Timothy Dale Holland, THE LOCATIONAL AND DEVELOPMENTAL EFFECT OF WATER POLLUTION ON INDUSTRY IN THE ROANOKE RIVER BASIN. (Under the direction of Edward P. Leahy) Department of Geography.

The purpose of this study is to determine the problems which water pollution is creating for the location and development of industry within the Roanoke River Basin. In recent years, there have been many studies conducted which were concerned with industrial water pollution problems in general and the Roanoke River Basin in particular, but these studies have been primarily technological in scope. Rarely have there been any studies which have been broadly based and which have considered the total regional implications of water pollution problems. This, however, is the objective of this study--a geographic analysis based on quantitative, qualitative, economic, environmental, and aesthetic factors.

The last fifteen years have shown rapid changes in industrial water use in the Roanoke River Basin. These changes are identified and analyzed in the study. Attention is focused on changes in the following areas: legal pollution controls, plant site development, industrial distribution, economies and diseconomies of scale, and the attractiveness of the Roanoke River Basin for the development of additional water-dependent industries.

Industrial water pollution problems are dealt with in a specific sense, via case studies, and on a general regional level. Through this dual approach, conclusions are reached which can be applied to national industrial water pollution problems. The conclusions contained in the

study do not make recommendations for solutions or projections of specific future problems. Rather, the conclusions reached serve as a capsule statement of regional industrial water pollution problems.

This study is an attempt to present a balanced picture of water pollution problems by considering municipal and domestic sewage treatment problems in addition to those of industry. Cooperative approaches to the solution of water pollution problems are considered, and the benefits to be derived by municipalities and industry are discussed. Changing patterns in the spatial distribution of industry resulting from such cooperation are identified in Chapter IV.

Of basic importance is man's relationship with his environment, but the total effect of industrial effluents on the Roanoke River Basin's economic, demographic, and physical sectors is considered. An attempt was made in the study to provide a balanced approach to the study of pollution problems; not one dominated by a highly restrictive discipline, such as biology or economics.

THE LOCATIONAL AND DEVELOPMENTAL EFFECT OF WATER POLLUTION ON INDUSTRY IN THE ROANOKE RIVER BASIN

A Thesis

Presented to

the Faculty of the Department of Geography

East Carolina University

Geography Research Paper No. 15

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts in Geography

by

Timothy Dale Holland

January 1972

THE LOCATIONAL AND DEVELOPMENTAL EFFECT OF WATER POLLUTION ON INDUSTRY IN THE ROANOKE RIVER BASIN

by

Timothy Dale Holland

APPROVED BY:

SUPERVISOR OF THESIS Edward P. Leahy

Edward P. Leahy

CHAIRMAN OF THE DEPARTMENT OF GEOGRAPHY Robert E. Cramer

Robert E. Cramer

DEAN OF THE GRADUATE SCHOOL John M. Howell

John M. Howell

ACKNOWLEDGMENT

Grateful acknowledgment is made to Dr. Edward P. Leahy of the East Carolina University for his efforts in supervising this thesis; and to Billie Holland and Jeff and Madeleine Wright whose encouragement was deeply appreciated.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

PREFACE

This study was prepared to fulfill the requirements for a Master of Arts Degree in Geography at East Carolina University. The study was also undertaken to assist in filling a void which has existed for some time in the academic discipline of geography. In the past, there have been many studies conducted which were concerned with industrial water pollution problems in general and the Roanoke River Basin in particular, but these studies have been largely technological in scope. Such studies, usually published by various governmental agencies or popular magazines, have seldom viewed the problem geographically. The study will be of the type which F. Kenneth Hare, Professor of Climatology at the University of Toronto, has called for in the geographic discipline. In many universities, environmental studies have been launched, but they are largely based on the physical and biological sciences. The geographers have played only a small role. Rarely have there been any studies which have been broadly based. This however, is what is contained in this study--a geographic analysis of industrial water pollutants in the Roanoke River Basin.

CHAPTER I

INTRODUCTION

The basic objective of this thesis is to identify the locational and developmental effect which water pollution is exerting on water-dependent industries in the Roanoke River Basin.[1] The current international concern over man's impact on environmental quality has caused manufacturing concerns to become increasingly aware of their effect on the quality of the water which they utilize in their production processes. The quality of water resources in any area and the potential for pollution problems has therefore become an important consideration in the locational decisions of industrial enterprises.[2] The problem also necessitates expenditures for water purification and waste treatment facilities. Thus, existing manufacturers as well as those considering an area as a possible location are affected. The focus of this study will be upon determining the impact of industrial water pollution on industrial development.

---

[1]Water-dependent industries are defined as those industries which require water as either a raw material or as a process material for the production of a commodity. This group includes power companies which are producing power by either thermal or hydro-electric facilities.

[2]Pollution as discussed herein means an alteration of the physical, chemical or domestic wastes, so as to create a nuisance and/or render waters harmful to public welfare and/or animal health, safety, or welfare; or unsuitable as a domestic, industrial, commercial, recreational, or agricultural water supply.

The basin forms a nearly perfect subject for a water pollution study. The Roanoke River Basin is an emerging industrial area which has developed a diversified industrial base. The firms in the area with large water demands are represented by the groups of: food products; paper and allied products; fabricated metal products; and wood and lumber products. In addition, the basin is interstate; it also spans both the Piedmont and the Coastal Plain; and there are both urban and rural industrial concentrations. The major persistent pollution problems in the basin have been concentrated in the four areas of the Smith River, the Smith Mountain Lake area, the Lower Dan River, and the Roanoke Rapids area of the Roanoke River. There have been serious but not continuous problems in other areas of the river basin. These problems have affected the industrial development within the basin to varying degrees. In some cases, the problems have exerted a strong negative influence on industries considering location within the river basin. The attempts of the North Carolina State Government; the Virginia State Government; and industrial, urban, and governmental authorities within the basin to maintain high quality water have alleviated some of the minor problems and improved the water quality within the basin as a whole and, at the same time, have presented developmental problems, changes, and solutions which might be applicable elsewhere.

Physical Description

The Roanoke River Basin adjoins eight other river basins. To the north and northeast it is tangent to the James and Chowan River Basins; on the southeast by the North Carolina-Virginia coastal drainage areas; to the south by the Tar, Neuse, Cape Fear, and Yadkin-Pee Dee River Basins; and on the west by the Kanawha River Basin.

The head waters of the Roanoke River Basin lie in the Great Valley of Virginia. The Roanoke River and its tributaries flow in a southeasterly direction across the Piedmont plateau; entering North Carolina in the Kerr Reservoir which is approximately 240 miles from the river's source. From the North Carolina-Virginia border, the Roanoke River continues in a southeasterly direction for 160 miles where it empties into Batchelor's Bay which is an extension of Albemarle Sound. The basin's drainage area is 9,630 square miles. Approximately 6,300 square miles of this lie in Virginia, with the remaining 3,330 in North Carolina.[1]

The major tributary of the Roanoke River is the Dan River. The Dan's head waters lie adjacent to the crest of the Blue Ridge Mountains. From this area the river crosses the North Carolina-Virginia state line four times before it enters the Kerr Reservoir. The river is 210 miles in length and drains an area of 2,850 square miles.[2]

The mean annual temperature varies from 59°F in the coastal areas to 56°F at Roanoke, Virginia. Rainfall varies from an annual average of forty inches in the western portions of the basin to forty-four inches in the coastal areas. This rainfall is distributed evenly throughout the year. A United States Geological Survey gauge at Roanoke Rapids, North Carolina, has recorded a thirty-five-year chart of river flow which flow was 261,000 cubic feet per second, and the minimum flow was 458

---

[1]Federal Security Agency, Public Health Service, Southeast Drainage Basins, (U. S. Government Printing Office, Washington, D. C., 1951), p. 40.

[2]Fig. 2. Rivers and reservoirs in the Roanoke River Basin indicates the relative significance of rivers and tributaries in terms of size and volume of flow by the use of upper case and lower case letters.

cubic feet per second.[1]

The surface water within the basin is of high natural quality. There are no natural minerals present which prohibit the use of the water for domestic or industrial purposes. Any impurities which now exist are the result of man's activities.

Economic Development

The 1970 population of the river basin is approximately 710,000. There are fifteen urban areas within the basin which constitute roughly 30 per cent of the basin's total population. The urban areas are evenly divided between North Carolina and Virginia. Only the Virginia cities of Roanoke and Danville have populations of over 30,000.

Although industry is of major economic significance, agriculture dominates the basin's landscape. The principal crops include tobacco, cotton, corn, peanuts, potatoes, grains, fruits, and vegetables.[2] The most important crops historically have been tobacco in the Coastal Plain and Piedmont areas and fruit in the western mountainous areas.

The industrial base is highly diversified. However, textiles, food processing, and paper and pulp milling have long dominated the industrial sector. Roanoke, Danville, and Martinsville are extensively diversified industrial centers. With the exception of these three areas, most of the industrial development is dispersed over a predominantly rural landscape.

---

[1] Ibid.

[2] Ibid.

