to be Pro-Rated Based on Sludge

a. Sludge Drying and Disposal		1,697,500

4. Cost to be Pro-Rated Equally

a. Administration Building	$75,000	
b. Maintenance Building	45,000	
Total to be pro-rated equally		120,000

5. Cost to be Pro-Rated Between Armstrong Cork Company and City of Macon Modifications to Existing Pump Station

a. Increase Capacity Existing Pumps	$ 8,000	
b. Two Variable Speed Drives with Motors	33,800	
c. Two Fixed Speed Motors	12,000	
d. Force Main	18,000	
Total cost to be pro-rated between Armstrong Cork Company and City of Macon		71,800

6.	Cost to be Borne 100 Percent by Participant		
	a. Armstrong Cork Company - Outfall Sewer		$ 65,000
	b. City of Macon - Screening, Grit Removal and Flow Measuring		85,000
	c. Georgia Kraft - Pumping and Force Main		175,000
7.	Cost to be Pro-Rated Based on Participants Construction Cost - Project Contingency 15%		699,400
8.	Total Estimated Construction Cost		$5,362,100
B.	ENGINEERING, ADMINISTRATION, LEGAL, ETC.		
1.	Cost to be Pro-Rated Based on Participants Construction Cost - Engineering 5.158%		$ 276,600
2.	Cost to be Pro-Rated Equally		
	a. Resident Inspection and Soil Investigation	$27,000	
	b. Legal and Administrative	15,000	
	Total to be Pro-Rated Equally		42,000
3.	Cost to be Pro-Rated Based on Participants Project Cost - Project Contingency 3%		170,100
TOTAL PROJECT COST			$5,850,800
Federal Grant (660 Program)			1,930,800
Participants' Cost			$3,920,000

Allocation of Operating Costs:

The distribution of the operating expense among the participants is based on the average of the percentage of influent flow, influent BOD and sludge produced.

The distribution of the operating cost of the plant utilizing bio-filters and fifteen hours detention is as follows:

	Armstrong Cork	City of Macon	Georgia Kraft
Flow	20.6%	26.5%	52.9%
BOD	55.4%	8.9%	35.7%
Sludge	56.2%	4.6%	39.2%
Total	132.3	40.0	127.8
Average	44.1%	13.3%	42.6%
Operating Cost with Chlorination	$162,700	$49,100	$157,200
Operating Cost without Chlorination	$122,800	$37,000	$118,700
ADDITIONAL OPERATING COST - Individual Pump Station Power			
	$1,400	$1,800	$8,400
TOTAL WITH CHLORINATION			
	$164,100	$50,900	$165,600
TOTAL WITHOUT CHLORINATION			
	$124,200	$38,800	$127,100

SECTION XV

ACKNOWLEDGEMENTS

We wish to acknowledge the support of the Honorable Ronnie Thompson, Mayor of the City of Macon, Georgia, and the Macon Board of Water Commissioners, Mr. Gordon Bush, Chairman, and Mr. M. L. Leggett and Dr. J. Robert Young, Sr., Commissioners.

All of the project activities were coordinated and administered by Mr. Emory C. Matthews, Secretary-Treasurer of the Board of Water Commissioners, Project Director.

The design and general supervision of the pilot plant was performed by Jordan, Jones and Goulding, Inc., Consulting Engineers, Atlanta, Georgia. The supervision of construction was performed by Mr. James R. Atwater, Engineer, Board of Water Commissioners.

Operation, analytical work and monthly reports were performed by Mr. Marion H. Poythress, Chemist, Board of Water Commissioners, under the supervision of Dr. Robert S. Ingols, Research Professor of the Georgia Institute of Technology. Dr. Ingols performed the bench tests from which data was obtained to encourage the pilot plant study.

Preparation of this report was performed by personnel of Jordan, Jones and Goulding, Inc. and Georgia Kraft Company. The contributions and review of Dr. Robert S. Ingols, John D. Fulmer, Jr., of Armstrong Cork Company and Vergil A. Minch of Mead Corporation are acknowledged.

We acknowledge the support of the State Water Quality Control Board, their Director Mr. R. S. Howard, and Mr. Charles H. Starlings, Director of Industrial Waste Services.

The support of the project by the Environmental Protection Agency and the aid provided by Mr. William J. Lacy, Mr. George R. Webster, Project Manager, and Mr. Edmond P. Lomasney, Project Officer, were greatly appreciated.

SECTION XVI

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SECTION XVII

GLOSSARY

BOD - Biochemical Oxygen Demand

COD - Chemical Oxygen Demand

MGD - Million Gallons per Day

gpm - Gallons per Minute

lbs/day - Pounds per Day

MGD/Sq.Mi. - Million Gallons per Day per Square Mile

MPN - Most Probable Number

mg/l - Milligrams per Liter

lbs/1000 Cu. Ft./Day - Pounds per Thousand Cubic Feet per Day

SECTION XVIII

APPENDICES

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APPENDIX I

GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION 225 North Avenue, Northwest · Atlanta, Georgia 30332

February 17, 1968

Summary of Bench Scale Data

In order to determine the feasibility of combined waste treatment of the City sewage in the Rocky Creek drainage area, Armstrong Cork effluent and Georgia Kraft effluent a bench study on the waste involved was instituted at the waste treatment facility of the City of Macon.

Daily samples from these three sources were collected. Each was mixed in proportion to the anticipated flow to the proposed treatment facility. The total volume anticipated is 15 MGD, (3 MGD City, 3 MGD Armstrong, 8-9 MGD from Georgia Kraft). The daily composites were mixed in these ratios.

The composite sample was fed slowly into the bench scale activated sludge devices. One was operated at 24 hours retention during the entire period. Another was operated with shorter and longer periods in the retention tank. Analyses were made daily for suspended solids, total solids, and settleable solids, B.O.D., and C.O.D., and pH.

Each individual waste was observed for the volume of settleable solids, B.O.D., and C.O.D., and pH.

The bench units received only domestic sewage on Saturday and Sunday in the same volume of the mixed composite they received the other five days.

When the activated sludge solids developed in sufficient quantity, orders were given to maintain sludge volume between 200-250 ml/1 with 30 minutes settling. When the volume of sludge exceeded 250, an amount of the aeration tank liquor was wasted before adding additional composite in order to obtain the desired volume of sludge.

Results:

The B.O.D. data indicates that the average of the composite approached 700 mg/1. With 24 hours retention the B.O.D. averaged 150 mg/1 on those days following the addition of composite samples. With 30 hours detention, the B.O.D. averaged 85-90 mg/1. The other data was taken to provide information to the agencies involved in studies but are not germane to the treatability of the waste. It is concluded that 30 hours detention will give a satisfactory B.O.D. for the effluent of a combined waste treatment facility containing City, Armstrong Cork, and Georgia Kraft wastes.

Because of the magnitude of the sludge volume produced and the difficulty in handling sludges containing high sulfur content, it is recommended:

1. That a pilot plant be designed and built to study the actual dosing cycles that might be anticipated in a final design of an actual plant. (Waste would be added on a 24 hour/day, 7 day/week schedule.)

2. That studies be conducted on techniques for treatment and disposal of the sludges obtained as a by-product of the pilot plant units.

3. That the feasibility of reducing power costs for aeration be studied with plastic film filter as a primary treatment step. (The B.O.D. of 700 justifies consideration of the high cost of the plastic film filter.)

BENCH SCALE DATA

	8/29	8/30	8/31	9/1	9/2	9/3	9/4	9/5	9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14	9/15	9/16	9/17	9/18
ARMSTRONG CORK CO.					NO SAMPLES RUN * LABOR DAY WEEK-END CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES RUN * LABOR DAY WEEK-END CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES RUN * LABOR DAY WEEK-END - CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES COLLECTED BY ARMSTRONG OR KRAFT				ATTENDING WATER POLLUTION CONTROL CONFERENCE CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	ATTENDING WATER POLLUTION CONTROL CONFERENCE - CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	ATTENDING WATER POLLUTION CONTROL CONFERENCE CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	ATTENDING WATER POLLUTION CONTROL CONFERENCE CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	ATTENDING WATER POLLUTION CONTROL CONFERENCE - CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT			NO SAMPLES COLLECTED ON WEEK-END - CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES COLLECTED ON WEEK-END - CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	
pH	7.1	6.3	6.7	6.6					6.8	7.2	6.7						7.0	7.3			-
B.O.D.	-	-	1500	1733					2100	1500	1567						1633	1266			-
C.O.D.	-	-	-	-					-	-	2000+						4416	4160			
Set. Sol.	-	14.5	75.0	90.0					20.0	75.0	110.0						20.0	170.0			-
GA. KRAFT CO.																					
pH	9.8	8.3	10.0	8.7					10.7	9.4	10.3						9.0	10.9			10.1
B.O.D.	-	-	280	240					270	430	330						190	-			190
C.O.D.	-	-	-	-					-	-	1200						880	-			1060
Set. Sol.	-	-	5.5	3.5					4.5	5.0	5.0						6.5	36.0			11.0
PIO NONO OUTFALL																					
pH	6.8	7.5	6.9	7.1					8.1	7.5	7.5						7.7	7.6			8.8
B.O.D.	-	-	143	130					140	195	225						135	155			150
C.O.D.	-	-	-	-					-	-	340						240	260			320
Set. Sol.	-	-	5.0	6.5					9.0	7.5	14.0						7.5	11.0			7.0
COMPOSITE : pH	7.6	7.9	8.7	7.8					9.8	9.0	9.6						7.8	9.8			9.4
B.O.D.	490	521	620	535					660	780	640						440	500			250
C.O.D.	-	-	-	-					-	-	1520						1340	1800			760
Set. Sol.	66.0	-	16.5	24.0					10.0	20.0	27.0						12.0	40.0			9.0
Tot. Sol.	1287	1739	2058	1612					-	1886	2180						2000	1986			1068
Tot. Vol. Sol.	788	1239	1446	1082					-	1326	1366						1284	1040			732
Sus. Sol.	298	586	530	140					-	510	500						730	1320			380
AERATION CELLS																					
pH: No. 1	7.7	7.3	7.9	8.1					7.3	8.5	8.3						8.7	8.3			8.0
No. 2	7.2	7.3	7.2	8.1					8.0	8.6	8.8						8.7	8.4			8.4
Diss. Oxy: No. 1	-	6.0	6.0	6.0					6.7	6.8	6.5						6.8	6.3			6.8
No. 2	-	6.0	6.0	6.0					6.4	6.3	6.3						6.8	6.4			6.0
Eff. B.O.D.: No. 1	-	103	141	105					-	190	70						63	70			33
No. 2	-	134	110	150					-	83	180						50	53			23
Eff. C.O.D.: No. 1	-	-	-	-					-	-	439						480	480			420
No. 2	-	-	-	-					-	-	640						460	460			380
Eff. Sos. Solids: No. 1	-	170	100	80					-	40	60						115	105			25
No. 2	-	210	100	15					-	220	190						40	65			90
Set. Sol. in Tks: No. 1	170.0	-	180.0	160.0					290.0	160.0	190.0						230.0	220.0			190.0
No. 2	120.0	-	110.0	110.0					20.0	190.0	60.0						230.0	210.0			200.0
GENERAL																					
% of Comp. From:																					
Armstrong	20%	20%	20%	20%					-	20%	20%						20%	20%			20%
Pio Nono	20%	20%	20%	20%					-	20%	20%						20%	20%			20%
Ga. Kraft	60%	60%	60%	60%					-	60%	60%						60%	60%			60%
Liters to Cell:																					
No. 1	12	12	12	12					12	12	8						12	12			12
No. 2	8	8	8	8					8	8	12						8	8			8
Sludge Drawn From																					
No. 1	-	-	-	-					-	-	-						-	-			-
No. 2	-	-	-	-					-	-	-						-	-			-
% B.O. D. Removed																					
No. 1	-	-	-	-					-	-	-						-	-			-
No. 2	-	-	-	-					-	-	-						-	-			-

	9/19	9/20	9/21	9/22	9/23	9/24	9/25	9/26	9/27
ARMSTRONG CORK CO.					NO SAMPLES COLLECTED ON WEEK-END CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES COLLECTED ON WEEK-END - CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES FROM ARMSTRONG 1 GAL. SHORT FROM GA. K. AUTO. SAMPLER STOPPED UP AT PIO NONO OUTFALL LINE		
pH	6.1	7.0	6.3	6.3				6.6	7.2
B.O.D.	1466	1700	1630	1930				1500	1430
C.O.D.	5840	4640	4400	5120				4080	4560
Set. Sol.	280.0	110.0	110.0	160.0				90.0	20.0
GA. KRAFT CO.									
pH	10.2	10.3	8.9	10.3				10.5	9.8
B.O.D.	260	250	300	560				580	420
C.O.D.	1000	860	940	5120				1480	1600
Set. Sol.	13.0	6.0	5.0	60.0				6.5	29.0
PIO NONO OUTFALL									
pH	7.6	7.9	7.3	7.5				7.9	7.3
B.O.D.	135	205	145	185				150	160
C.O.D.	240	460	420	1500				300	400
Set. Sol.	2.0	5.0	7.0	12.0				8.0	6.5
COMPOSITE									
pH	8.6	9.6	7.5	8.8				9.8	9.3
B.O.D.	520	560	800	740				660	540
C.O.D.	840	1560	1880	1760				1600	1880
Set. Sol.	55.0	27.0	23.0	24.0				10.0	27.0
Tot. Sol.	2040	1060	1402	2186				1756	2000
Tot. Vol. Sol.	1394	688	922	1476				1106	1260
Sus. Sol.	890	390	690	570				240	840
AERATION CELLS									
pH : No. 1	8.1	8.5	8.7	8.8				8.7	7.8
No. 2	8.6	8.7	8.9	9.0				8.7	7.9
Diss. Oxy: No. 1	6.5	6.4	6.0	6.3				6.9	5.8
No. 2	6.5	6.8	6.3	6.3				6.9	6.8
Eff. B.O.D.: No. 1	130	73	70	140				90	50
No. 2	113	110	116	177				90	50
Eff. C.O.D.: No. 1	780	440	460	680				320	400
No. 2	400	500	520	640				320	400
Eff. Sos. Solids: No. 1	35	0	155	110				0	50
No. 2	45	0	165	110				0	0
Set. Sol. in Tks: No. 1	240.0	230.0	205.0	200.0				200.0	310.0
No. 2	230.0	225.0	205.0	190.0				150.0	250.0
GENERAL									
% of Comp. From:									
Armstrong	20%	20%	20%	20%				20%	20%
Pio Nono	20%	20%	20%	20%				20%	20%
Ga. Kraft	60%	60%	60%	60%				60%	60%
Liters to Cell:									
No. 1	12	12	12	12				12	12
No. 2	8	8	8	8				8	8
Sludge Drawn From:									
No. 1	-	-	-	-				-	-
No. 2	-	-	-	-				-	-
% B.O.D. Removed:									
No. 1	-	-	-	-				-	-
No. 2	-	-	-	-				-	-

	9/28	9/29	9/30	10/1	10/2	10/3	10/4	10/5	10/6	10/7	10/8	10/9
ARMSTRONG CORK CO.			NO SAMPLES COLLECTED CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES COLLECTED - CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES COLLECTED - CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES COLLECTED - CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES COLLECTED - CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT			NO SAMPLES COLLECTED CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES COLLECTED CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	
pH	6.8	6.9						7.0	6.7			6.9
B.O.D.	1970	2350						1800	1700			1400
C.O.D.	7690	-						4400	4740			3600
Set. Sol.	120.0	30.0						60.0	100.0			25.0
GA. KRAFT CO.												
pH	8.8	9.8						10.8	10.8			10.7
B.O.D.	290	360						600	610			770+
C.O.D.	1250	-						1680	3810			1950
Set. Sol.	15.5	15.0						4.0	3.5			6.0
PIO NONO OUTFALL												
pH	7.6	7.7						7.4	7.5			7.6
B.O.D.	150	120						150	220			150
C.O.D.	389	-						460	420			300
Set. Sol.	5.5	0.4						5.5	10.0			6.0
COMPOSITE												
pH	8.2	8.8						10.2	10.2			9.8
B.O.D.	640	720						1440	680			780
C.O.D.	2330	-						2000	1700			1880
Set. Sol.	35.0	18.0						10.5	12.0			8.0
Tot. Sol.	2218	1576						1240	2230			1964
Tot. Vol. Sol.	1202	-						822	1610			1430
Sus. Sol.	1050	100						670	620			380
AERATION CELLS												
pH : No. 1	8.2	8.3						7.7	8.4			8.3
No. 2	8.4	8.6						7.8	8.6			8.6
Diss. Oxy: No. 1	5.8	5.5						7.0	5.5			6.8
No. 2	5.8	5.7						6.8	6.5			7.0
Eff. B.O.D.: No. 1	40	110						230	250			220
No. 2	50	90						250	250+			190
Eff. C.O.D.: No. 1	432	-						520	840			800
No. 2	475	-						660	930			680
Eff. Sos. Solids: No. 1	125	0						45	140			100
No. 2	65	0						80	90			0
Set. Sol. in Tks: No. 1	420.0	420.0						120.0	110.0			120.0
No. 2	300.0	520.0						140.0	120.0			100.0
GENERAL												
% of Comp. From:												
Armstrong	20%	20%						20%	20%			20%
Pio Nono	20%	20%						20%	20%			20%
Ga. Kraft	60%	60%						60%	60%			60%
Liters to Cell:												
No. 1	12	12						12	12			12
No. 2	8	8						18	18			18
Sludge Drawn From:												
No. 1	-	-					4 L.	-	-			-
No. 2	-	-					4 L.	-	-			-
% B.O.D. Removed:												
No. 1	-	-						85	63			72
No. 2	-	-						83	63(-)			76

	10/10	10/11	10/12	10/13	10/14	10/15	10/16	10/17	10/18	10/19	10/20
ARMSTRONG CORK CO.					NO SAMPLES COLLECTED - CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES COLLECTED - CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT			CHANGED NO. 2 CELL FROM 18 HR. RETENTION PERIOD TO 36 HR. RETENTION PERIOD (8 L)		
pH	7.7	6.9	6.8	6.7			7.5	7.1	7.5	10.5	7.3
B.O.D.	1670	1100	1670	2070			1900	630	1470	1330	1800
C.O.D.	3600	4720	6400	-			4640	2800	5200	5840	4800
Set. Sol.	10.0	45.0	60.0	100.0			16.0	25.0	50.0	40.0	80.0
GA. KRAFT CO.											
pH	10.8	10.5	10.6	10.0			9.9	10.0	10.7	10.8	10.8
B.O.D.	590	460	400	360			540	470	500	650	700
C.O.D.	1680	1320	1360	-			1720	1680	1740	2000+	2480
Set. Sol.	10.0	10.5	6.0	31.0			5.5	9.0	9.0	13.0	11.0
PIO NONO OUTFALL											
pH	7.5	7.4	7.7	7.8			7.5	7.4	7.6	7.8	7.7
B.O.D.	180	240	140	170			150	150	130	160	230
C.O.D.	560	460	340	-			340	560	300	380	420
Set. Sol.	10.5	8.0	5.0	10.0			10.5	6.0	7.0	5.0	7.0
COMPOSITE											
pH	10.2	9.6	9.7	9.0			9.5	9.3	10.0	10.5	10.1
B.O.D.	760	540	620	680			880	440	520	640	840
C.O.D.	1760	1640	1920	-			1880	2240	2040	2160	2320
Set. Sol.	10.0	20.0	19.0	25.0			7.0	10.0	17.0	17.0	10.5
Tot. Sol.	2756	2064	2260	2034			2180	2210	2286	2774	2556
Tot. Vol. Sol.	1596	1352	1572	1352			1562	1358	1480	1814	1624
Sus. Sol.	880	890	650	620			310	660	600	1030	230
AERATION CELLS											
pH : No. 1	8.3	8.8	8.7	8.4			7.8	8.4	8.2	8.6	9.0
No. 2	8.5	9.0	8.7	8.5			7.8	8.5	8.5	8.9	9.0
Diss. Oxy: No. 1	7.0	6.8	6.7	6.6			5.3	5.3	5.2	4.5	5.1
No. 2	6.8	6.5	6.4	7.0			5.2	5.0	5.2	5.0	5.4
Eff. B.O.D.: No. 1	210	180	220	180			150	110	200	270	180
No. 2	260+	210	230	-			260	180	210	160	180
Eff. C.O.D.: No. 1	660	580	720	-			500	480	720	960	1120
No. 2	860	700	820	-			780	660	760	780	1080
Eff. Sos. Solids: No. 1	90	15	30	80			0	60	16	36	0
No. 2	90	0	0	-			-	60	50	32	45
Set. Sol. in Tks: No. 1	165.0	180.0	120.0	170.0			250.0	310.0	310.0	200.0	210.0
No. 2	205.0	210.0	170.0	200.0			350.0	690.0	600.0	120.0	180.0
GENERAL											
% of Comp. From:											
Armstrong	20%	20%	20%	20%			20%	20%	20%	20%	20%
Pio Nono	20%	20%	20%	20%			20%	20%	20%	20%	20%
Ga. Kraft	60%	60%	60%	60%			60%	60%	60%	60%	60%
Liters to Cell:											
No. 1	12	12	12	12			12	12	12	12	12
No. 2	18	18	18	Pl.Eff.			18	18	8	8	8
Sludge Drawn From:											
No. 1	-	-	-	-			-	-	5 L.	-	-
No. 2	-	-	-	-			-	-	3 L.	-	-
% B.O.D. Removed:											
No. 1	72	67	65	74			83	75	62	58	79
No. 2	66	62	63	-			71	60	60	75	79

	10/21	10/22	10/23	10/24	10/25	10/26	10/27	10/28	10/29	10/30
ARMSTRONG CORK CO.	NO SAMPLES COLLECTED CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES COLLECTED CELLS FED WITH SEWAGE DISPOSAL PLANT PRIMARY EFFLUENT						NO SAMPLES COLLECTED - CELLS FED WITH 75% Ga.K. & 25% SEWAGE TREATMENT PLANT PRIMARY EFFLUENT	NO SAMPLES COLLECTED - CELLS FED WITH 75% Ga.K. & 25% SEWAGE TREATMENT PLANT PRIMARY EFFLUENT	
pH			6.9	7.0	7.3	7.0	7.8			7.2
B.O.D.			1370	1600	1470	1530	530			1570
C.O.D.			3840	5360	7360	4320	3200			6000
Set. Sol.			18.0	90.0	50.0	130.0	80.0			38.0
GA. KRAFT CO.										
pH			10.2	10.7	10.5	10.8	10.4			10.7
B.O.D.			690	450	420	540	690			500
C.O.D.			2190	2640	2040	1960	2960			1800
Set. Sol.			8.0	14.0	10.0	8.0	38.0			7.5
PIO NONO OUTFALL										
pH			7.5	7.2	7.3	7.5	7.5			7.8
B.O.D.			90	180	180	170	190			100
C.O.D.			200	220	420	420	440			160
Set. Sol.			0.5	5.5	5.0	3.0	6.0			5.0
COMPOSITE										
pH			10.0	10.1	9.8	10.1	9.8			10.3
B.O.D.			580	500	460	680	640			680
C.O.D.			1910	2000	2280	2360	2160			1960
Set. Sol.			3.5	9.0	5.0	24.0	19.0			14.0
Tot. Sol.			2106	2592	2432	2738	2356			2322
Tot. Vol. Sol.			1366	1646	1452	1820	1546			1490
Sus. Sol.			350	580	970	750	770			270
AERATION CELLS										
pH : No. 1			8.3	8.5	8.7	8.5	8.9			8.5
No. 2			8.4	8.6	8.9	8.6	9.0			8.5
Diss. Oxy: No. 1			4.8	4.0	4.5	4.5	7.0			7.0
No. 2			4.8	4.3	5.0	5.0	7.1			7.1
Eff. B.O.D.: No. 1			110	130	130	250	150			160
No. 2			110	70	90	160	100			110
Eff. C.O.D.: No. 1			520	620	680	900	800			780
No. 2			500	420	580	500	660			740
Eff. Sos. Solids: No. 1			105	0	85	250	80			0
No. 2			105	0	95	160	35			0
Set. Sol. in Tks: No. 1			250.0	400.0	410.0	420.0	270.0			300.0
No. 2			200.0	280.0	300.0	320.0	200.0			230.0
GENERAL										
% of Comp. From:										
Armstrong			20%	20%	20%	20%	20%			20%
Pio Nono			20%	20%	20%	20%	20%			20%
Ga. Kraft			60%	60%	60%	60%	60%			60%
Liters to Cell:										
No. 1			12	12	12	12	12			12
No. 2			8	8	8	8	8			8
Sludge Drawn From:										
No. 1			-	-	-	2½ L.	-			-
No. 2			-	-	-	1½ L.	-			-
% B.O.D. Removed:										
No. 1			81	74	72	63	77			74
No. 2			81	86	80	77	84			84