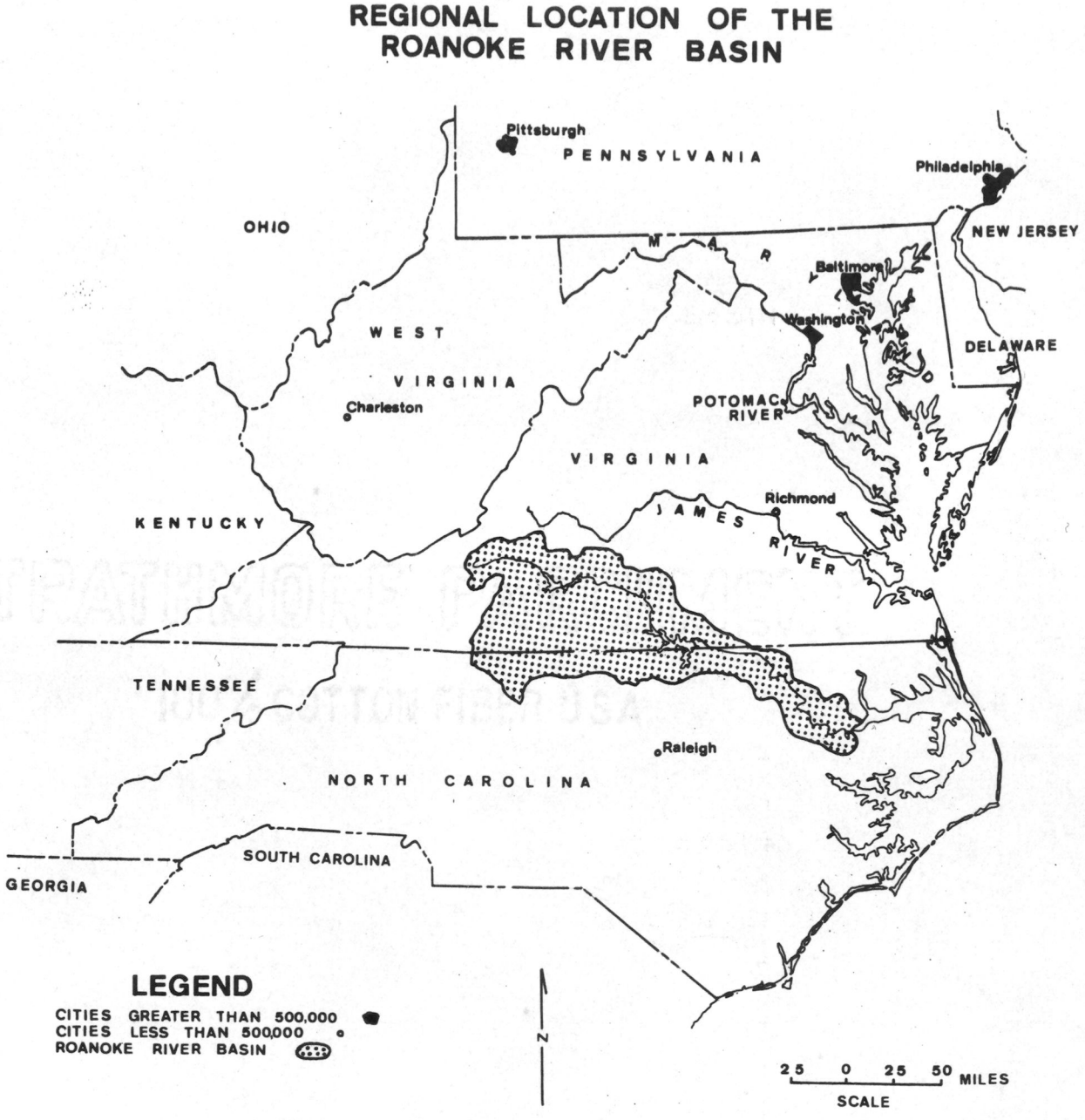

REGIONAL LOCATION OF THE
ROANOKE RIVER BASIN
Pittsburgh
PENNSYLVANIA
Philadelphia
OHIO
NEW JERSEY
M A R
Baltimore
Washington
WEST
VIRGINIA
DELAWARE
Charleston
POTOMAC
RIVER
VIRGINIA
Richmond
KENTUCKY
JAMES
RIVER
TENNESSEE
Raleigh
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
LEGEND
CITIES GREATER THAN 500,000
CITIES LESS THAN 500,000
ROANOKE RIVER BASIN
N
25 0 25 50 MILES
SCALE

Fig. 1

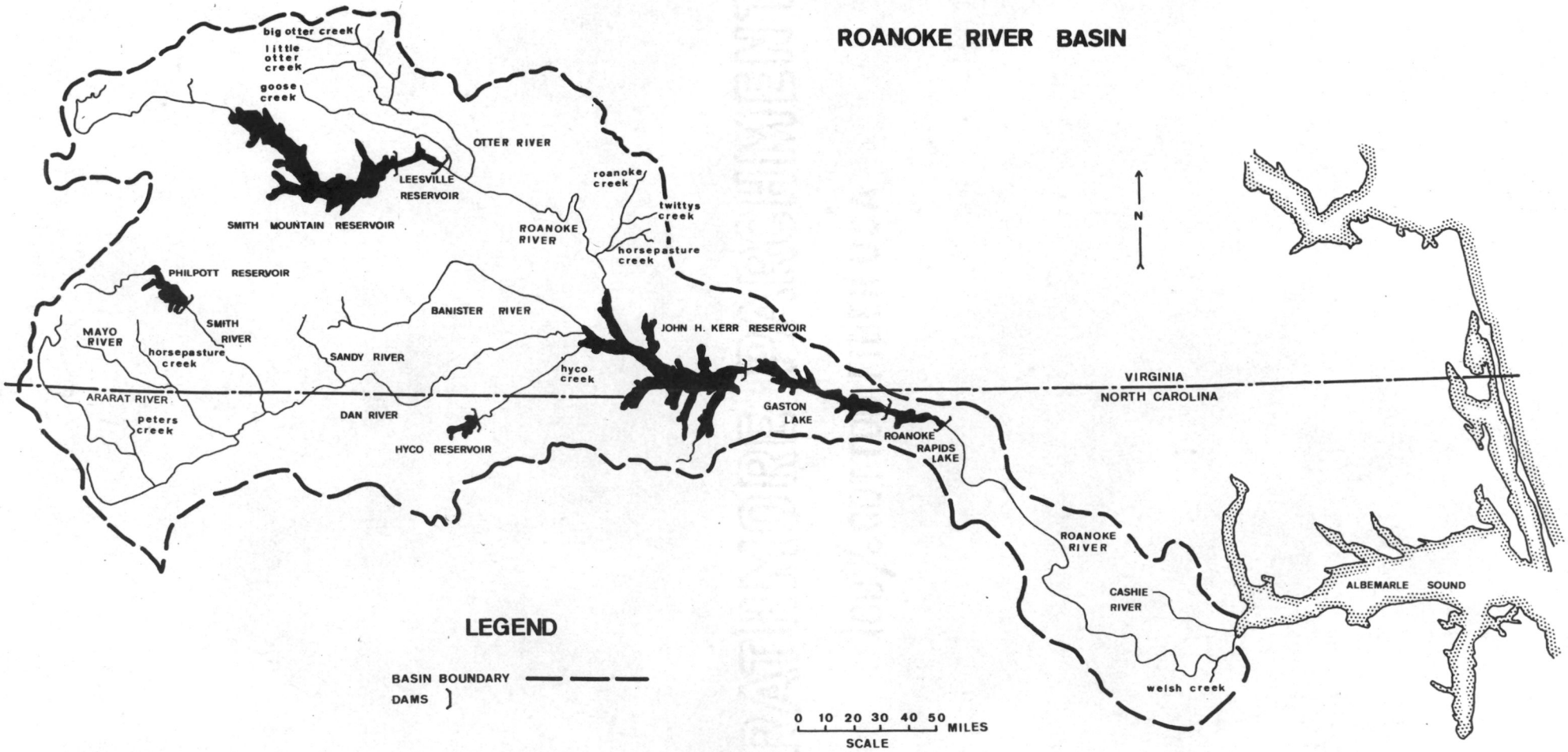

RIVERS AND RESERVOIRS IN THE
ROANOKE RIVER BASIN
big otter creek
little otter creek
goose creek
OTTER RIVER
LEESVILLE RESERVOIR
SMITH MOUNTAIN RESERVOIR
roanoke creek
twittys creek
ROANOKE RIVER
horsepasture creek
PHILPOTT RESERVOIR
BANISTER RIVER
JOHN H. KERR RESERVOIR
SMITH RIVER
MAYO RIVER
horsepasture creek
SANDY RIVER
hyco creek
VIRGINIA
NORTH CAROLINA
ARARAT RIVER
peters creek
DAN RIVER
HYCO RESERVOIR
GASTON LAKE
ROANOKE RAPIDS LAKE
N
ROANOKE RIVER
CASHIE RIVER
ALBEMARLE SOUND
welsh creek
LEGEND
BASIN BOUNDARY
DAMS
0 10 20 30 40 50 MILES
SCALE

Fig. 2

Methodology

This study relied heavily upon empirical observations and interviews. The interviews were centered on the North Carolina Department of Air and Water Resources, the Virginia State Water Control Board, the Water Resources Institute of the University of North Carolina, the Water Resources Research Center of the Virginia Polytechnic Institute and State University, and key individuals in industry and local government who were directly concerned with industrial water pollution. The interviews included industries located within all sections of the basin. The Weyerheauser Company at Plymouth, North Carolina; the Albemarle Paper Company at Roanoke Rapids, North Carolina; and the Martin Processing Company at Martinsville, Virginia, were studied intensively because they provided a good cross section of industrial water use. These firms offered examples of modern and antiquated control procedures, diseconomies, changing plant site development requirements, pollution-induced marketing disadvantages, and the difficulties encountered in attempting to comply with state and federal control guidelines. In general, they provided case studies of contemporary industrial water pollution problems which will be beneficial in a locational analysis. In addition, the interrelationship of man to his environment is a basic consideration of the study and will appeal to the interests of the geographic discipline. A broad approach was taken in order to achieve a comprehensive analysis of the industrial water pollution problems in the Roanoke River Basin, from which applications can be made to other areas, thereby providing a general locational analysis.

CHAPTER II

INDUSTRIAL WATER USE IN THE ROANOKE RIVER BASIN

There are forty water-dependent industries currently located in the Roanoke River Basin. These industries may be grouped as follows: textiles, utilities, food, lumber and wood products, paper and allied products, fabricated metal products, rubber and plastics products, electrical equipment, and chemicals and allied products. Of these eight groups, the paper, textiles, and food and kindred products groups account for the majority of the industrial water use in the river basin.

Sixteen of the forty water-dependent industries within the river basin cooperated in this study. Information on the remaining twenty-four industries was available from the Virginia State Water Control Board and the North Carolina Department of Air and Water Resources. The cooperating industries represent all of the water-dependent industrial groups within the river basin; and, due to the availability of data, more emphasis will be placed on these industries. The following sections of this chapter will locate and describe the industrial water users within the river basin by industrial groups and identify the areas of the river basin in which the discharge of industrial effluents has created serious water pollution problems.