	10/31	11/1	11/2	11/3	11/4	11/5	11/6	11/7
ARMSTRONG CORK CO.								
pH	7.5	7.2	6.6	7.6	NO SAMPLES COLLECTED - CELLS FED WITH DISPOSAL PLANT PRIMARY EFFLUENT	NO SAMPLES COLLECTED - CELLS FED WITH DISPOSAL PLANT PRIMARY EFFLUENT	7.8	7.3
B.O.D.	1330	1000	1530	1600			1300	770
C.O.D.	7760	3680	3820	4160			3840	2700
Set. Sol.	120.0	80.0	70.0	70.0			40.0	20.0
GA. KRAFT CO.								
pH	10.9	10.7	10.3	10.7			10.1	10.6
B.O.D.	380	400	320	460			370	370
C.O.D.	1760	1320	1610	1420			1420	1430
Set. Sol.	12.0	17.0	50.0	10.5			9.0	10.0
PIO NONO OUTFALL								
pH	7.6	7.5	7.6	7.6			8.1	7.8
B.O.D.	200	160	170	170			170	140
C.O.D.	420	360	350	460			220	0
Set. Sol.	7.0	5.0	6.0	5.0			3.5	7.0
COMPOSITE								
pH	10.1	9.8	9.3	9.8			9.5	10.3
B.O.D.	480	440	540	600			560	380
C.O.D.	2600	1320	1580	1570			1340	1300
Set. Sol.	33.0	8.5	26.0	10.0			5.0	7.0
Tot. Sol.	2284	1660	1782	2082			2038	2130
Tot. Vol. Sol.	2284	1030	1216	1330			1260	1200
Sus. Sol.	1640	510	380	540			520	580
AERATION CELLS								
pH : No. 1	8.9	8.9	8.3	8.8			8.6	8.7
No. 2	9.0	9.0	8.4	8.8			8.8	8.9
Diss. Oxy: No. 1	7.8	7.0	6.0	8.0			8.3	8.0
No. 2	7.8	7.1	6.1	8.0			8.5	8.3
Eff. B.O.D.: No. 1	80	80	100	170			70	70
No. 2	60	40	70	90			60	50
Eff. C.O.D; No. 1	580	500	480	600			370	410
No. 2	560	500	380	430			330	390
Eff. Sos. Solids: No. 1	0	42	40	40			60	75
No. 2	55	30	15	55			58	55
Set. Sol. in Tks: No. 1	300	300	340	310			200	490
No. 2	200	250	280	280			150	290
GENERAL								
% of Comp. From:								
Armstrong	20%	20%	20%	20%			20%	20%
Pio Nono	20%	20%	20%	20%			20%	20%
Ga. Kraft	60%	60%	60%	60%			60%	60%
Liters to Cell:								
No. 1	12	12	12	12			12	12
No. 2	8	8	8	8			8	8
Sludge Drawn From:								
No. 1	1 L.	1 L.	1 L.	1 L.			2 L.	-
No. 2	-	-	1 L.	1 L.			1 L.	-
% B.O.D. Removed:								
No. 1	83	82	81	72			87	82
No. 2	87	91	87	85			89	87

11/8/67

CONTENTS OF AERATION CELLS	CELL No.1	CELL No.2
(a.) Total Sus. Sols. mg/l	2700.0	2552.0
(b.) Total Vol. Sus. Sols. mg/l	2252.0	2172.0
(c.) Total Fixed Sus. Sols. mg/l	448.0	380.0
Settleable Solids Ml/1/30 Min.	300.0	250.0

APPENDIX II

SUMMARY

PILOT PLANT SAMPLES

-A-

Plant Influent - Raw Wastes

PERIOD	pH	TOTAL SOLIDS mg/1	TOTAL VOL. SOLIDS mg/1	SUSP. SOLIDS mg/1	VOL. SUSP. SOLIDS mg/1	SETTLEABLE SOLIDS ml/1/hr	BOD mg/1	COD mg/1
Apr. 15 - May 5 (21 Days)								
ARMSTRONG CORK								
No. Data Points	(12)	(12)	(12)	(12)	(1)	(12)	(12)	(12)
Maximum	7.1	6482	5126	3915	3235	140	1950	5380
Minimum	5.7	3046	2298	1530	3235	50	1150	3520
Average	6.4	4271	3155	2115	3235	95	1510	4110
GEORGIA KRAFT								
No. Data Points	(12)	(12)	(12)	(12)	(1)	(12)	(12)	(12)
Maximum	10.0	1078	702	285	53	25	460	1170
Minimum	8.7	792	364	45	53	1.2	260	720
Average	9.3	889	483	154	53	4.6	370	920
CITY OF MACON								
No. Data Points	(11)	(11)	(11)	(11)	(1)	(11)	(11)	(11)
Maximum	7.3	540	448	310	113	10	200	480
Minimum	7.0	282	156	45	113	2.5	140	350
Average	7.2	435	255	177	113	7.4	180	380

PERIOD	pH	TOTAL SOLIDS mg/l	TOTAL VOL. SOLIDS mg/l	SUSP. SOLIDS mg/l	VOL. SUSP. SOLIDS mg/l	SETTLEABLE SOLIDS ml/l/hr	BOD mg/l	COD mg/l
May 13 - May 18 (6 Days)								
ARMSTRONG CORK								
No. Data Points	(4)	(4)	(4)	(4)	(1)	(4)	(4)	(4)
Maximum	6.9	3996	2716	1910	1530	100	1700	3960
Minimum	6.3	3694	2170	1480	1530	40	800	2980
Average	6.6	3853	2487	1710	1530	80	1310	3470
GEORGIA KRAFT								
No. Data Points	(4)	(4)	(4)	(4)	(0)	(4)	(4)	(4)
Maximum	9.8	1018	488	280		26	320	920
Minimum	7.0	680	286	100		2.5	180	480
Average	8.4	787	361	165		9.8	250	710
CITY OF MACON								
No. Data Points	(4)	(4)	(4)	(4)	(0)	(4)	(4)	(4)
Maximum	7.2	676	492	240		16	260	480
Minimum	6.8	400	164	165		8	180	340
Average	7.0	540	300	201		12	220	420
May 19 - June 15 (28 Days)								
ARMSTRONG CORK								
No. Data Points	(17)	(17)	(17)	(17)	(4)	(17)	(15)	(17)
Maximum	7.7	4636	2818	2480	1820	130	1850	3990
Minimum	6.2	2098	1180	1320	1020	20	950	2450
Average	6.9	3738	2543	1670	1370	80	1570	3480
GEORGIA KRAFT								
No. Data Points	(17)	(17)	(17)	(17)	(3)	(17)	(15)	(17)
Maximum	10.4	1346	678	270	100	2.5	500	1140
Minimum	8.9	820	372	10	0	0.8	160	340
Average	9.8	1028	515	130	63	2.4	380	930
CITY OF MACON								
No. Data Points	(17)	(17)	(17)	(17)	(4)	(17)	(15)	(17)
Maximum	7.3	1020	598	415	220	17	320	1020
Minimum	7.1	418	288	175	70	6.5	160	210
Average	7.2	632	366	237	150	9.5	210	460

PERIOD	pH	TOTAL SOLIDS mg/l	TOTAL VOL. SOLIDS mg/l	SUSP. SOLIDS mg/l	VOL. SUSP. SOLIDS mg/l	SETTLEABLE SOLIDS ml/l/hr	BOD mg/l	COD mg/l
June 16 - June 26 (11 Days)								
ARMSTRONG CORK								
No. Data Points	(9)	(9)	(8)	(9)	(4)	(9)	(8)	(8)
Maximum	6.5	4908	3902	2220	1220	120	2150	4130
Minimum	6.0	3140	2010	760	920	9	1450	3300
Average	6.2	3983	2894	1560	1100	80	1820	3740
GEORGIA KRAFT								
No. Data Points	(9)	(9)	(8)	(9)	(4)	(9)	(8)	(8)
Maximum	10.4	1272	624	140	58	2.5	580	1200
Minimum	10.0	824	478	35	20	0.9	260	780
Average	10.2	1058	540	91	41	1.9	420	980
CITY OF MACON								
No. Data Points	(9)	(9)	(8)	(9)	(3)	(9)	(8)	(8)
Maximum	7.5	780	482	210	160	8	310	420
Minimum	7.0	478	298	100	115	5	150	290
Average	7.2	624	380	168	140	6.2	240	360
July 8 - July 25 (18 Days)								
ARMSTRONG CORK								
No. Data Points	(12)	(12)	(12)	(12)	(5)	(12)	(12)	(12)
Maximum	7.2	4904	2810	2310	2310	120	2000	6050
Minimum	6.8	2420	1450	980	1080	30	1050	2420
Average	6.9	3624	2315	1700	1610	80	1450	3680
GEORGIA KRAFT								
No. Data Points	(12)	(12)	(12)	(12)	(4)	(12)	(12)	(12)
Maximum	9.9	1364	754	155	65	9	500	2000
Minimum	8.6	702	378	35	15	0.6	220	560
Average	9.7	1153	601	83	34	2.6	380	1170
CITY OF MACON								
No. Data Points	(12)	(12)	(12)	(12)	(4)	(12)	(12)	(12)
Maximum	7.6	726	380	275	230	10	290	410
Minimum	7.1	474	268	55	30	6.5	130	280
Average	7.3	590	325	196	140	7.4	190	370

PERIOD	pH	TOTAL SOLIDS mg/1	TOTAL VOL. SOLIDS mg/1	SUSP. SOLIDS mg/1	VOL. SUSP. SOLIDS mg/1	SETTLEABLE SOLIDS ml/1/hr	BOD mg/1	COD mg/1
Aug. 19 - Aug. 28 (10 Days)								
ARMSTRONG CORK		N O	F L O W S					
GEORGIA KRAFT								
No. Data Points	(7)	(7)	(6)	(6)	(0)	(7)	(7)	(7)
Maximum	10.2	1150	535	150		2.5	760	1690
Minimum	9.9	880	365	95		0.5	380	910
Average	10.0	1040	417	121		1.5	450	1110
CITY OF MACON								
No. Data Points	(5)	(5)	(4)	(5)	(0)	(5)	(5)	(5)
Maximum	7.7	722	482	190		9	200	410
Minimum	7.2	155	150	105		7	150	300
Average	7.4	498	268	146		8	180	370
Aug. 29 - Sept. 12 (15 Days)								
ARMSTRONG CORK		N O	F L O W S					
GEORGIA KRAFT								
No. Data Points	(5)	(5)	(5)	(5)	(1)	(5)	(5)	(5)
Maximum	10.2	1000	360	135	70	2.0	450	1340
Minimum	9.0	705	165	25	70	0.8	380	870
Average	9.5	890	274	74	70	1.6	410	1010
CITY OF MACON								
No. Data Points	(6)	(6)	(6)	(6)	(1)	(6)	(6)	(6)
Maximum	7.6	790	415	210	170	9	220	420
Minimum	7.2	350	120	100	170	4.5	160	380
Average	7.4	605	285	178	170	6.7	190	400