The Water-Dependent Industries

Most of the wastes received by the rivers and streams of the river basin is discharged by factories. This is due to the low density of the population and the lack of large public sewer systems. There are only four cities within the river basin which have a population of 20,000 or greater and discharge wastes into a water body. The remaining portions of the population are either dispersed over a rural landscape or concentrated in small towns of 10,000 population or less. In the rural areas, most domestic wastes are discharged into individual septic tanks. The small towns within the river basin do, in some cases, operate public sewerage facilities. However, most of the domestic sewage in the small towns is treated by individual facilities.

Paper and Pulp

There are three pulp and paper producers located within the river basin, all of which are located in or below the fall zone of the Roanoke River. This group requires the greatest volume of water of any industrial group in the river basin. The Weyerheauser Company at Plymouth, North Carolina, and the Albemarle Paper Company and the Federal Paper Board Company at Roanoke Rapids, North Carolina, require a total of sixty-seven million gallons of water per day. The Federal Paper Board Company requires only 200,000 gallons per day.[1] The Weyerheauser and Albemarle Companies, which will be discussed in greater detail in Chapter III, require forty-two million and twenty-five million gallons of water per day, respectively.

---

[1]State of North Carolina Department of Air and Water Resources, Significant Sources of Waste Discharged, Municipal and Industrial Roanoke River Basin, Raleigh, North Carolina, January 13, 1971, (Mimeographed).

TABLE 1

INDUSTRIAL WATER USE
IN THE ROANOKE RIVER BASIN[1]

	Industry[2]	Daily Water Use In Gallons
1.	Georgia Pacific Company	2,400
2.	Weyerheauser Company	42,000,000
3.	Produce Processors, Incorporated	2,400
4.	Martin Dale Canning Company	***
5.	Beaunit Mills, Incorporated	1,200,000
6.	Albemarle Paper Company	25,000,000
7.	J. P. Stevens and Company	***
8.	Federal Paper Board Company	200,000
9.	Vepco Gaston Dam	Hydro-Electric
10.	John H. Kerr Dam	Hydro-Electric
11.	Perfect Packed Products	700,000
12.	C. P. and L. Roxboro Steam Plant	2,400,000
13.	Burlington Industry Clarksville Finishing Plant	***
14.	Virginia Crafts, Incorporated	536,000
15.	Burlington Industry Brookneal Finishing Plant	***
16.	Burlington Industry Clarksville Finishing Plant	***
17.	Burlington Industry Halifax Worsted Plant	***
18.	Halifax Cotton Mills	***
19.	Klopman Mills, Incorporated	5,000,000
20.	Piedmont Manufacturing Company	200,000
21.	Leesville Lake Dam	Hydro-Electric
22.	Smith Mountain Dam	Hydro-Electric
23.	Corn Valley Packers, Incorporated	***
24.	Dan River Mills, Incorporated	16,000,000
25.	Bassett-Walker Knitting Company	350,000
26.	duPont Nylon Plant	37,600,000
27.	Fieldcrest Mills, Incorporated	1,250,000
28.	Martin Processing Company	800,000
29.	Stanley Furniture Company	5,000
30.	Bassett Furniture Company	9,000
31.	Philpott Dam	Hydro-Electric
32.	Gunnoe's Sausage Company	6,000
33.	W. A. Parker Canning	1,100
34.	Bunker Hill Packing Corporation	***
35.	Norfolk and Western East End Shops	***
36.	Roanoke Steel and Electric	***
37.	Overstreet Food Processing	***
38.	Norfolk and Western Shaffer Crossing Shops	12,000
39.	International Telephone and Telegraph Company	15,000
40.	Green Hill, Incorporated	***

---

[1] The locations of these industries are coded to the numbered locations on Fig. 3.

[2] Daily water use data is unavailable for all industries for which water is indicated by asterisks. The hydro-electric production of power does not add pollutants to the water or increase water temperatures. Also, the daily water use varies and, therefore, was not given.

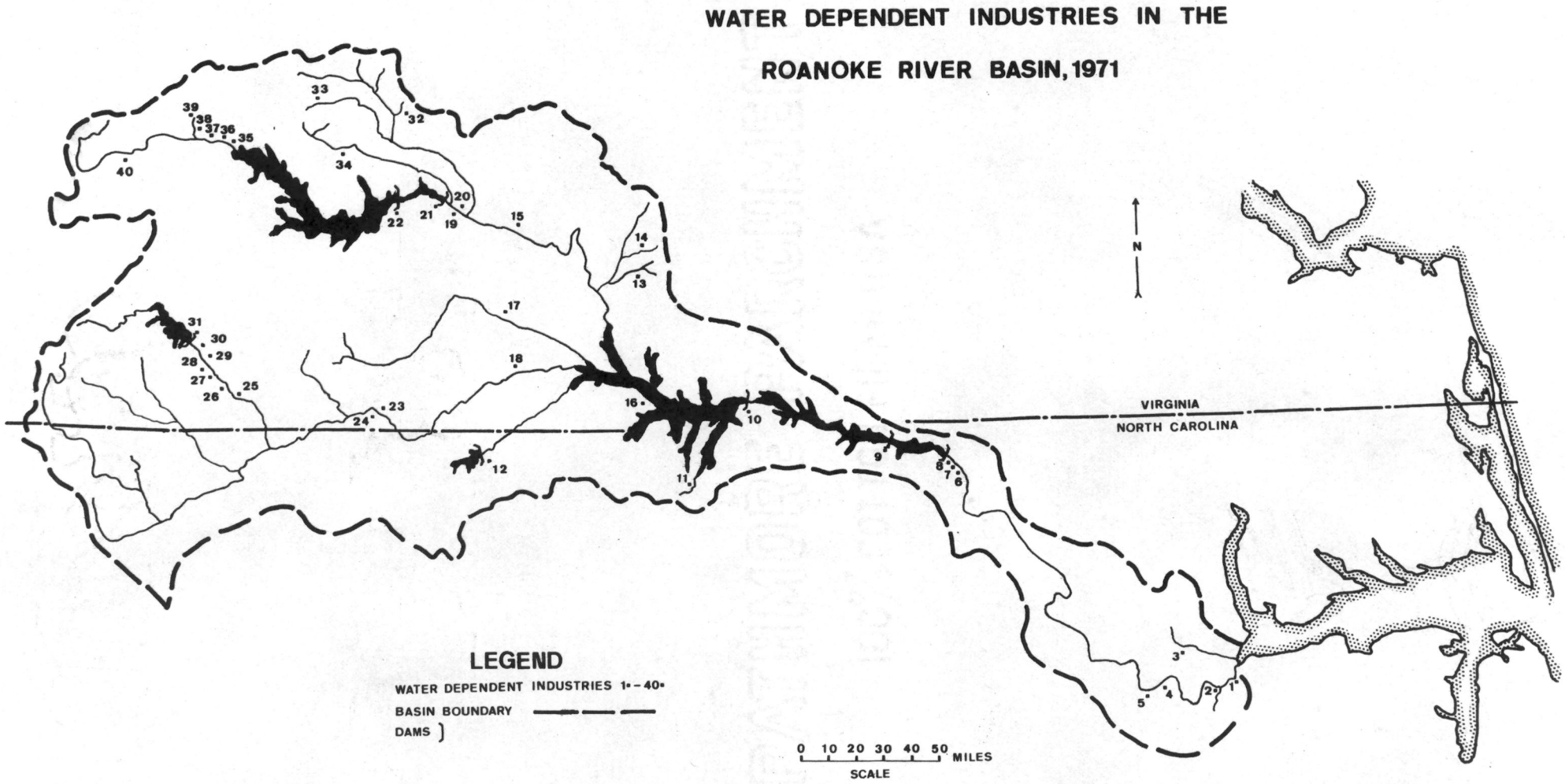

WATER DEPENDENT INDUSTRIES IN THE
ROANOKE RIVER BASIN, 1971
VIRGINIA
NORTH CAROLINA
N
LEGEND
WATER DEPENDENT INDUSTRIES 1 - 40
BASIN BOUNDARY
DAMS
0 10 20 30 40 50 MILES
SCALE

Fig. 3

In each case, the considerations of water in the company's locational decision focused on two factors. The first was the availability of sufficient quantities of water for production, and the second was utilization of the river as an effluent carrier. The Albemarle and Weyerheauser Companies now operate their own waste treatment facilities. The Federal Paper Board Company discharges 200,000 gallons of effluent each day. This waste is treated by the Roanoke Rapids Sanitary District, which discharges 3,300,000 gallons of domestic and industrial waste per day into the Roanoke River.[1] If the processes of production were the same and the volume of water discharged by the company were as large as that of the Albemarle Company, the cost of having wastes treated in municipal facilities would be prohibitive. Charges for treating industrial wastes are based on the strength of the waste and the volume. The strength factor is directly related to the amount of organic matter contained in the effluent. Such organic matter rapidly depletes the oxygen supply in water and requires at least secondary (aeration facilities and settling ponds) treatment for effective reduction of the harmful materials contained in the wastes.[2]

The Federal Paper Board Company produces paper board by reprocessing waste and scrap paper. When this paper was originally produced, much of the waste organic material was removed. Reprocessing by the Federal Paper Board Company generates only a small amount of additional waste organic matter. This waste may be effectively treated by the

---

[1] Ibid.

[2] Don Erwin Ettridge, An Economic Study of the Effect of Municipal Sewer Surcharges on Industrial Wastes, (Water Resources Research Institute of University of North Carolina, Raleigh, North Carolina, November 1970), p. 8.

Roanoke Rapids Sanitary District. The estimated cost of this service to the company is $8,800 per year, which is more economical than building its own facility.[1]

The pulp and paper industries have significantly reduced the harmful effects of the effluents which they discharge. This is due to public pressure to protect the environment, the economic feasibility of treating wastes, legal pressure to improve waste treatment facilities, and responsive and concerned executive personnel. Each of these plants has taken steps to effectively abate water pollution, while on a national scale the paper and pulp industry has been notoriously lax in its efforts to adequately treat wastes.

Lumber and Wood Products

The Stanley Furniture Company, Stanleytown, Virginia; the Bassett Furniture Company, Bassett, Virginia; and the Georgia Pacific Company, Washington County, North Carolina, are the only water-dependent industries in the river basin which produce lumber and wood products. The Stanley and Bassett Furniture Companies are located adjacent to the Smith River within 500 yards of each other. Both are located in unincorporated mill towns which developed after the plants were constructed. The Georgia-Pacific Company is located on the banks of the Roanoke River west of Plymouth, North Carolina. None of these plants has access to municipally operated sewerage facilities and, therefore, has been faced with constructing treatment facilities or discharging untreated wastes into the rivers.

The Georgia Pacific Company, which operates a sawmill and planing

---

[1] Ibid., pp. 89-106.

mill, has selected the second alternative. Operation of the facility requires 2,400 gallons of water per day. This water is used to wash the unhewn lumber before it enters the planing process. This washing process does not add significant amounts of chemicals or organic matter to the waste water which is discharged into the river. The waste water discharged into the Roanoke River by the plant is of high enough quality that the North Carolina Department of Air and Water Resources has not required the company to construct waste treatment facilities.[1]

The Stanley and Bassett Furniture Companies use 5,000 and 9,900 gallons of water per day, respectively.[2] Until 1969, both plants used a process for finishing furniture which is known as the wet booth process.[3] In 1969, Bassett Furniture Company abandoned this process because of the water pollution which resulted from it. The water which was used in the wet booth method collected solvents and phenols which had a harmful effect on the Smith River. In 1969, these phenols and solvents were taken into the Fieldale water supply which withdraws water from the Smith River two miles downstream from the Bassett plant.[4] Discharges from the

---

[1]North Carolina Department of Air and Water Resources, "Significant Sources of Waste Discharged." (Mimeographed).

[2]Virginia Department of Water Resources, Municipal and Institutional Wastes Discharges County: Henry, Richmond, Virginia, January, 1971, (Mimeographed).

[3]In the wet booth process, the unfinished furniture is placed in a three-sided booth. An individual with a spray gun stands at the open side of the booth and applies the finish to the furniture. Approximately 50 per cent of the spray misses the furniture and is termed overspray. The overspray is drawn to the back of the booth by fans and is picked up in a stream of water which flows down the back of the booth. The filtering water is recycled and normally changed once a week--Jeff Wright, Plant Manager, Interview, American Furniture Company, Martinsville, Virginia, January 5, 1971.

[4]A. L. Philpott, Virginia State Representative, 37th District, Interview, Bassett, Virginia, January 3, 1971.

Stanley Furniture Company also contributed to this incident. The Bassett Company discontinued the process while the Stanley Company still uses it.[1] Both plants installed waste treatment facilities prior to the incident. Stanley installed a primary system in 1956, and Bassett installed a similar system in 1958. However, primary systems will not effectively treat wastes containing solvents and phenols. Stanley upgraded its system to a secondary level in 1970.[2]

Until 1970, the Bassett Company operated the Bassett Mirror Company, utilizing water in the mirror polishing process. This process used an iron oxide polishing compound which was washed off with water, and the waste was discharged into the Smith River without receiving treatment. This introduced large amounts of iron into the river and in periods of low flow caused the river to turn a reddish color. Rather than install treatment facilities, the plant began purchasing prepolished mirrors in 1969.[3]

At present, both plants use water primarily for drinking and sanitary purposes. The Stanley Company discharges approximately 28,200 gallons of waste per month from its wet booth process. All of this waste is treated and chlorine added after treatment. However, surface runoff from both plants flows untreated into the Smith River and thereby introduces much untreated waste into the river. This situation is particularly bad during heavy rains when the surface water washes the

---

[1]Hack Padgett, Plant Engineer, Questionnaire, Stanley Furniture Company, Stanleytown, Virginia, January 15, 1971.

[2]Philpott, Interview, January 3, 1971.

[3]Ibid.

asphalt and concrete areas of the plant grounds.[1]

The furniture companies have taken steps to improve their pollution control facilities but not until problems had arisen as a result of the wastes which they discharged. The Georgia Pacific Company does not generate enough harmful waste to constitute a threat to the ecology of the Roanoke River. As a group, the lumber and wood products industries may be viewed as improving their pollution control facilities. However, the problem of surface drainage will remain until a method is devised for collecting and treating this surface drainage.[2]

Utilities

Hydro and thermal electric power plants have caused only slight pollution problems in the Roanoke River Basin. The following six power plants are all of those located within the basin: Vepco Gaston Dam, Halifax County, North Carolina; Carolina Power and Light Company Roxboro Steam Electric Plant, Person County, North Carolina; John H. Kerr Dam, Mecklinburg County, Virginia; Philpott Dam, Henry County, Virginia; Smith Mountain Dam, Pittsylvania-Bedford Counties, Virginia; and Leesville Lake Dam, Campbell County, Virginia. The Roxboro Steam and Electric Plant is the only one using a thermal electric process and, therefore, is the only one which could pose a possible threat to a river or stream.

The Roxboro Steam Plant produces electricity using coal as a full supply. The water required varies greatly, but the plant is designed to use a maximum of 2,400,000 gallons per day. The pollution problem is that of thermal pollution. To prevent thermal pollution, a 3,800 acre

---

[1] Padgett, Questionnaire, January 15, 1971.

[2] Ibid.

cooling pond has been installed at the plant. The cooling pond has prevented an increase in the temperature of the Hyco River which receives the water discharged from the cooling pond.[1]

Pollution problems arising at the other five dams have been very minor and, in all cases, have resulted from the design of the dams. The intake ducts at each dam have been located on the bottom of the reservoirs where the oxygen content of the water is lower than at any other point in the reservoirs. Therefore, in all cases, the water leaving the dams is of a lower oxygen content than that entering the upper reaches of each reservoir. This method of dam construction has not resulted in any fish kills or other harmful effects on the ecology of the river basin. However, the situation at the Kerr, Gaston, and Roanoke Rapids Dams lowered the oxygen content of the water enough to affect some of the industrial water users located immediately downstream which require process water containing a high oxygen content.[2] There have been no complaints concerning the oxygen content of the water discharged from the other three dams and no sub-surface dams constructed in these reservoirs.[3]

The production of electricity in the Roanoke River Basin has not created any significant pollution problems. At present, no future problems are predicted to arise from either the hydro-electric or thermal facilities. This is an outstanding contrast to the national pollution picture in which thermal pollution has added heat to the nation's waters

---

[1]North Carolina Department of Air and Water Resources, "Significant Sources of Waste Discharged." (Mimeographed).

[2]Julian R. Taylor, Chief of Stream Monitoring Branch, North Carolina Department of Air and Water Resources, Raleigh, North Carolina, February 12, 1970.

[3]The construction of submerged dams at the Kerr, Gaston, and Roanoke Rapids Dams will be discussed in greater detail in Chapter III, p. 66.

to such an extent that it has seriously affected aquatic life, accelerated biological processes, reduced the oxygen content of the water, increased the growth of aquatic plants, and created taste and odor problems which have made many water bodies undesirable for domestic and industrial purposes.[1]

Rubber and Plastics Products

The Piedmont Manufacturing Company of Altavista, Virginia, is the only water-dependent industry located in the river basin which produces either rubber or plastics. Piedmont Manufacturing produces tire valves for distribution to various tire companies. The plant, which was constructed in the mid-1960's, employs 350 people and is of major significance in the industrial development of the river basin.[2]

The plant requires 200,000 gallons of water per day of which 160,000 gallons are used as process water and 38,000 gallons are used as a raw material in the production of rubber.[3] The process water must not be excessively acidic or alkaline. If it were, it would have a harmful effect on the production and processing of the rubber valves. The Roanoke River, along which the plant is located, provides water which naturally meets the requirement. Two-thousand gallons of the water required daily by the plant are used for drinking and sanitary purposes.

---

[1] Federal Water Quality Administration, Clean Water for the 70's, (Washington, D. C.: U. S. Government Printing Office, 1970), p. 6.

[2] Virginia Division of State Planning and Community Affairs, Data Summary, Campbell County, (Richmond, Virginia: Division of State Planning and Community Affairs, December, 1970), p. 13.

[3] Process water is that water which is used to wash, dye, or otherwise assist in the manufacture of a product but is not included as an element in or part of the final product.

The plant installed waste treatment facilities in July, 1967. The facilities were completed shortly after the plant began operation. One-hundred-sixty-thousand gallons of effluent are treated daily by this system and discharged into the Roanoke River. The Altavista Municipal System treats 8,000 gallons of sewage for the plant daily. Thus, all wastes, industrial and human, produced by the plant are treated by either municipal or industrial systems before being discharged into the Roanoke River.[1]

The process water required by the plant is used in a washing process to rinse residue from the rubber itself and from those valves which require metal plating. In the rinsing processes, the water picks up chromium, cyanide, ammonium presulfate, acid, and alkali wastes.

Unless these waste materials were removed by treatment facilities, they would seriously affect the quality of the water in the Roanoke River and prevent usage of the water for drinking and for most industrial purposes. In order to adequately treat the wastes, the plant constructed a system which provided for a settling pond, an aeration pond, and a filtering system.[2] The system has been effective enough to prevent any fish kills, and the Virginia State Water Control Board has not received complaints to the plant's discharge of waste.[3]

Chemicals and Allied Products

The duPont Nylon Plant of Martinsville, Virginia, is the only water-

---

[1]Elton V. Buckley, Chief Chemist, Questionnaire, Piedmont Manufacturing Company, Altavista, Virginia, April 7, 1971.

[2]Elton V. Buckley, Chief Chemist, Letter, Piedmont Manufacturing Company, Altavista, Virginia, April 7, 1971.

[3]Buckley, Questionnaire, April 7, 1971.

dependent chemical industry located within the river basin. All of the nylon produced by the plant is used for making nylon hosiery. duPont's Martinsville plant employs 3,750 people and, in terms of physical size, is one of the largest factories in the Roanoke River Basin.[1]

The plant, which is located on the Smith River, uses 37,600,000 gallons of water per day of which 37,513,600 gallons are required for the production of nylon.[2] The remaining 84,400 gallons are used for drinking water, sanitary purposes, and for operation of the plant's cafeteria.[3] Of the water required for production, 1,513,000 gallons are specially treated and purified for use as a raw material in the production of nylon, and the remaining 36,000,000 gallons are used for cooling.