PERIOD	pH	TOTAL SOLIDS mg/l	TOTAL VOL. SOLIDS mg/l	SUSP. SOLIDS mg/l	VOL. SUSP. SOLIDS mg/l	SETTLEABLE SOLIDS ml/l/hr	BOD mg/l	COD mg/l
<u>Oct. 17 - Oct. 31</u> (15 Days)								
ARMSTRONG CORK								
No. Data Points	(11)	(11)	(11)	(10)	(10)	(11)	(11)	(11)
Maximum	7.3	9740	5855	6920	4740	180	2100	10320
Minimum	5.9	3830	3015	1240	1120	50	1400	4080
Average	6.7	6038	4093	3170	2160	120	1800	6380
GEORGIA KRAFT								
No. Data Points	(11)	(11)	(11)	(10)	(10)	(11)	(10)	(11)
Maximum	10.4	1545	690	140	78	1.5	580	1380
Minimum	9.5	890	200	40	10	0.1	310	910
Average	10.0	1124	404	89	34	0.7	410	1080
CITY OF MACON								
No. Data Points	(11)	(11)	(11)	(10)	(10)	(11)	(10)	(10)
Maximum	7.7	685	400	240	170	9.5	240	480
Minimum	7.3	480	205	140	90	5.5	160	360
Average	7.5	561	306	187	123	7.8	190	400
<u>Nov. 2 - Nov. 5</u> (4 Days)								
ARMSTRONG CORK								
No. Data Points	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Maximum	7.1	4025	2705	2040	1330	80	1650	3900
Minimum	6.0	3750	2600	1450	1090	50	850	3770
Average	6.6	3888	2653	1750	1210	65	1250	3840
GEORGIA KRAFT								
No. Data Points	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Maximum	9.9	1680	585	165	140	14	360	1420
Minimum	9.8	1190	505	160	55	0.7	240	1110
Average	9.8	1440	545	163	98	7.4	300	1270
CITY OF MACON		N O	F L O W S					

PERIOD	pH	TOTAL SOLIDS mg/l	TOTAL VOL. SOLIDS mg/l	SUSP. SOLIDS mg/l	VOL. SUSP. SOLIDS mg/l	SETTLEABLE SOLIDS ml/l/hr	BOD mg/l	COD mg/l
Nov. 6 - Nov. 21 (16 Days)								
ARMSTRONG CORK								
No. Data Points	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)
Maximum	7.0	8820	6040	2990	2440	140	1400	8720
Minimum	5.7	2615	1845	1210	900	50	850	2760
Average	6.3	4599	3396	2050	1420	90	1180	4640
GEORGIA KRAFT								
No. Data Points	(9)	(9)	(9)	(9)	(9)	(8)	(9)	(9)
Maximum	10.4	2130	870	555	280	10	520	2190
Minimum	7.8	570	385	80	40	5	200	370
Average	9.5	1465	585	250	140	8.2	350	1380
CITY OF MACON								
No. Data Points	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)
Maximum	7.7	680	410	215	180	10	250	450
Minimum	7.5	450	200	80	65	8.5	200	320
Average	7.6	580	310	174	136	9.5	230	390
Nov. 23 - Dec. 4 (12 Days)								
ARMSTRONG CORK								
No. Data Points	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(6)
Maximum	6.8	6000	4970	4490	2930	120	1650	6200
Minimum	6.0	2660	1880	980	820	50	920	3000
Average	6.3	4310	3130	2800	1920	80	1280	4250
GEORGIA KRAFT		NO	FLOWS					
CITY OF MACON								
No. Data Points	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(6)
Maximum	7.5	620	370	365	300	10	280	640
Minimum	7.2	490	220	155	95	7.5	160	360
Average	7.4	550	310	224	154	8.8	210	440

-B-

Primary Sedimentation
Influent

PERIOD	pH	TOTAL SOLIDS mg/1	TOTAL VOL. SOLIDS mg/1	SUSP. SOLIDS mg/1	VOL. SUSP. SOLIDS mg/1	SETTLEABLE SOLIDS ml/1/hr	BOD mg/1	COD mg/1
Apr. 15 - May 5 (21 Days)								
No. Data Points	(12)	(0)	(0)	(12)	(1)	(12)	(12)	(12)
Maximum	8.6			825	253	27	980	1550
Minimum	5.7			240	253	5	360	840
Average	6.8			529	253	17	612	1330
May 13 - May 18 (6 Days)								
No. Data Points	(3)	(0)	(0)	(3)	(0)	(4)	(3)	(3)
Maximum	7.8			800		60	900	2140
Minimum	6.9			255		18	460	950
Average	7.2			592		25	650	1660
May 19 - June 15 (28 Days)								
No. Data Points	(17)	(14)	(14)	(17)	(4)	(17)	(16)	(17)
Maximum	9.0	1812	1240	1410	420	32	820	1700
Minimum	6.5	1202	928	390	245	5.5	460	980
Average	7.7	1556	970	550	320	13.5	625	1425
June 16 - June 26 (11 Days)								
No. Data Points	(9)	(9)	(8)	(9)	(3)	(9)	(8)	(8)
Maximum	9.5	1694	1144	855	440	16.0	720	1730
Minimum	7.5	1310	980	240	285	7.0	440	1210
Average	8.2	1522	1056	477	346	11.3	635	1580

PERIOD	pH	TOTAL SOLIDS mg/1	TOTAL VOL. SOLIDS mg/1	SUSP. SOLIDS mg/1	VOL. SUSP. SOLIDS mg/1	SETTLEABLE SOLIDS ml/1/hr	BOD mg/1	COD mg/1
<u>July 8 - July 25</u> (18 Days)								
No. Data Points	(12)	(12)	(12)	(12)	(4)	(12)	(12)	(12)
Maximum	7.6	2006	1278	755	345	31	720	2250
Minimum	6.9	1244	682	255	190	7	300	1110
Average	7.3	1541	980	496	260	15.5	508	1450
<u>Aug. 19 - Aug. 28</u> (10 Days)								
No. Data Points	(7)	(7)	(6)	(6)	(0)	(7)	(7)	(7)
Maximum	10.2	1150	535	175		20	680	1660
Minimum	9.8	880	365	95		0.5	370	910
Average	9.9	1033	419	129		8.6	430	1080
<u>Aug. 29 - Sept. 12</u> (15 Days)								
No. Data Points	(5)	(5)	(5)	(5)	(1)	(5)	(5)	(5)
Maximum	10.2	1000	360	135	70	20	450	1340
Minimum	9.0	705	165	60	70	0.8	390	870
Average	9.5	894	274	74	70	5.2	416	1260

OCTOBER 17 UNTIL END OF STUDY, ONLY ARMSTRONG SETTLED

Primary Sedimentation Effluent

PERIOD	pH	TOTAL SOLIDS mg/1	TOTAL VOL. SOLIDS mg/1	SUSP. SOLIDS mg/1	VOL. SUSP. SOLIDS mg/1	SETTLEABLE SOLIDS ml/1/hr	BOD mg/1	COD mg/1
Apr. 15 - May 5 (21 Days)								
No. Data Points	(12)	(6)	(6)	(12)	(1)	(12)	(12)	(12)
Maximum	7.2	1800	1204	580	133	31	800	1380
Minimum	6.0	1288	666	135	133	2	360	590
Average	6.5	1440	885	304	133	7.1	540	1010
May 13 - May 18 (6 Days)								
No. Data Points	(4)	(4)	(4)	(4)	(0)	(4)	(4)	(4)
Maximum	6.7	1810	988	1120		80	1000	2100
Minimum	5.8	772	384	65		1	320	600
Average	6.2	1271	739	454		28	600	1290
May 19 - June 15 (28 Days)								
No. Data Points	(17)	(17)	(17)	(17)	(4)	(17)	(16)	(17)
Maximum	7.5	1980	1042	1005	170	28	960	1560
Minimum	6.0	822	772	135	75	0.5	460	980
Average	6.9	1396	843	347	104	3.5	550	1340
June 16 - June 26 (11 Days)								
No. Data Points	(9)	(9)	(8)	(9)	(4)	(8)	(9)	(9)
Maximum	8.1	1514	1080	330	125	2.5	640	1180
Minimum	7.2	1040	704	85	90	0.8	480	980
Average	7.6	1264	903	182	110	1.4	648	1080

PERIOD	pH	TOTAL SOLIDS mg/l	TOTAL VOL. SOLIDS mg/l	SUSP. SOLIDS mg/l	VOL. SUSP. SOLIDS mg/l	SETTLEABLE SOLIDS ml/l/hr	BOD mg/l	COD mg/l
<u>July 8 - July 25</u> (18 Days)								
No. Data Points	(12)	(12)	(12)	(12)	(4)	(12)	(12)	(12)
Maximum	7.6	1572	970	320	225	3.0	600	1420
Minimum	6.4	780	622	70	45	0.5	360	740
Average	7.2	1271	813	187	108	1.6	480	1120
<u>Aug. 19 - Aug 28</u> (10 Days)								
No. Data Points	(7)	(7)	(6)	(6)	(0)	(7)	(7)	(7)
Maximum	9.8	1040	490	225		5.0	390	1010
Minimum	8.0	688	275	65		0	220	650
Average	8.8	832	330	114		2.7	310	850
<u>Aug. 29 - Sept. 12</u> (15 Days)								
No. Data Points	(6)	(6)	(6)	(5)	(1)	(6)	(6)	(6)
Maximum	8.4	815	380	120	45	8.0	390	990
Minimum	7.4	350	120	90	45	3.5	160	380
Average	7.7	643	262	106	45	4.8	310	640
<u>Oct. 17 - Oct. 31</u> (15 Days)								
No. Data Points	(11)	(11)	(11)	(10)	(10)	(11)	(10)	(11)
Maximum	9.9	1505	790	215	125	4.5	660	2000
Minimum	7.7	910	410	85	45	1.8	400	820
Average	8.4	1225	360	145	80	2.6	520	1150
<u>Nov. 2 - Nov. 5</u> (4 Days)								
No. Data Points	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Maximum	9.0	1730	1085	255	160	8.0	740	1480
Minimum	9.0	1550	825	95	65	1.4	400	1270
Average	9.0	1640	955	175	113	4.7	570	1375

PERIOD	pH	TOTAL SOLIDS mg/l	TOTAL VOL. SOLIDS mg/l	SUSP. SOLIDS mg/l	VOL. SUSP. SOLIDS mg/l	SETTLEABLE SOLIDS ml/l/hr	BOD mg/l	COD mg/l
<u>Nov. 6 - Nov. 21</u> (16 Days)								
No. Data Points	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)
Maximum	9.3	2290	1110	280	300	8.0	580	7080
Minimum	7.0	1000	590	115	85	3.0	320	880
Average	8.0	1470	775	222	146	5.6	470	1880
<u>Nov. 23 - Dec. 4</u> (12 Days)								
No. Data Points	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(6)
Maximum	7.0	2160	1440	675	280	5.0	1340	1680
Minimum	6.3	1060	700	110	85	3.0	460	560
Average	6.7	1430	980	321	219	4.6	690	1090