The plant only treats 1,600,000 gallons of water per day. The 36,000,000 gallons used for cooling do not require treatment because the water does not have a harmful effect on the plant's equipment. Currently the water used for cooling is discharged directly into the river without treatment. However, the 80,000 gallons of wastes discharged daily from the plant's sanitary system and cafeteria are treated.[4] Those discharged from the cafeteria are treated in a settling and retention pond, while those discharged from the plant's sewer system receive aeration and filtering treatment.[5] On July 1, 1972, the plant will begin

---

[1]Virginia Division of State Planning and Community Affairs, Data Summary, Henry County, (Richmond, Virginia: Division of State Planning and Community Affairs, December 1970), p. 12.

[2]Dana W. Lewis, Pollution Control Coordinator, Questionnaire, duPont Nylon Plant, Martinsville, Virginia, January 8, 1971.

[3]Dana W. Lewis, Pollution Control Coordinator, Interview, duPont Nylon Plant, Martinsville, Virginia, May 7, 1971.

[4]Lewis, Interview, May 7, 1971.

[5]Lewis, Questionnaire, January 8, 1971.

operation of a large system consisting of aeration, settling and retention ponds which will treat all wastes discharged from the plant, including those discharged from the cooling system.[1]

The duPont plant has not had a serious effect on the quality of water in the Smith River. However, the plant has experienced problems in obtaining adequate supplies of water and water of acceptable quality. The Smith River has not maintained a steady flow and at times has not supplied ample amounts of water. The quality of the water has been affected by communities and industries located upstream which discharge untreated wastes into the river. The engineers at duPont expect the quality of the water to improve as industries and communities install treatment facilities. However, the dependability of the river flow is not expected to improve.[2]

Fabricated Metal Products

There are three factories located within the Roanoke River Basin which produce fabricated metals. These three are the Norfolk and Western Railway Company Shaffer Crossing Shops, the Norfolk and Western Railway Company East End Shops, and the Roanoke Electric Steel Corporation.[3] All of these factories are located in the City of Roanoke adjacent to the Roanoke River and require water for the cooling and washing of their products.[4]

---

[1]Lewis , Interview, May 7, 1971.

[2]Lewis, Questionnaire, January 8, 1971.

[3]Virginia State Water Control Board, Factors Related to Water Quality of the Roanoke River and Smith Mountain Lake, (Richmond, Virginia: Virginia State Water Control Board, May 1967), pp. 14-15.

[4]These three industries refused to cooperate in the collection of data for this study. All of the information contained herein was obtained from the Virginia State Water Control Board.

During the years 1965-1966, the Virginia State Water Control Board conducted biological studies in the upper portions of the Roanoke River Basin. These studies revealed that the Norfolk and Western Shaffers Crossing Shops, which produce parts for railroad equipment, were discharging effluents containing extensive amounts of toxic material. Since then, the company has installed a 12,000 gallon retention pond, three blending tanks for chemical treatment which encourage the precipitation of solid particles, an aeration pond, an oil/water separator which removes the oil by gravity, a pressure tank which forces air into the wastes, and a final filter for removing any remaining oil and solid matter.[1] The effluent currently being discharged is free of oil and has excellent clarity. However, some of the toxic materials are still present in the effluents.

There are three discharge points at the Norfolk and Western East End Shops. The treatment facilities consist of two oil/water separators and a settling basin. One of the oil/water separators and the settling pond are at present discharging effluents which do not have a harmful effect on the Roanoke River. However, one of the oil/water separators is malfunctioning and is discharging oil and toxic materials. The Virginia State Water Control Board has ordered the company to remedy this situation.

The Roanoke Electric Steel Corporation discharges waste water which is produced during the cooling of steel. These wastes are discharged into Peters Creek approximately 200 yards from the creek's entrance into the Roanoke River. These wastes have a toxic effect on both Peters Creek and the Roanoke River. The Virginia State Water Control Board has

---

[1]State Water Control Board, "Water Quality of the Roanoke River and Smith Mountain Lake," p. 14.

not been satisfied with the company's efforts to treat the wastes and has ordered the company to improve the situation immediately.

Of all the industrial groups within the river basin, the fabricated metals group has had the most detrimental effect. The toxic and oily wastes discharged by these plants have seriously reduced the oxygen content of the water in portions of the Roanoke River and increased the growth of algae by providing phenols and other chemical nutrients for the plants. Such a situation prohibits the use of water for drinking, recreational, and most industrial purposes.[1]

Electrical Equipment

The International Telephone and Telegraph Company of Roanoke, Virginia, is the only water-dependent industry in the river basin which produces electrical equipment. The plant produces special purpose electron tubes and has 200 employees. Fifteen-thousand gallons of water are required daily as process water. All water required by the plant for sanitary and drinking purposes is supplied and treated by Roanoke County. The 5,000 gallons of the process water, which are taken from the Roanoke River, are treated by plant facilities to remove all bacteria and mineral content. This water is used to wash the metal parts prepared in the plant for use in the electron tubes.

Ten-thousand gallons of the process water is used solely for cooling purposes. This water is repumped through casing which surrounds those pipes and equipment which are subject to overheating. This cooling water does not pick up any harmful chemicals, and its temperature is not significantly increased. Therefore, this water is discharged into the

---

[1] Ibid.

Roanoke River without receiving treatment. The process water which is used for washing the metal parts picks up acidic materials and solid metal particles. To treat these wastes, the company installed a waste treatment system in 1958 when the plant was constructed. The treatment facilities consist of a settling pond and a neutralizing tank in which chemicals are added which neutralize the acid.[1]

The plant has normally provided for adequate treatment of its effluents. However, in July 1963, the treatment system broke down. The result was a fish kill in which a small number of catfish and minnows were killed. The State Water Control Board assessed the company $17.11.

The company is pleased with its present location. Its main concern is the future development of water-dependent industries upstream. The process water used by the plant must be very pure; and the location of industries upstream which produced toxic, alkaline, acidic, or oily wastes would seriously hamper the plant's production. In addition, the plant requires a dependable quantity of water. The executives of the plant feel that a large water user located upstream may reduce the quantity of water presently available to the plant.[2]

Food and Kindred Products

There are eight food processors located within the Roanoke River Basin which require water for processing or as a raw material. Inform-

---

[1] Ollie Wayne, Plant Manager, Questionnaire, International Telephone and Telegraph Company, Roanoke, Virginia, March 16, 1971.

[2] Ibid.

ation was available for five plants.[1] These are small companies which rely entirely on company-owned wells for their water supplies. However, each plant discharges wastes, either treated or untreated, into a river or stream of the Roanoke River Basin. All of these plants require water which meets the health standards of their state.

Produce Processors, Incorporated, of Bertie County, North Carolina, requires 2,400 gallons of process water per day during the peak period of production in the summer and early fall months. This water, which is obtained from a well, is used to wash vegetables which are cooked and packaged at the plant. Since the plant specializes in fresh vegetables, its operation is reduced during the winter months; and, therefore, the water requirements vary. The company has constructed two lagoons which serve as settling ponds. These ponds remove the solid organic material which would deplete the oxygen in the Cashie River into which the plant discharges its wastes.[2]

The Martin Dale Canning Company of Martin County, North Carolina, requires 1,750 gallons of water per day as both a processing and a raw material. Like Produce Processors, the plant processes vegetables. However, the Martin Dale Company cans its vegetables and requires some water as a raw material to be canned with the vegetables as cooking juices. The plant has one lagoon which serves as a settling pond to remove the solid organic material. Thus, this oxygen-demanding organic matter is not discharged into Sweetwater Creek which receives the com-

---

[1]Information was available on the following plants: Produce Processors, Incorporated, Bertie County, North Carolina; Martin Dale Canning Company, Martin County, North Carolina; Perfect Packed Products, Henderson, North Carolina; Gunnoe's Sausage Company, Goodes, Virginia; and W. A. Parker Canning Company, Thaxton, Virginia.

[2]North Carolina Department of Air and Water Resources, "Significant Sources of Waste Discharged." (Mimeographed).

pany's wastes. The North Carolina Department of Air and Water Resources has not received any complaints concerning the company's discharge of wastes.[1]

The Perfect Packed Products Company of Henderson, North Carolina, cans pickles, olives, peppers, and cherries.[2] The company's total employment increases to 600 during the peak growing season in the summer months.[3] Production requires an average of 7,000 gallons of water per day. Of course, this figure is higher during the summer months.[4] Primary treatment facilities were first constructed in 1959.[5] By order of the North Carolina Department of Air and Water Resources, the plant constructed an aeration lagoon in 1968 at a cost of $75,000.[6] Before discharging the wastes into Nutbush Creek, the facility treats all processing wastes and removes all solid organic material by settling action and aids in replenishing the oxygen by aeration. The company, which obtains its water from the Town of Henderson, has not experienced any problems in either the supply or quality of its process water.[7] In addition, there have been no complaints concerning the company's discharge of wastes

---

[1]North Carolina Department of Air and Water Resources, "Significant Sources of Waste Discharged." (Mimeographed).

[2]Sidney Rubin, Plant Manager, Questionnaire, Perfect Packed Products Company, Incorporated, Henderson, North Carolina, April 8, 1971.

[3]Ibid.

[4]North Carolina Department of Air and Water Resources, "Significant Sources of Waste Discharged." (Mimeographed).

[5]Rubin, Questionnaire, April 8, 1971.

[6]North Carolina Department of Air and Water Resources, Fifth Biennial Report. (Raleigh, North Carolina: North Carolina Department of Air and Water Resources, January 1969), p. B-27.

[7]Rubin, Questionnaire, April 8, 1971.

since the plant improved its facilities in 1968.[1]

The W. A. Parker Canning Company of Thaxton, Virginia, cans tomatoes and employs an average of thirty-five people. The plant requires 1,100 gallons of water daily, as both a processing material and as a raw material, all of which are obtained from wells.[2] Five-hundred gallons of water are required daily for the washing of tomatoes; and the remaing 600 gallons, which are used to cook the tomatoes, are canned with the vegetable. This company is one of two food processors in the river basin which does not currently operate waste treatment facilities. However, in the washing of tomatoes, the water does not acquire significant amounts of organic material or harmful chemicals and, therefore, does not affect the Big Otter River which receives the wastes. To date, no action has been taken to force the company to construct facilities to treat the process water, and no fish kills have resulted from the discharge of untreated process water.[3]

The Gunnoe's Sausage Company of Goodes, Virginia, employs fifty people and specializes in the preparation of pork sausage. Preparation of the meat requires 6,000 gallons of water per day for washing purposes. At present, none of this process water is treated before being discharged into the Big Otter River. This has resulted in the discharge of substantial amounts of organic matter into the river. The result has been problems of odor and oxygen depletion. The Virginia State Water Control Board has ordered the company to construct a lagoon treatment system

---

[1]Taylor, Interview, February 12, 1970.

[2]W. A. Parker, President, Interview, W. A. Parker Canning Company, Thaxton, Virginia, April 2, 1971.

[3]Ibid.

which would remove the organic material by settling action.[1]

The plant obtains all of its water from a company-owned well. There have not been any problems in the quality of the supply. However, the quantity of the supply has fluctuated greatly. The company, which does not have access to a municipal water supply, foresees this as its major future water-associated problem.[2]

The food and kindred products producers within the Roanoke River Basin have not had a serious effect on the water quality of the basin. In addition, this group is the least concerned with the effect of pollution on surface water supplies since all of the plants obtain water from either wells or municipal sources. Therefore, these plants will receive little attention in the subsequent discussions of the effect of water pollution on industrial location and development in the Roanoke River Basin.

Textiles

There are fourteen textile plants in the Roanoke River Basin. Information was available for seven of these plants.[3] Due to the high level of purity which is required in the process water used by textile producers, these plants all require water which is free of suspended solids, color, and iron and low in hardness. In addition, the textile group has,

---

[1]C. O. Gunnoe, President, Questionnaire, Gunnoe's Sausage Company, Goodes, Virginia, April 1, 1971.

[2]Ibid.

[3]Information was available for the following plants: Beaunit Mills, Incorporated, Martin County, North Carolina; Bassett-Walker Knitting Company, Martinsville, Virginia; Virginia Krafts, Incorporated, Keysville, Virginia; Klopman Mills, Incorporated, Altavista, Virginia; Martin Processing Company, Martinsville, Virginia; Fieldcrest Mills, Incorporated, Fieldale, Virginia; and Dan River Mills, Incorporated, Danville, Virginia.

in some cases, seriously affected the quality of water within the river basin by discharging large amounts of organic material, toxic substances, alkaline material, and heated wastes which raise the temperature of the receiving river or stream.[1]

The Beaunit Mills, Incorporated, of Martin County, North Carolina, produce knit fabrics.[2] The plant's production requires 1,200,000 gallons of water per day, which are used to wash and dye the knitted fabric.[3] This water is treated before being discharged into the Roanoke River. Until 1967, these wastes were treated by circulation through a settling pond. In 1967, the plant improved its treatment facilities by adding a mechanical aerator at a cost of $30,000. The North Carolina Department of Air and Water Resources has not received any complaints during the past five years concerning waste discharges from the plant.[4]

Fieldcrest Mills, Incorporated, of Fieldale, Virginia, produces terry cloth towels and employs 1,500 people. The plant requires 1,250,000 gallons of water per day for both washing and dyeing purposes. This water, which is obtained from the Smith River, must be free of solids, and neither acidic nor alkaline.[5] Such stringent requirements have caused the company problems in the past because of industrial effluents

---

[1]James C. Pangle, "An Approach to Stream Pollution Abatement," Danville, Virginia: Research Division, Dan River Mills, Incorporated, January 1969), p. 125.

[2]North Carolina Department of Labor, North Carolina Directory of Manufacturing Firms 1968. (Raleigh, North Carolina: North Carolina Department of Labor, 1968), p. 22.

[3]North Carolina Department of Air and Water Resources, "Significant Sources of Wastes Discharged." (Mimeographed).

[4]North Carolina Department of Air and Water Resources, Fifth Biennial Report, p. B-24.

[5]W. O. Stone, Division Vice-President, Questionnaire, Fieldcrest Mills, Incorporated, Fieldale, Virginia, January 6, 1971.

being discharged by industries located upstream. The Bassett and Stanley Furniture Companies, the Bassett Mirror Company, and the Martin Processing Company, all of which have discharged substantial amounts of effluents in the past, have been primarily responsible for lowering the quality of the process water withdrawn from the river by the Fieldcrest plant. This situation seriously affected the Fieldcrest plant in 1969 and in 1970, causing a curtailment in the production process due to the lowered quality of the water received from the Smith River.[1]

The company first installed water treatment facilities in 1965. This facility consisted of a settling pond and a simple gravel filtering system. At its own initiative, the plant is in the process of upgrading its treatment facilities by adding an aeration pond. This will reduce the amount of oxygen-depleting material which the company discharges into the Smith River. At present, the wastes discharged by the plant create large amounts of foam in the river, but this readily breaks up and disappears approximately 100 yards downstream. The plant has never received any reprimands from the State of Virginia and has never been responsible for any fish kills.[2]

The Bassett-Walker Knitting Company of Martinsville, Virginia, produces knitted fabric and employs 1,500 people. The plant requires 300,000 gallons of water per day for the washing and dyeing of the fabric which is produced by the plant. All of the water is derived from wells and is pure, requiring only softening prior to use in processing.

The plant began construction of waste treatment facilities in 1969. These facilities, which provide both settling and aeration ponds, were

---

[1]Philpott, Interview, January 3, 1971.

[2]Stone, Questionnaire, January 6, 1971.

Fig. 4. At present, the wastes discharged by Fieldcrest Mills create large amounts of foam in the river,....

Fig. 5. ....but this readily breaks up and disappears downstream. Scenes on the Smith River at the Fieldcrest Mills effluent discharge.

completed in January 1971. Since completion of the facilities, all wastes are treated before being discharged into the Smith River.[1]

Because the plant acquires all of its water from wells, it has not suffered from inferior water quality caused by the discharge of industrial or municipal effluents upstream. Although the existing treatment facilities were constructed by order of the Virginia State Water Control Board, the company has never been involved in any fish kills or any legal action resulting from its discharge of wastes.[2]

Klopman Mills of Altavista, Virginia, which is a division of Burlington Industries, employs 950 people. The plant produces polyester-cotton fabrics and requires 5,000,000 gallons of process water per day. This water is required for the dyeing and washing of the fabric. The plant withdraws water from the Roanoke River and uses it in the production process without prior treatment. The Roanoke River provides water which is naturally free of turbidity and is soft.

At present, the plant operates a primary treatment system which consists of a settling pond. All of the process water used by the plant is treated in this facility before being discharged. The plant is currently involved in a construction program which will add concrete walls to the existing settling ponds to prevent erosion and an aeration system to reduce the oxygen-depleting material. These improvements in the existing facility will cost $650,000.[3]

---

[1] L. D. Walker, President, Questionnaire, Bassett-Walker Knitting Company, Incorporated, Martinsville, Virginia, April 14, 1971.

[2] Ibid.

[3] J. B. Tallison, Vice-President and General Manager, Questionnaire, Klopman Mills, Incorporated, Altavista, Virginia, January 11, 1971.

Klopman Mills is extremely proud of its treatment facilities and voluntarily coordinated its improvement efforts with the Virginia State Water Control Board.[1] In addition, the pollution control efforts of the plant have had the approval and support of the citizenry of Altavista, Virginia.[2] The concern of Klopman Mills for the protection of the water resources in the Roanoke River Basin was exemplified by J. B. Tallison, Vice-President, when he stated, "Every business and municipality along this important river should take every step necessary to protect our water supply."[3]

Virginia Krafts, Incorporated, of Keysville, Virginia, employs 300 people and produces tufted rugs. The plant requires 536,000 gallons of process water per day, which are obtained from the Ash Camp Creek, a tributary of the Roanoke River. During the summers of 1963 and 1964, the quantity of water available in the creek was insufficient due to drought, and the plant had to stop production. The quality of the water withdrawn from the creek has been sufficient and meets the requirements of low turbidity and softness.[4]

At present, the plant does not treat its wastes and discharges them directly into Ash Camp Creek. However, the plant is currently designing a primary treatment system which will provide for settling ponds. Con-

---

[1] Altavista Journal, "Klopman To Build Costly Plant To Control Effluent." (Altavista, Virginia: Altavista Journal, April 16, 1970) p. 8.

[2] Ibid.

[3] J. B. Tallison, Vice-President and General Manager, Letter to Timothy Dale Holland, Klopman Mills, Incorporated, Altavista, Virginia, January 11, 1971.

[4] J. C. Kiepe, Jr., President, Questionnaire, Virginia Krafts, Incorporated, Keysville, Virginia, April 7, 1971.

struction of the facility will be completed in the fall of 1971.[1] This facility will reduce the levels of dye, bleach, acetic acid, and salt which are currently being discharged into the creek. The discharge of untreated wastes has not resulted in any fish kills or complaints from the citizens of the area. However, construction of the proposed facility was ordered by the Virginia State Water Control Board.[2] The present amount of effluents being discharged by the plant would adversely affect the location of water-dependent industries downstream.

Dan River Mills, Incorporated, of Danville, Virginia, is the largest water-dependent industry within the river basin. The plant, which produces multiple types of textiles, employs 9,000 people. Water is required in the production process for the dyeing and washing of the textiles. At present, the plant uses 16 million gallons of water per day, all of which are acquired from the Dan River.[3]

The plant requires process water which is soft and has no turbidity, color, iron, or manganese. Water meeting these requirements may be obtained from the Dan River and used in the production process without receiving prior treatment. Dan River Mills has been fortunate in that there are no industries located immediately upstream which discharge effluents into the river.

Currently, 6 million gallons of the plant's wastes are treated by the City of Danville. All of the municipally treated wastes are dis-

---

[1] Ibid.

[2] Ibid.