Primary Sedimentation Sludge Draw Off

PERIOD	GALLONS	% SOLIDS	% VOL. SOLIDS
April 15 - May 5 (21 Days)			
No. Data Points	(12)	(0)	(0)
Maximum	5000		
Minimum	2000		
Average	4500		
May 13 - May 18 (6 Days)			
No. Data Points	(4)	(1)	(1)
Maximum	9200	3	80
Minimum	7820	3	80
Average	8450	3	80
May 19 - June 15 (28 Days)			
No. Data Points	(27)	(2)	(2)
Maximum	8470	3.1	84
Minimum	4610	1.8	75
Average	6243	2.5	80
June 16 - June 26 (11 Days)			
No. Data Points	(11)	(1)	(1)
Maximum	6920	2.9	81
Minimum	4840	2.9	81
Average	5908	2.9	81
July 8 - July 25 (8 Days)			
No. Data Points	(18)	(0)	(0)
Maximum	9180		
Minimum	4070		
Average	5824		
Aug. 19 - Aug. 28 (10 Days)			
No. Data Points	(10)	(0)	(0)
Maximum	3800		
Minimum	2780		
Average	3115		

PERIOD	GALLONS	% SOLIDS	% VOL. SOLIDS
Aug. 29 - Sept. 12 (15 Days)			
No. Data Points	(15)	(0)	(0)
Maximum	4125		
Minimum	0		
Average	3163		
Oct. 17 - Oct. 31 (15 Days)			
No. Data Points	(15)	(0)	(0)
Maximum	19,290		
Minimum	11,200		
Average	15,311		
Nov. 2 - Nov. 5 (4 Days)			
No. Data Points	(4)	(0)	(0)
Maximum	12,800		
Minimum	11,800		
Average	12,150		
Nov. 6 - Nov. 21 (16 Days)			
No. Data Points	(16)	(0)	(0)
Maximum	18,200		
Minimum	9,800		
Average	11,140		
Nov. 23 - Dec. 4 (12 Days)			
No. Data Points	(12)	(0)	(0)
Maximum	10,200		
Minimum	9,600		
Average	9,850		

Plant No. 1 - Large Unit

PERIOD	MIXED LIQUOR DETENTION TIME HRS.	SUSPENDED SOLIDS mg/1	VOL. SUSP. SOLIDS mg/1	SETTLEABLE SOLIDS ml/1/hr	pH	DISSOLVED OXYGEN mg/1	TEMP. °F
Apr. 15 - May 5 (21 Days)							
No. Data Points	(21)	(12)	(1)	(20)	(17)	(20)	
Maximum	24	2680	235	990	7.7	7.4	
Minimum	24	250	235	22	7.0	3.8	
Average	24	1490	235	406	7.3	5.3	
May 13 - May 18 (6 Days)							
No. Data Points	(6)	(4)	(0)	(6)	(6)	(6)	
Maximum	24	2220		690	7.6	6.9	72
Minimum	24	1720		550	7.3	5.4	61
Average	24	1860		620	7.4	5.8	70
May 19 - June 15 (25 Days)							
No. Data Points	(25)	(12)	(5)	(25)	(18)	(23)	
Maximum	30	3440	2480	850	7.6	4.9	78
Minimum	30	2020	1560	400	7.3	1.8	70
Average	30	2720	2190	640	7.4	3.6	
June 16 - June 26 (11 Days)							
No. Data Points	(11)	(9)	(3)	(11)	(9)	(9)	
Maximum	30	5400	3540	880	7.5	2.0	84
Minimum	30	3620	2920	820	7.4	1.4	76
Average	30	4320	3290	860	7.5	1.7	

(PLANT NO. 1 - LARGE UNIT) MIXED LIQUOR

PERIOD	DETENTION TIME HRS.	SUSPENDED SOLIDS mg/l	VOL. SUSP. SOLIDS mg/l	SETTLEABLE SOLIDS ml/l/hr	pH	DISSOLVED OXYGEN mg/l	TEMP. °F
July 8 - July 25 (18 Days)							
No. Data Points	(18)	(10)	(5)	(18)	(11)	(18)	
Maximum	24	4480	3600	710	7.5	1.2	84
Minimum	24	3240	2660	310	7.5	5.1	78
Average	24	3860	3130	490	7.5	2.7	
Aug. 19 - Aug. 28			NOT IN OPERATION				
Aug. 29 - Sept. 12 (15 Days)							
No. Data Points	(15)	(3)	(2)	(15)	(7)	(15)	
Maximum	30	910	710	150	8.0	8.0	82
Minimum	30	590	470	11	7.6	4.2	68
Average	30	750	590	64	7.7	5.7	
Oct. 17 - Oct. 31 (15 Days)							
No. Data Points	(15)	(2)	(2)	(15)	(4)	(14)	
Maximum	19.2	4910	3610	860	7.5	2.4	77
Minimum	19.2	4150	3320	750	7.5	0.8	62
Average	19.2	4530	3470	830	7.5	2.3	
Nov. 2 - Nov. 5 (4 Days)							
No. Data Points	(4)	(1)	(1)	(4)	(1)	(4)	
Maximum	30	5780	4800	800	7.6	6.0	74
Minimum	30	5780	4800	700	7.6	0.5	60
Average	30	5780	4800	740	7.6	3.2	

(PLANT NO. 1 - LARGE UNIT) MIXED LIQUOR

PERIOD	DETENTION TIME HRS.	SUSPENDED SOLIDS mg/1	VOL. SUSP. SOLIDS mg/1	SETTLEABLE SOLIDS ml/1/hr	pH	DISSOLVED OXYGEN mg/1	TEMP. °F
Nov. 6 - Nov. 21 (16 Days)							
No. Data Points	(16)	(3)	(3)	(16)	(15)	(15)	
Maximum	24	5260	4320	880	7.8	8.7	65
Minimum	24	4950	3860	680	7.3	5.3	56
Average	24	5100	4010	795	7.6	7.2	61
Nov. 23 - Dec. 4	NOT IN OPERATION						

(PLANT NO. 1 - LARGE UNIT) FINAL SETTLING TANK EFFLUENT

PERIOD	TOTAL SOLIDS mg/l	TOTAL VOL. SOLIDS mg/l	SUSPENDED SOLIDS mg/l	VOL. SUSP. SOLIDS mg/l	SETTLEABLE SOLIDS ml/l/hr	BOD 5 DAY, 20°C mg/l	COD mg/l	pH
Apr. 15 - May 5 (21 Days)								
No. Data Points	(9)	(9)	(12)	(1)	(12)	(12)	(12)	(13)
Maximum	1946	1356	1980	30	500	540	1310	7.7
Minimum	930	248	90	30	3	100	560	7.1
Average	1351	752	587	30	99	230	900	7.4
May 13 - May 18 (6 Days)								
No. Data Points	(4)	(4)	(4)	(0)	(4)	(4)	(4)	(4)
Maximum	2962	1800	2000		850	310	2420	7.5
Minimum	754	302	45		0	50	360	7.8
Average	1338	716	734		214	160	1020	7.7
May 19 - June 15 (25 Days)								
No. Data Points	(15)	(15)	(15)	(5)	(15)	(15)	(15)	(16)
Maximum	1106	506	265	90	5	100	550	8.1
Minimum	738	322	30	0	0	20	310	7.6
Average	900	430	120	45	0.6	53	430	8.0
June 16 - June 26 (11 Days)								
No. Data Points	(9)	(8)	(9)	(4)	(9)	(9)	(9)	(9)
Maximum	1198	520	120	55	1.6	50	460	8.1
Minimum	790	420	30	20	0	30	350	8.0
Average	963	460	64	31	0.6	40	390	8.0
July 8 - July 25 (18 Days)								
No. Data Points	(10)	(10)	(10)	(4)	(10)	(10)	(10)	(10)
Maximum	1322	684	515	245	45	60	670	8.2
Minimum	588	292	20	190	0.9	10	310	7.9
Average	1028	485	171	128	6.4	33	440	8.1

(PLANT NO. 1 - LARGE UNIT) FINAL SETTLING TANK EFFLUENT

PERIOD	TOTAL SOLIDS mg/l	TOTAL VOL. SOLIDS mg/l	SUSPENDED SOLIDS mg/l	VOL. SUSP. SOLIDS mg/l	SETTLEABLE SOLIDS ml/l/hr	BOD 5 DAY, 20°C mg/l	COD mg/l	pH
Aug. 19 - Aug. 28			NOT IN OPERATION					
Aug. 29 - Sept. 12 (15 Days)								
No. Data Points	(5)	(5)	(4)	(1)	(5)	(5)	(5)	(5)
Maximum	825	350	160	150	0	90	500	8.0
Minimum	300	95	20	150	0	20	220	7.9
Average	580	255	70	150	0	50	350	8.0
Oct. 17 - Oct. 31 (15 Days)								
No. Data Points	(11)	(11)	(10)	(10)	(11)	(10)	(11)	(11)
Maximum	1525	725	585	460	55	120	850	8.3
Minimum	600	275	50	28	0	24	200	8.1
Average	1021	438	235	166	17	65	490	8.2
Nov. 2 - Nov. 5 (4 Days)								
No. Data Points	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Maximum	1580	795	560	460	48	290	980	8.2
Minimum	1115	530	300	190	40	130	910	8.2
Average	1348	663	430	330	44	210	950	8.2
Nov. 6 - Nov. 21 (16 Days)								
No. Data Points	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)
Maximum	1120	680	290	100	18	70	810	8.3
Minimum	770	200	80	40	0.2	20	290	7.9
Average	950	390	143	73	4.6	40	470	8.1
Nov. 23 - Dec. 4			NOT IN OPERATION					

PERIOD	(PLANT NO. 1 - LARGE UNIT) SLUDGE				
	RETURN SLUDGE G.P.M.	SETT. SOLIDS RETURN SLUDGE ml/l/hr	SLUDGE WASTED GALLONS	SLUDGE WASTED % SOLIDS	SLUDGE WASTED % VOL. SOL.
Apr. 15 - May 5 (21 Days)					
No. Data Points	(20)	(19)	(21)	(0)	(0)
Maximum	64	1000	29000		
Minimum	64	80	0		
Average	64	700	3270		
May 13 - May 18 (6 Days)					
No. Data Points	(6)	(6)	(6)	(1)	(1)
Maximum	64	980	14300	3	70
Minimum	64	830	4500	3	70
Average	64	930	9400	3	70
May 19 - June 15 (25 Days)					
No. Data Points	(25)	(25)	(25)	(3)	(3)
Maximum	64	990	5400	1.5	80
Minimum	58	970	0	1.0	75
Average	63	980	1300	1.2	83
June 16 - June 26 (11 Days)					
No. Data Points	(11)	(11)	(11)	(1)	(1)
Maximum	58	1000	1800	3.0	87
Minimum	58	990	0	3.0	87
Average	58	1000	160	3.0	87
July 8 - July 25 (18 Days)					
No. Data Points	(18)	(18)	(18)	(3)	(3)
Maximum	42	990	5500	3.6	77
Minimum	36	530	0	2.1	66
Average	42	960	1360	2.7	73

(PLANT NO. 1 - LARGE UNIT) SLUDGE

PERIOD	RETURN SLUDGE G.P.M.	SETT. SOLIDS RETURN SLUDGE ml/1/hr	SLUDGE WASTED GALLONS	SLUDGE WASTED % SOLIDS	SLUDGE WASTED % VOL. SOL.
Aug. 19 - Aug. 28			NOT IN OPERATION		
Aug. 29 - Sept. 12 (15 Days)					
No. Data Points	(15)	(12)	(12)	(0)	(0)
Maximum	48	420	0		
Minimum	48	60	0		
Average	48	160	0		
Oct. 17 - Oct. 31 (15 Days)					
No. Data Points	(15)	(15)	(15)	(0)	(0)
Maximum	48	990	1900		
Minimum	48	980	0		
Average	48	990	220		
Nov. 2 - Nov. 5 (4 Days)					
No. Data Points	(4)	(4)	(4)	(1)	(1)
Maximum	48	990	3000	1.9	80
Minimum	48	980	1000	1.9	80
Average	48	990	1750	1.9	80
Nov. 6 - Nov. 21 (16 Days)					
No. Data Points	(16)	(16)	(16)	(4)	(4)
Maximum	48	990	2000	1.8	80
Minimum	48	980	0	1.2	78
Average	48	990	890	1.5	79
Nov. 23 - Dec. 4			NOT IN OPERATION		