[3] James C. Pangle, Jr., Pollution Control Engineer, Questionnaire, Dan River, Incorporated, Danville, Virginia, January 8, 1971.

charged from the dye process.[1] A portion of the remaining 10 million gallons is treated before being discharged into the river. All of the untreated and plant-treated wastes are discharged from the finishing process. These wastes contain large amounts of oxygen-depleting organic materials which come from natural impurities present in cotton. Such impurities are removed during the washing and finishing process.[2] Until 1970, all of these wastes were discharged into the river without receiving treatment. In view of the increasing State and Federal pollution control requirements and penalties, the plant personnel began to investigate economical and effective approaches to waste control. The system which was installed in 1970 is a model of efficiency but only treats 2 million gallons of waste per day, leaving 8 million gallons of waste untreated.[3]

Dan River selected an experimental approach to determine which waste treatment process would require the least area and the smallest financial investment. The existing treatment facilities consist of an activated sludge unit which treats wastes by mechanical mixing combined with chemical and biological action, anaerobic lagoon which utilizes simple biological action, and an aerobic lagoon which relies on mechanical aeration. The project is still in its experimental stages; but the plant has come to the conclusion that the sludge unit requires the least land (which is an important factor for a plant located in an urban area), the anaerobic

---

[1] Ibid.

[2] Pangle, "Approach to Stream Pollution Abatement," January 1969, p. 121.

[3] Herbert M. Dawson, Superintendent of Water Production, Letter to Walter E. Mather, Water, Gas, and Electric Departments, Danville, Virginia, March 31, 1971.

lagoon costs the least to operate, while the aerobic lagoon provides the best reduction of oxygen-demanding wastes.[1] The City of Danville currently has an application submitted to the Department of Housing and Urban Development for the expansion and improvement of its municipal waste treatment facility. Dan River Mills will not invest any more money in its treatment facilities until a decision is reached on the Danville application. If the application is approved, Dan River will then consider the economic feasibility of having all of its wastes treated by the facility.[2] The plant will have to decide on a solution in the near future. The Virginia State Water Control Board will not allow the plant to continue discharging untreated wastes.

The Martin Processing Company of Martinsville, Virginia, will be discussed in detail in Chapter Three, page 71, and, therefore, will receive only minimal attention in this chapter. The plant specializes in dyeing mylar and textiles. The dyeing process requires 800,000 gallons of water per day, which are obtained from the Smith River. The plant currently operates waste treatment facilities; but they are inadequate, and improvement has been ordered by the Virginia State Board of Water Control.[3]

Significant Concentrations of Water Pollution

There are four major pollution problem areas in the Roanoke River Basin which are the result of the discharge of industrial effluents. These problem areas are the result of the cumulative effect of discharges

---

[1]Pangle, "Approach to Stream Pollution Abatement," January 1969, p. 125.

[2]Dawson, Letter, March 31, 1971.

[3]William C. Overman, Engineer, Questionnaire, Langley, McDonald, and Overman, Norfolk, Virginia, January 29, 1971.

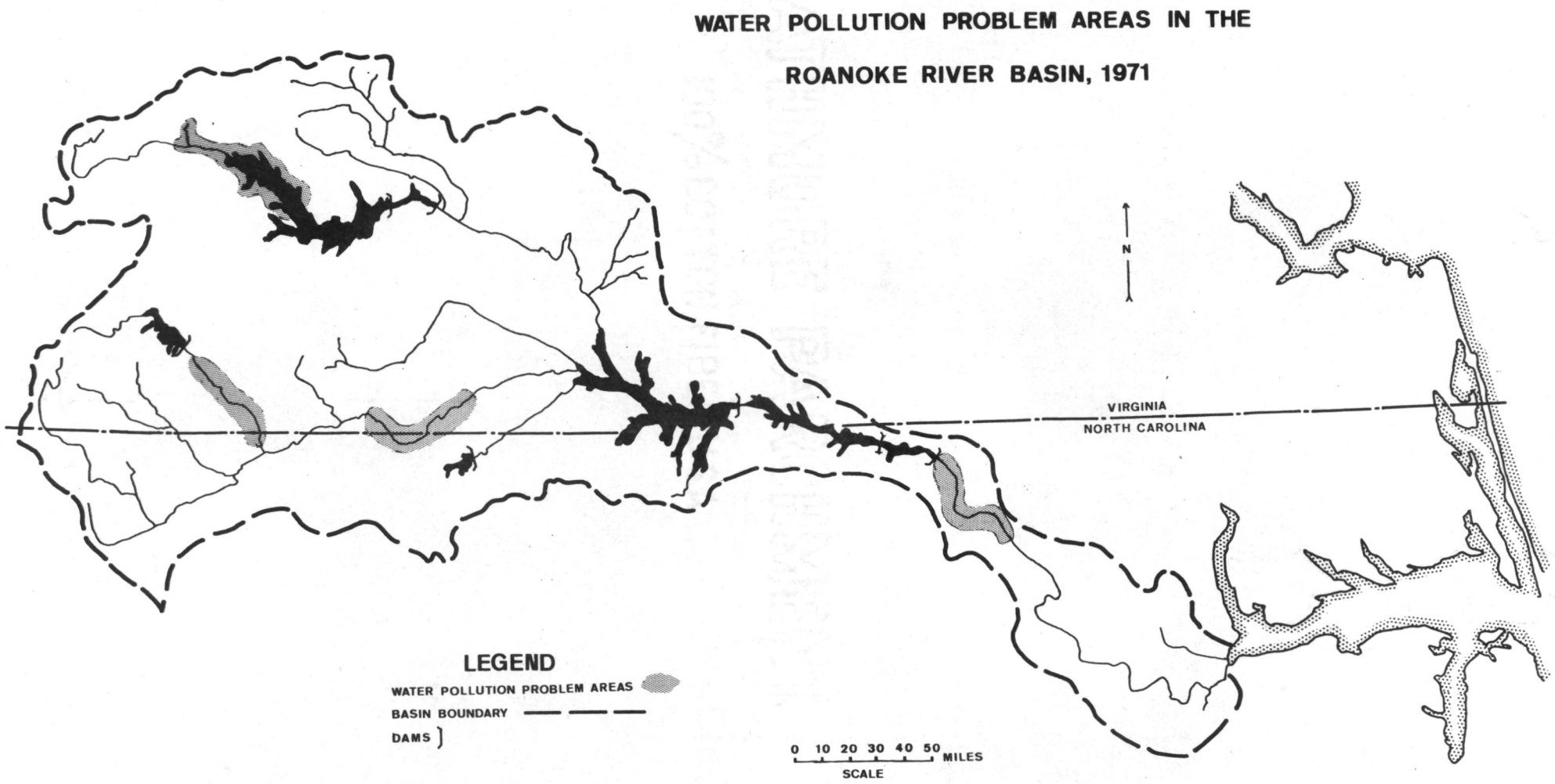

WATER POLLUTION PROBLEM AREAS IN THE
ROANOKE RIVER BASIN, 1971
N
VIRGINIA
NORTH CAROLINA
LEGEND
WATER POLLUTION PROBLEM AREAS
BASIN BOUNDARY
DAMS
0 10 20 30 40 50 MILES
SCALE

Fig. 6

from several industries. The location of these areas is based on numerous interviews and investigations undertaken during the preparation of this study. A statistical correlation of industrial concentrations and water pollution was attempted. However, due to insufficient water samples, such an approach was impossible. The areas identified (see Fig. 6) are sufficiently polluted to affect the use of the water for recreational, industrial, and drinking purposes.

Smith River

In 1969, the duPont Nylon Plant of Martinsville, financed a biological study of the Smith River. This study was undertaken by several professors in the Department of Biology at Virginia Polytechnic Institute and State University. The final report stated that the Smith River was almost completely dead as a result of the discharge of industrial effluents.[1] Within a three mile segment of the river, there are six major water-dependent industries discharging 2,463,000 gallons of wastes per day. The singular discharge from any one plant would not seriously affect the river, which has a high gradient and provides good natural aeration and treatment of wastes. The six plants are currently discharging alkaline materials, solvents, phenols, acidic materials, and organic oxygen-demanding materials. The combination of these has seriously affected the use of the river as a source of drinking water and as a future location for water-dependent industries requiring high-quality water. In addition, the Smith River is designated as a state trout stream. The discharge of industrial effluents has seriously affected the propagation

---

[1] A. J. McGinty, Plant Manager, Interview, duPont Nylon Plant, Martinsville, Virginia, December 15, 1970.

of trout and has necessitated periodic stocking of the stream in order that it be maintained as a trout stream.[1]

Smith Mountain Lake

The discharge of industrial effluents by the metal fabricating and electrical and food processing industries in the City of Roanoke have resulted in serious water pollution problems in Smith Mountain Lake and that portion of the Roanoke River located between the city and the lake. The industries located in Roanoke have discharged heavy metals, toxic compounds, organic materials, and acidic materials into the river. The problem is serious enough that if the discharge of all wastes into the Roanoke River were stopped, it would take a minimum of two years to return the lake to its natural state.[2] The major problem has been the high concentrations of acidic waste which are primarily the result of the industrial discharges from the Roanoke Steel and Electric Company and the Norfolk and Western Railroad Shops of Roanoke.[3] A process of eutrophication has already begun in the upper reaches of the lake. This process is extensive growth of algae in a water body which is caused by an excess of plant nutrients. In the case of Smith Mountain Lake, the problem is being increased by industrial effluents. The excessive growth of algae rapidly depletes oxygen and creates odor problems. The eutrophication process prohibits the use of water for industrial, drinking, and

---

[1]Philpott, Interview, January 3, 1971.

[2]John D. Healy and Herbert N. Hamric, III, Environmental Plus or Minus? (Lynchburg, Virginia, Central Virginia Planning District Commission, August 1970) p. 2.

[3]Jack Hoffman, Chief of Fish Division of The Commission of Game and Inland Fisheries, Meeting of the Reservoirs Regional Committee, Bedford, Virginia, April 14, 1971.

recreational purposes.[1]

Lower Dan River

The pollution problem which exists in the Dan River is primarily the result of the effluents discharged from the Dan River plant. There are other industrial effluents treated by the municipal treatment facility, but these are adequately treated. The wastes discharged from the Dan River Mills are particularly important because of their effect on the fish population of the Dan River. When the Corps of Engineers constructed Kerr Dam on the Roanoke River, several species of fish and one in particular, the striped bass, were landlocked. This fish population, plus fish placed there by the Virginia Game and Fish Commission, choose the Roanoke River for spawning. However, the Appalachian Power Company chose to build a dam, the Smith Mountain Dam; and, with the construction of this dam, the fish chose the Dan River for spawning. This new spawning route takes these fish into the Danville area of the river which receives the Dan River wastes.[2] Additional development of water-dependent industries in the Danville area could seriously affect the fish population in the river and prevent recreational and municipal uses of the river.