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Plant No. 2 - Small Unit

MIXED LIQUOR AND MIXED LIQUOR RETURN TO FILTER

PERIOD	DETENTION TIME HRS.	SUSPENDED SOLIDS mg/1	VOL. SUSP. SOLIDS mg/1	SETT. SOLIDS ml/1/hr	pH	DISSOLVED OXYGEN mg/1	MIXED LIQ. RETURN G.P.M.	TEMP. °F
Apr. 15 - May 5 (21 Days)								
No. Data Points	(21)	(13)	(1)	(19)	(17)	(20)	(20)	
Maximum	12	2820	695	980	7.4	6.8	10	
Minimum	12	730	695	50	6.8	1.4	10	
Average	12	1960	695	480	7.1	3.4	10	
May 13 - May 18 (6 Days)								
No. Data Points	(6)	(4)	(0)	(6)	(6)	(6)	(6)	
Maximum	12	3460		690	7.6	3.5	10	74
Minimum	12	1960		400	6.9	2.0	10	63
Average	12	2570		530	7.3	2.5	10	69
May 19 - June 15 (28 Days)								
No. Data Points	(28)	(14)	(4)	(27)	(21)	(26)	(26)	
Maximum	15	4620	3540	920	7.6	2.4	10	82
Minimum	15	2220	2600	500	7.1	0.6	10	70
Average	15	3780	3230	660	7.4	1.6	10	76
June 16 - June 26 (11 Days)								
No. Data Points	(11)	(9)	(3)	(11)	(9)	(9)	(11)	
Maximum	15	5240	4380	840	7.5	1.5	10	87
Minimum	15	4000	3960	550	7.3	0.6	10	76
Average	15	4900	4110	675	7.4	1.1	10	80

(PLANT NO. 2 - SMALL UNIT) MIXED LIQUOR AND MIXED LIQUOR RETURN TO FILTER

PERIOD	DETENTION TIME HRS.	SUSPENDED SOLIDS mg/l	VOL. SUSP. SOLIDS mg/l	SETT. SOLIDS ml/l/hr	pH	DISSOLVED OXYGEN mg/l	MIXED LIQ. RETURN G.P.M.	TEMP. °F
July 8 - July 25 (18 Days)								
No. Data Points	(18)	(12)	(4)	(18)	(10)	(18)	(18)	
Maximum	12	3100	2660	600	7.6	3.2	10	85
Minimum	12	2000	1620	220	7.5	0.6	10	78
Average	12	2450	2130	350	7.6	1.1	10	80
Aug. 19 - Aug. 28 (10 Days)								
No. Data Points	(10)	(3)	(0)	(10)	(9)	(10)	(10)	
Maximum	18.8	4600		910	7.5	1.8	10	83
Minimum	18.8	3400		850	7.3	1.6	10	70
Average	18.8	4100		885	7.4	1.7	10	77
Aug. 29 - Sept. 12 (15 Days)								
No. Data Points	(15)	(3)	(2)	(15)	(6)	(15)	(15)	
Maximum	18.8	5070	4120	940	7.5	6.0	10	83
Minimum	18.8	4360	3760	910	7.2	1.1	10	68
Average	18.8	4750	3940	930	7.3	2.5	10	76
Oct. 17 - Oct. 31 (15 Days)								
No. Data Points	(15)	(1)	(1)	(15)	(3)	(14)	(15)	
Maximum	12	5320	4110	960	7.6	4.1	10	78
Minimum	12	5320	4110	930	7.5	0.8	10	62
Average	12	5320	4110	950	7.5	2.5	10	68
Nov. 2 - Nov. 5 (4 Days)								
No. Data Points	(4)	(1)	(1)	(4)	(1)	(4)	(4)	
Maximum	18.8	4910	3990	960	7.7	3.2	10	74
Minimum	18.8	4910	3990	940	7.7	0.8	10	60
Average	18.8	4910	3990	953	7.7	2.5	10	66

(PLANT NO. 2 - SMALL UNIT) MIXED LIQUOR AND MIXED LIQUOR RETURN TO FILTER

PERIOD	DETENTION TIME HRS.	SUSPENDED SOLIDS mg/1	VOL. SUSP. SOLIDS mg/1	SETT. SOLIDS ml/1/hr	pH	DISSOLVED OXYGEN mg/1	MIXED LIQ. RETURN G.P.M.	TEMP. °F
Nov. 6 - Nov. 21 (16 Days)								
No. Data Points	(16)	(4)	(3)	(16)	(5)	(15)	(16)	
Maximum	15	5660	4370	980	7.8	8.4	10	67
Minimum	15	4350	3440	950	7.3	3.2	10	48
Average	15	4932	3890	970	7.6	6.8	10	57
Nov. 23 - Dec. 4 (12 Days)								
No. Data Points	(12)	(2)	(3)	(12)	(5)	(10)	(12)	
Maximum	18.8	5670	4730	980	7.6	8.9	10	
Minimum	18.8	5320	4550	940	7.2	4.9	10	
Average	18.8	5495	4640	963	7.4	6.9	10	

(PLANT NO. 2 - SMALL UNIT) FINAL SETTLING TANK EFFLUENT

PERIOD	TOTAL SOLIDS mg/l	TOTAL VOL. SOLIDS mg/l	SUSPENDED SOLIDS mg/l	VOL. SUSP. SOLIDS mg/l	SETTLEABLE SOLIDS ml/l/hr	BOD 5 DAY, 20°C mg/l	COD mg/l	pH
Apr. 15 - May 5 (21 Days)								
No. Data Points	(9)	(9)	(12)	(1)	(12)	(12)	(12)	(13)
Maximum	1278	720	580	25	2.0	380	1240	7.6
Minimum	890	450	35	25	0.2	100	380	6.9
Average	1065	556	305	25	5.4	210	790	7.3
May 13 - May 18 (6 Days)								
No. Data Points	(4)	(4)	(4)	(0)	(4)	(4)	(4)	(4)
Maximum	1030	514	200		7.0	100	950	7.6
Minimum	680	238	40		0.0	50	400	7.4
Average	804	369	120		3.2	80	620	7.5
May 19 - June 15 (28 Days)								
No. Data Points	(17)	(17)	(17)	(5)	(17)	(15)	(17)	(18)
Maximum	1210	574	375	160	0.9	110	700	8.0
Minimum	748	364	85	30	0.0	50	320	7.6
Average	931	469	225	76	0.3	60	545	7.9
June 16 - June 26 (11 Days)								
No. Data Points	(9)	(8)	(9)	(4)	(9)	(9)	(9)	(9)
Maximum	1224	702	275	130	6.0	90	760	8.0
Minimum	840	488	105	55	0.0	50	470	8.0
Average	1038	557	158	95	0.3	70	539	8.0
July 8 - July 25 (18 Days)								
No. Data Points	(12)	(12)	(12)	(14)	(12)	(12)	(12)	(12)
Maximum	1308	704	195	95	8.0	50	620	8.2
Minimum	708	312	35	25	0.1	40	350	8.0
Average	951	524	167	51	1.0	44	480	8.1

(PLANT NO. 2 - SMALL UNIT) FINAL SETTLING TANK EFFLUENT

PERIOD	TOTAL SOLIDS mg/1	TOTAL VOL. SOLIDS mg/1	SUSPENDED SOLIDS mg/1	VOL. SUSP. SOLIDS mg/1	SETTLEABLE SOLIDS ml/1/hr	BOD 5 DAY, 20°C mg/1	COD mg/1	pH
Aug. 19 - Aug. 28 (10 Days)								
No. Data Points	(7)	(6)	(6)	(0)	(7)	(7)	(7)	(8)
Maximum	888	360	58		0.1	45	400	8.3
Minimum	100	20	25		0.0	10	280	8.0
Average	661	227	40		0.0	24	320	8.1
Aug. 29 - Sept. 12 (15 Days)								
No. Data Points	(6)	(6)	(5)	(1)	(6)	(6)	(6)	(6)
Maximum	700	700	75	65	0.0	40	280	8.1
Minimum	455	130	30	65	0.0	0	150	7.8
Average	575	297	56	65	0.0	24	200	7.1
Oct. 17 - Oct. 31 (15 Days)								
No. Data Points	(11)	(11)	(10)	(10)	(11)	(10)	(11)	(11)
Maximum	1325	615	420	300	60	125	780	8.2
Minimum	500	190	22	0	0.0	15	180	8.0
Average	978	402	160	100	18	54	454	8.1
Nov. 2 - Nov. 5 (4 Days)								
No. Data Points	(2)	(2)	(2)	(2)	(2)	(2)	(2)	
Maximum	1275	905	75	55	0.0	25	490	
Minimum	605	290	60	38	0.0	20	360	
Average	980	348	68	47	0.0	23	400	
Nov. 6 - Nov. 21 (16 Days)								
No. Data Points	(9)	(9)	(9)	(9)	(9)	(9)	(9)	
Maximum	1400	700	210	120	40	110	840	
Minimum	755	195	50	25	0.0	15	200	
Average	1010	411	102	54	11	49	498	

(PLANT NO. 2 - SMALL UNIT) FINAL SETTLING TANK EFFLUENT

PERIOD	TOTAL SOLIDS mg/l	TOTAL VOL. SOLIDS mg/l	SUSPENDED SOLIDS mg/l	VOL. SUSP. SOLIDS mg/l	SETTLEABLE SOLIDS ml/l/hr	BOD 5 DAY, 20°C mg/l	COD mg/l	pH
Nov. 23 - Dec. 4 (12 Days)								
No. Data Points	(7)	(7)	(7)	(7)	(7)	(7)	(6)	
Maximum	1280	780	260	99	2.5	140	780	
Minimum	490	200	50	28	0.0	30	180	
Average	773	456	116	51	0.4	71	220	

(PLANT NO. 2 - SMALL UNIT) SLUDGE

PERIOD	RETURN SLUDGE G.P.M.	SETT. SOLIDS RETURN SLUDGE ml/1/hr	SLUDGE WASTED GALLONS	SLUDGE WASTED % SOLIDS	SLUDGE WASTED % VOL. SOLIDS
Nov. 2 - Nov. 5 (4 Days)					
No. Data Points	(4)	(4)	(4)	(1)	(1)
Maximum	42	990	1000	1.7	78
Minimum	42	990	0	1.7	78
Average	42	990	250	1.7	78
Nov. 6 - Nov. 21 (16 Days)					
No. Data Points	(16)	(16)	(16)	(4)	(4)
Maximum	42	990	3200	1.8	82
Minimum	36	970	0	1.1	79
Average	41	987	950	1.5	80
Nov. 23 - Dec. 4 (12 Days)					
No. Data Points	(12)	(12)	(12)	(1)	(1)
Maximum	36	990	3000	1.8	80
Minimum	36	980	0	1.8	80
Average	36	990	670	1.8	80
Apr. 15 - May 5 (21 Days)					
No. Data Points	(20)	(19)	(20)	(0)	(0)
Maximum	42	1000	11000		
Minimum	42	175	0		
Average	42	765	940		
May 13 - May 18 (6 Days)					
No. Data Points	(6)	(6)	(6)	(1)	(1)
Maximum	42	980	11400	3	72
Minimum	42	690	0	3	72
Average	42	930	4350	3	72

(PLANT NO. 2 - SMALL UNIT) SLUDGE

PERIOD	RETURN SLUDGE G.P.M.	SETT. SOLIDS RETURN SLUDGE ml/1/hr	SLUDGE WASTED GALLONS	SLUDGE WASTED % SOLIDS	SLUDGE WASTED % VOL. SOLIDS
May 19 - June 15 (28 Days)					
No. Data Points	(28)	(28)	(28)	(2)	(2)
Maximum	42	1000	2400	1	100
Minimum	42	850	0	0.4	74
Average	42	970	350	0.7	87
June 16 - June 26 (11 Days)					
No. Data Points	(11)	(11)	(11)	(1)	(1)
Maximum	42	1000	3600	3	87
Minimum	42	1000	0	3	87
Average	42	1000	150	3	87
July 8 - July 25 (18 Days)					
No. Data Points	(18)	(16)	(18)	(2)	(2)
Maximum	36	990	5400	4.5	100
Minimum	36	600	0	1.7	93
Average	36	880	2090	3.1	97
Aug. 19 - Aug. 28 (10 Days)					
No. Data Points	(10)	(10)	(10)	(1)	(1)
Maximum	42	990	3000	1	77
Minimum	42	980	0	1	77
Average	42	975	300	1	77
Aug. 29 - Sept. 12 (15 Days)					
No. Data Points	(15)	(15)	(15)	(0)	(0)
Maximum	42	990	0		
Minimum	42	980	0		
Average	42	990	0		

(PLANT NO. 2 - SMALL UNIT) SLUDGE

PERIOD	RETURN SLUDGE G.P.M.	SETT. SOLIDS RETURN SLUDGE ml/1/hr	SLUDGE WASTED GALLONS	SLUDGE WASTED % SOLIDS	SLUDGE WASTED % VOL. SOLIDS
Oct. 17 - Oct. 31 (15 Days)					
No. Data Points	(15)	(15)	(15)	(0)	(0)
Maximum	42	1000	4000		
Minimum	42	980	0		
Average	42	990	267		

APPENDIX III

Summary of Bacteriological Study of Waste Water and Wood Pulp Samples

One sample each of mill waste, mill effluent, and wood pulp were obtained by Dr. R. S. Ingols from the mill of Armstrong Cork Company, Macon, Georgia. Bacteriological analysis of these samples was initiated within 48 hours after their delivery to the laboratory.

Design of the analysis was to provide more definitive information on the aerobic and facultative anaerobic bacteria in these samples showing fermentation in lactose broth. The specific question was whether another genus would give positive results with the *Standard Methods* procedure for faecal *Escherichia coli*.

In the limited time available for the study selected differential culture methods were used to isolate *E. coli* and lactose-positive bacteria. A total of twenty-five (25) bacteria from among the mill samples submitted were isolated by the culture methods indicated in Table 1. In addition to bacterial colonies showing lactose fermentation on primary differential media certain colonies were selected on the basis of appearance and subsequent Gram reaction as suspected coliform organisms. With the exception of Isolate #1 the reaction of these isolates in lactose fermentation broth (Durham tubes) is shown in Table 2. All isolates fermenting lactose with the formation of gas were Gram-negative bacilli; all other bacteria among the 25 isolates were also Gram-negative bacilli.

The influence of mixed-bacterial populations on results obtained in the lactose broth test for coliforms is suggested by the results shown in Table 3. Suppression of the lactose-positive bacteria apparently occurred in two out of the three samples tested in lactose broth. Lactose broth, therefore, does not appear to be a reliable first or presumptive test for the presence of coliform bacteria in these mill samples; the number of false negative reaction could be expected to be high.

A direct cultural examination of the mill samples for the presence of faecal *Escherichia coli* was made by inoculation of the samples into E-C medium (Difco) at 45.5C. All three samples produced growth and gas formation within 72 hours (Table 4) as a positive test.

Individual bacterial cultures isolated from the mill samples were also tested in the E-C medium at 45.5C; also tested were mixed cultures of selected isolates. Isolates Nos. 21, 23, 24, and 15 produced growth and gas formation in mixed as well as in pure culture, indicating that in the limited reconstituted systems over-growth of cultures suppressing development of gas-forming organisms did not occur.

Other organisms included in the original twenty-five (25) isolates from mill samples fermenting lactose with gas formation were tested in the E-C medium at 45.5C. Only two (2) additional isolates (os. 16 and 25) produced growth under this condition but did not produce gas (Table 7).

Since the immediate objective of this study was to examine the mill waste samples for the identity of the lactose positive samples as possibly E. coli, control cultures of a number of members of the Enterobacteriaceae were tested in the E-C medium at 45.5C. Only one genus -- Klebsiella-produced growth and gas; Escherichia coli, Citrobacter sp., Proteus mirabilis, and Providencia stuartii produced growth but no gas; Enterobacter cloacae and E. aerogenes showed marginal growth only (Table 6).

Similarly, parallel biochemical tests were done with control cultures of Enterobacteriaceae and lactose-positive isolates from mill waste to determine the degree of affinity between the two sets of bacterial cultures. The tentative identification of the mill waste isolates is based exclusively on a comparison of these cultures with those in the control group. Hence, the identification is actually a 'most like' affinity of the unknown to a particular genus in the control group, members of this group, particularly E. coli, being the organisms of specific interest in terms of the disposal requirements for the mill waste.

Results of the biochemical tests for both groups are in Table 7 (mill isolates) and Table 8 (control group). A presumptive grouping of the mill isolates according to their affinity to a particular genus in the control group is contained in Tables 9 and 10.

One isolate - No. 15, mill effluent-appears to be Escherichia coli; the majority showing greater similarity to the Klebsiella-Enterobacter genera. The 'most like' affinity basis for these identifications are emphasized. Positive identification of the isolates will require more detailed studies.

Several results were obtained from this limited study that indicate a direct relevancy to the examination of wastes from wood processing. The IMViC (indole, methyl red, Voges-Proskauer, citrate) reactions and reaction on cellobiose might be a presumptive test group for lactose-positive isolates suspected as being E. coli. More extensive testing of different strains of E. coli and Proteus sp. will be necessary to prove the validity of this hypothesis.

Another result of significance is the positive test by Klebsiella in the E-C medium at 45.5C, a source of possible confusion with fecal E. coli. Also, Proteus mirabilis and P. stuartii, like E. coli in the control group, produced growth but no gas. Recognizing the strict requirement for control of temperature in the performance of this test, further inquiry should be made into the confirmation of these findings.

Further, the primary screening of wood waste-water for the presence of lactose fermenting bacteria should be studied in brilliant green bile broth rather than plain lactose broth to avoid false negative results, apparently due to over-growth of populations suppressing the lactose-positive bacteria.

Submitted by

Edward L. Fincher,
Consultant

TABLE 1

Cultural Sources of Bacterial Isolates
From Waste Water and Sewage Samples

Bacterial Isolate	Primary Sample Source	Primary Culture Medium	Lactose Fermentation*
1	Mill Waste	Trypticase Soy Agar	-
2	(11/15/69)	" " "	+
3	"	" " "	-
4	"	" " "	+
5	"	" " "	-
6	"	Desoxycholate Agar	-
7	"	" "	+
8	"	" "	+
9	"	" "	-
10	Municipal Sewage	Eosin-Methylene Blue Agar	+
11	(11/15/69)	" " " "	+
12	"	" " " "	-
13	Mill Waste	" " " "	+
14	(11/15/69)	" " " "	+
15*	Mill Effluent	Desoxycholate Agar	+
16	(12/12/69)	" "	+
17	"	Brilliant Green Bile Broth	-
18	"	" " " "	+
19	"	" " " "	-
20	White Water	Desoxycholate Agar	+
21	(12/12/69)	" "	+
22	"	" "	-
23	"	" "	+
24	Pulp Waste	" "	+
25	(12/12/69)	" "	-

*Durham fermentation tube.

TABLE 2

Fermentation Tests - 35 C.

Isolate (AS)	Brilliant Green Bile Broth 18 Hrs.	Brilliant Green Bile Broth 36 Hrs.	Brilliant Green Bile Broth 54 Hrs.	Lactose Broth 18 Hrs.	Lactose Broth 36 Hrs.	Lactose Broth 54 Hrs.
2	+/-	+/15	+/25	+/-	+/9	+/15
3	+/-	+/-	+/-	+/-	+/-	+/-
4	+/-	+/-	+/8	+/-	+/3	+/8
5	+/-	+/-	+/-	+/-	+/-	+/-
6	+/-	+/-	+/-	+/-	+/-	+/-
7	+/-	+/-	+/-	+/-	+/-	+/6
8	+/-	+/-	+/10	+/-	+/9	+/20
9	+/-	+/-	+/-	+/-	+/-	+/-
10	+/-	+/-	+/-	+/-	+/-	+/2
11	+/3	+/12	+/12	+/-	+/5	+/5
12	+/-	+/-	+/-	+/-	+/-	+/-
13	+/1	+/38	+/38	+/7	+/20	+/20
14	+/-	+/6	+/9	+/-	+/4	+/10
15	+/5	+/10	+/10	+/3	+/13	+/9
16	+/2	+/6	+/12	+/-	+/-	+/3
17	+/-	+/-	+/-	+/-	+/-	+/-
18	+/-	+/-	+/4	+/-	+/3	+/8
19	+/-	+/-	+/-	+/-	+/-	+/-
20	+/10	+/50	+/40	+/4	+/15	+/17
21	+/-	+/17	+/18	+/-	+/2	+/7
22	-/-	-/-	-/-	-/-	+/-	+/-
23	+/-	+/14	+/14	+/-	+/2	+/8
24	+/-	+/25	+/25	+/-	+/12	+/12
25	-/-	-/-	-/-	-/-	+/-	+/-

Growth/No Gas (-) or quantity of gas in mm.

TABLE 3

Direct Inoculation of Waste Water Samples
Into Fermentation Media

Primary Sample Source	Inoc. Size	Brilliant Green Bile Broth 25C	Brilliant Green Bile Broth 35C	Lactose Broth 25C	Lactose Broth 35C
Mill Effluent	1 ml	+/9	+/45	+/2	+/4
White Water	1 ml	+/13	+/32	+/-	+/-
Pulp Waste	Loop	+/2	+/33	+/-	+/-

* * * * * *

TABLE 4

Direct Inoculation of Waste Water Samples
Into E-C Medium at 45.5C

Primary Sample Source	Inoculum Size	Incubation Time - Hours 24	48	72
Mill Effluent	Loop	+/-	+/-	+/-
" "	1 ml	+/25	+/25	+/26
White Water	Loop	+/1	+/4	+/4
" "	1 ml	+/-	+/13	+/13
Pulp Waste	Loop	+/-	+/7	+/8

+/ = Growth; /No. mm = Gas

TABLE 5

Growth and Gas Formation of Single and Recombined Bacterial Isolates in E-C Medium at 45.5C

Culture Number	Incubation Time - Hours		
	24	48	72
13/14/20/21/22/23	+/-	+/11	+/13
13	-/-	-/-	-/-
14	-/-	-/-	-/-
20	-/-	-/-	-/-
21	+/3	+/14	+/16
22	+/-	+/-	+/-
23	+/-	+/12	+/14
24/25	+/-	+/8	+/8
24	+/-	+/8	+/8
25	+/-	+/-	+/-
15/16/17/18/19	+/13	+/16	+/15
16/17/18/19	+/-	+/-	+/-
15	+/15	+/17	+/17
16	+/-	+/-	+/-
17	+/-	+/-	+/-
18	-/-	-/-	-/-
19	-/-	-/-	-/-

+/ = Growth; /No. mm = quantity of gas

Inoculum Source: trypticase soy broth (5 ml), 16 hrs., 33C.

Inoculum Size: 0.1 ml into 10 ml E-C medium

TABLE 6

Growth and Gas Formation of Selected *Enterobacteriaceae* in E-C Medium at 45.5C

Culture	Incubation Time - Hours 24	48	72
Escherichia coli	+/-	+/-	+/-
Citrobacter sp.	±/-	+/-	+/-
Enterobacter cloacae	±/-	±/-	±/-
Enterobacter aerogenes	±/-	±/-	±/-
Enterobacter hafniae	-/-	-/-	-/-
Enterobacter liquefaciens	-/-	-/-	-/-
Pectobacterium sp.	-/-	-/-	-/-
Proteus vulgaris	-/-	-/-	-/-
Proteus mirabilis	+/-	+/-	+/-
Proteus morganii	-/-	-/-	-/-
Proteus rettgeri	-/-	-/-	-/-
Providencia alcalifaciens	-/-	-/-	-/-
Providencia stuartii	+/-	+/-	+/-
Klebsiella sp.	+/-	+/6	+/6

+/ = Growth; /No. mm = Gas

Inoculum source: trypticase soy broth (5 ml), 16 hrs., 33C.

Inoculum size: 0.1 ml into 10 ml E-C medium

TABLE 7

Biochemical Reactions of Lactose-Positive Bacterial Isolates from Mill Waste Water and Municipal Sewage

	Biochemical Tests Mill Waste Water Isolates													Sewage	
	2	7	8	13	14	15	16	18	20	21	23	24	25	10	11
Indole	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Methyl Red	-	+	+	-	+	+	-	-	-	-	-	-	-	+	+
Voges-Pros.	+	-	-	+	-	-	+	+	+	+	+	+	-	-	-
Simmons Citrate	+	+	-	+	+	-	+	+	+	+	+	±	+	+	+
H_2S(SIM)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Urease	+	-	-	+	+	-	+	+	+	+	+	+	-	±	±
Motility	-	±	+	-	±	+	±	±	-	-	±	±	+	+	±
Gelatin	-	-	-	-	-	-	-	-	-	-	0	0	0	-	-
Lactose	+	+	+	+	+	+	+	+	+	+	+	+	+/NG	+	+
Sucrose	+	+	+	+	+	+	+	+	+/NG	+	+	+	0	+	+
Mannitol	+	+	+	+	+	+	+	+	+/NG	+	+	+	0	+	+
Inositol	+	-	-	+	+	-	+	+	+/NG	+/NG	+	+	0	+/NG	+/NG
Arabinose	+/NG	+/NG	-	+/NG	-	-	+/NG	+/NG	+/NG	+/NG	+/NG	+/NG	0	-	+/NG
Cellobiose	+	+	+	+	+	-	+	+	+/NG	+	+	+	0	+	-
E-C Medium-45.5C	-	-	-	-	-	+/G	+/NG	-	-	+/G	+/G	+/G	+/NG	-	-

+/ = growth /G = gas; /NG = no gas 0 = test not done

TABLE 8

Biochemical Reactions of Control Cultures of Selected Genera from *Enterobacteriaceae*

	Escherichia coli	*Citrobacter sp.*	*Enterobacter cloacae*	*Enterobacter aerogenes*	*Enterobacter hafniae*	*Enterobacter liquefaciens*	*Pectobacterium sp.*	*Proteus vulgaris*	*Proteus mirabilis*	*Proteus morganii*	*Proteus rettgeri*	*Providencia alcalifaciens*	*Providencia stuartii*	*Klebsiella sp.*
Indole	+	-	-	-	+	-	+	+	-	+	+	-	+	-
Methyl Red	+	+	-	-	+	+	-	+	+	+	+	+	+	-
Voges-Pros.	-	-	+	+	+	±	-	-	-	-	-	-	-	+
Simmons Citrate	-	+	+	+	-	+	+	-	-	-	+	+	+	+
H_2S(SIM)	-	+	±	-	-	-	-	+	+	+	-	-	-	-
Urease	-	+	+	-	-	±	-	+	+	+	+	-	-	+
Motility	+	+	+	+	+	d	+/-	+	+	+	+	+	+	-
Gelatin	-	-	-	-	-	+	+	+	+	-	-	-	-	-
Lactose	+	d	+	+	-/+	d	d	-	-	-	-	-	-	+
Sucrose	-	d	+	+	-	+	+	+	d	-	±/NG	d	d	+
Mannitol	+	+	+	+	+	+	+	-	-	-	+/NG	-	-	+
Inositol	-	-	+	+	-	+/NG	-	-	-	-	+/NG	-	-	+
Arabinose	+/NG	+	-	+/NG	+/NG	-	+/NG	+/NG	-	-	+/NG	-	-	+
Cellobiose	-	0	+	+	-	-	-	-	0	0	±/NG	0	0	+
E-C Medium-45.5C	+/NG	±/NG	-	±/NG	-	-	-	-	+/NG	-	-	-	+/NG	+/G

d = different biochemical types (+, (+), -) (+) delayed positive - Ewing
0 = test not done
+/- = majority positive } Ewing
-/+ = majority negative }

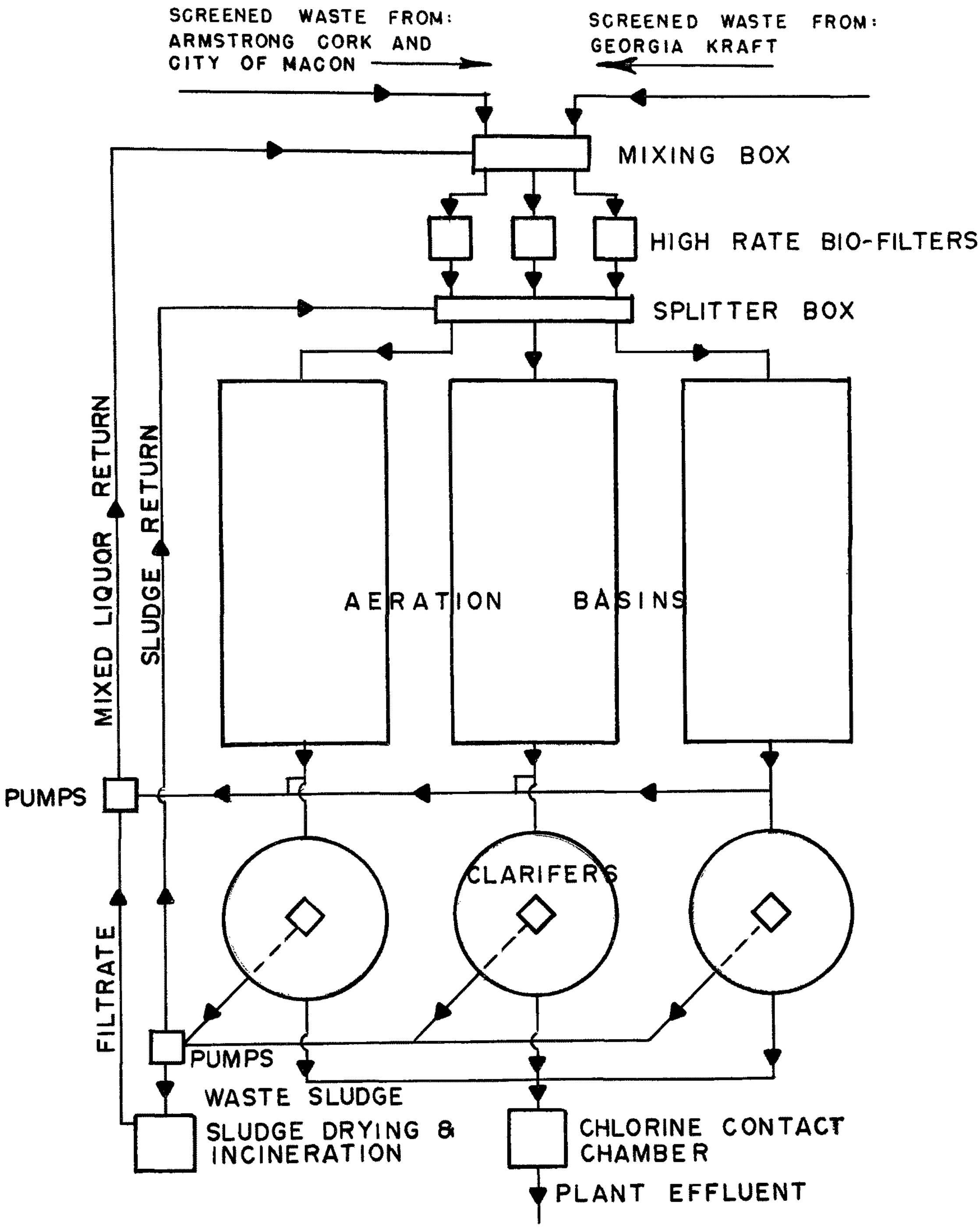
TABLE 9

Presumptive Grouping of Lactose-Positive Isolates

Isolate Number	Primary Source of Water Sample	Groups
15	Mill Effluent	Escherichia
10	Sewage	
11	Sewage	Citrobacter
14	Mill Waste	
2	Mill Waste	
13	Mill Waste	
16	Mill Effluent	
18	Mill Effluent	Klebsiella-Enterobacter
20	White Water	(Aerobacter)
21	White Water	
23	White Water	
24	Pulp Waste	
7	Mill Waste	Proteus-Providence
8	Mill Waste	Unknown
25	Pulp Waste	

TABLE 10

Isolate Number	Tentative Genera and Species Identification: Probable	Possible
15	Escherichia coli	--
10	--	Citrobacter-like
11	--	Citrobacter-like
14	--	Citrobacter-like
2	Klebsiella	Enterobacter cloacae
13	Enterobacter cloacae	Klebsiella
16	Klebsiella	Enterobacter aerogenes
18	Enterobacter cloacae	Klebsiella
20	Enterobacter cloacae	Klebsiella
21	Klebsiella	--
23	Klebsiella	--
24	Klebsiella	--
7	--	Providencia alcalifaciens-like
8	--	--
25	--	--



APPENDIX IV

FLOW DIAGRAM

JOINT TREATMENT FACILITY

1 Accession Number

2 Subject Field & Group

05D

SELECTED WATER RESOURCES ABSTRACTS
INPUT TRANSACTION FORM

5 Organization

Board of Water Commissioners
City of Macon
Macon, Georgia

6 Title

Combined Treatment of Municipal, Kraft Linerboard, and Fiberboard Manufacturing Wastes,

10 Author(s)

Clark, Edward A.
Goulding, Randolph
Ingols, Robert S.
Turner, Billy G.

16 Project Designation

EPA 11060DPD

21 Note

22 Citation

23 Descriptors (Starred First)

*Sewage Treatment, *Activated Sludge, *Pilot Plants, *Cost Sharing, *Chlorination, Municipal Wastes, Wood Wastes, Nutrient Requirements, Sludge, Biochemical Oxygen Demand, Cost Analysis, Aerobic Treatment, Filtration, Oxygen Requirements, Settling Basins, Sludge Disposal, Biological Treatment, Dewatering

25 Identifiers (Starred First)

*Mechanical Aeration, *High Rate Plastic Media Bio-Filter, *Combined Treatment, Shock Loads,

27 Abstract The successful treatment of prorated quantities of domestic waste and wastewater from an 850 ton-per-day kraft linerboard mill and a 600 ton-per-day groundwood-cold caustic fiberboard mill was obtained in a 120 gallon-per-minute pilot plant. The pilot plant consisted of combined and/or separate primary sedimentation followed by two parallel secondary treatment systems each of which received half of the plant influent. One secondary system consisted of twenty-four hours of aeration while the other consisted of a high rate plastic media bio-filter followed by fifteen hours of aeration. Both systems had secondary sedimentation and sludge return and both averaged approximately ninety-two percent BOD removal.

Auxilary studies indicated that supplementary nutrients were not required, that chlorination was the best means of disinfection but required large amounts chlorine, and that settled secondary sludge, containing one to three percent solids, was difficult to dewater.

Estimated construction costs for combined and separate treatment plants were prepared. A treatment plant utilizing plastic media bio-filters along with fifteen-hour aeration was the most economical combined facility and was more economical than separate facilities. (Clark, J, J, & G)

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