Roanoke River at Roanoke Rapids

That portion of the Roanoke River which is located between Roanoke Rapids, North Carolina, and Weldon, North Carolina, has been seriously affected by industrial water pollution. The main sources of the pollution are the Albemarle Paper Company, the Federal Paper Board Company,

---

[1]Healy and Hamric, Environmental Plus or Minus?, p. 1.

[2]Pangle, "Approach to Stream Pollution Abatement," January 1969, p. 122.

and the Roanoke Rapids municipal system. Roanoke Rapids' municipal system treats substantial amounts of industrial wastes, most of which come from the J. P. Stevens textile plants which are located in the city.[1]

Of the three sources of waste discharge, the Albemarle Paper Company is the most serious. There have been numerous complaints from fishermen concerning Albemarle's discharge of effluents. In some instances, the pulp material in the river has been concentrated enough to coat fishing lines.[2] The presence of effluents in such amounts will prevent the use of the water for drinking purposes and most industrial uses.

The problem in this area of the river basin is particularly serious because striped bass spawn there every spring. The result has been periodic fish kills of substantial size, the last of which occurred in 1967. It was the cumulative effect of the three sources of pollution which caused the fish kills.[3]

Improved treatment facilities at the Albemarle Paper Company are the primary reason that there have not been any major fish kills since 1967. However, the situation is still critical. Albemarle plans to install an improved treatment facility in 1972 which will substantially reduce the amounts of organic material, rosin soap, and tannic acid being discharged into the river.[4] Such improvements will alleviate much of the existing

---

[1]Taylor, Interview, February 12, 1970.

[2]Colonel J. A. Denison, Commander of the Wilmington District, Army Corps of Engineers, Meeting of the Roanoke River Basin Association, 4-H Center, Smith Mountain Lake, Virginia, May 21, 1971.

[3]Taylor, Interview, February 12, 1970.

[4]J. W. Gladstone, Technical Service Superintendent, Interview, Albemarle Paper Company, Roanoke Rapids, North Carolina, February 5, 1970.

problem and make the area more attractive for recreational uses and the future development of water-dependent industries.

Summary

There is a wide distribution of water-dependent industries within the basin. Forty plants depend on the basin's surface waters as either an effluent carrier or as a water supply. This industrial use of the basin's waters has created serious water pollution problem areas. In each case, there is a direct connection between the pollution problem areas and industrial concentrations within the river basin. The effect of these problem areas on the existing and future industrial development in the basin will be discussed in Chapter Four.

CHAPTER III

CASE STUDIES

The first two chapters of this study dealt with industrial water pollution in the Roanoke River Basin in broad categories. This initial approach defines the problems inherent to industrial water pollution and gives one some perspective of the magnitude of industrial water use within the Roanoke River Basin and the United States as a whole. But general statements based on specific problems and statistics often lose their clarity. One grasps more readily the information provided by the study of specifics.

Case studies have often been used in geography to clarify topics of interest and to provide a base from which the subject of study may be expanded. The case studies in this chapter will serve such a purpose, linking the generalities of the first two chapters to the specific problems discussed in the final two chapters.

The following three industries were selected for the case studies: the Weyerheauser Company, Plymouth, North Carolina; the Albemarle Paper Company, Roanoke Rapids, North Carolina; and the Martin Processing Company, Martinsville, Virginia. These industries were selected because the problems confronting them in water pollution abatement are felt to be representative of water pollution control problems in the Roanoke River Basin. Problems in water pollution abatement stem from regional location, site selection, legal controls, production processes, waste treatment facilities, and attitudes toward environmental protection.

When the three industries located at their present sites, the adjacent rivers were considered only as sources of water and as vehicles for the discharge of effluents. Little attention was devoted to the protection of the rivers. As a result of this attitude, the development of each plant was accompanied by increasing water pollution control problems.

Two of the three plants now find themselves located at sites which, from the viewpoint of topography, economic production, and water quality, are less than desirable for the optimum treatment of wastes. This situation is the norm and not the exception for water-dependent industries in the Roanoke River Basin. The ensuing case studies will demonstrate that considerations of waste control facilities will be an important factor in future locational decisions for water-dependent industries in the future.

The Weyerheauser Company

The Weyerheauser Paper Company at Plymouth, North Carolina, is located adjacent to the Roanoke River eight miles upstream from the river's entry into Albemarle Sound. The plant site is situated on a narrow peninsula which is surrounded by the river on one side and a hardwood swamp on the other. This location was originally chosen in 1937 by the Kieckhefer Container Company which owned the plant until 1957.[1]

---

[1]H. Scott Jenkins, Technical Director, Interview, Weyerheauser Company, Plymouth, North Carolina, February 26, 1970.

The Locational Decision

The Kieckhefer Company's decision to locate in the South was accompanied by a massive expansion of the South's paper and pulp industry between 1929 and 1941. During this twelve-year period, the number of integrated facilities in the South increased by twenty-one.[1] Originally the Plymouth plant produced only 150 to 200 tons of pulp per day. But the mill was converted to an integrated facility in 1940 with the addition of one paperboard machine.[2] The factors which influenced the rapid expansion of the South's paper and pulp industry are also the reasons for the Kieckhefer Company's decision to locate a mill at Plymouth.

Factors Affecting the Regional Location

Considerations of environmental protection did not enter into the Kieckhefer Company's decision to locate a mill in the South. Since the discharge of industrial effluents was largely uncontrolled by both state and federal sources, the costs involved in adequate waste treatment facilities were not considered. The only concern as to waste disposal was the availability of water as a vehicle in which to dispose of wastes. The South had an abundance of water which, in 1937, solved the only requirement for waste discharge.

The important factors in the regional location were those which would reduce the costs involved in the acquisition and assembly of raw

---

[1]Olin L. Mouzon, "The Southern Pulp and Paper Industry, Its Past, Its Significance, Its Future," Southern Pulp and Paper Manufacturer, IV (October 1, 1941), p. 22.

[2]Weyerheauser Paper Company, "Weyerheauser Plymouth Complex Strengthens Economy in Eastern North Carolina." Plymouth, North Carolina, 1965, (Mimeographed).

materials. The paper and pulp industry has traditionally been raw-material oriented. Plants which process pulp into paper may be market-oriented, but integrated facilities and pulp plants are raw-material oriented.[1]

During the 1920's and 1930's the supply of wood in the Great Lakes States began to decline. In their search for new forested areas, the paper and pulp industry turned to the South. At this time, the cotton acreage in the South was rapidly declining; and this released 4,000,000 to 5,000,000 acres of farmland for forests.[2] In addition, the long growing season and the vast expanse of rapidly growing pine forests provided for rapid reforestation of the land.[3] The 210,000,000 acres of forested land in the South provided a short term solution to the problem of diminishing forest resources in the North. Several other factors encouraged the southern location. There was an increasing availability of labor in the South's rural areas. In 1930, the farms required 854,000 fewer man hours of labor than had been required in 1900.[4] Thus, many men were released from farm labor and were looking for employment. In addition, the rivers of the South's Coastal Plain provided opportunities for water transportation via barge. This gave access to the Intercoastal Waterway, providing a direct link to the major markets in the Northeast. Not only was the water transportation of products economical, but competition

---

[1]Gunnar Alexandersson, Geography of Manufacturing (Prentice Hall, Inc., Englewood Cliffs, N. J. 1967), pp. 105-106.

[2]Mouzon, Southern Pulp and Paper, p. 20.

[3]G. Sterling Bailey, Director of Environmental Resources, Interview, Weyerheauser Company, Plymouth, North Carolina, February 26, 1970.

[4]Mouzon, Southern Pulp and Paper, p. 22.

with railroads served to hold down the cost of the shipment of products by rail.[1] For these reasons, the Kieckhefer Company chose to locate in the South in 1937.

Site Selection

As in the regional location, consideration of waste control and water pollution prevention did not enter into the selection of a site. However, water availability was the most important factor in the selection of a site. In 1937 all of the Kieckhefer paper plants were located in the North. Cheap transportation of pulp was a necessity and the location at Plymouth provided a twelve-foot channel which was ample for barge traffic and was only fifty-one miles from the Intra-coastal Waterway. The significance of this is demonstrated by the fact that over one-half of the pulp initially produced at the Plymouth plant went to the Kieckhefer paperboard plant in Delair, New Jersey, via the Intercoastal Waterway. The remaining pulp went by rail to the Kieckhefer plants in White Pigeon and Three Rivers, Michigan.[2] Of secondary importance was the availability of water for the production process. The initial production of pulp placed minimum requirements on the quality of the water supply. Since the water was used only to produce steam for power and to wash and boil wood chips, the only requirements were that the water not have a corrosive effect on the machinery and that the supply be dependable. The Roanoke River, being a fresh water body and low in acidity, was not corrosive and the average flow at Plymouth of 4,200 cubic feet per

---

[1] Bailey, Interview, February 26, 1970.

[2] "Plymouth Awakes," The State, (Raleigh, North Carolina: State Printing Office, August 28, 1937) p. 2.

second was more than ample.[1] At a later date, when the mill began to produce large quantities of paper, the quality of the process water would increase in importance. Of least significance was the availability of the river as an effluent carrier. The design of the plant site in 1937 made no provisions for waste treatment facilities and for the recirculation of process water. All effluents were discharged directly into the river without any regard for the ecology of the Roanoke River.[2]

The site selection showed little consideration of topographic factors. The land is only a few feet above sea level and provides no rock base upon which to construct large buildings. In fact, the entire mill has been constructed on pilings. However, this location is justified by a long-term reduction in transportation costs. In addition to being adjacent to the river, the site is within one-half mile of Norfolk Southern and Atlantic Coast Rail Lines. Direct connections are provided by spur lines. Since construction of spur lines over one-half mile in length is often prohibitive, the location was ideal. The Plymouth site was surrounded by vacant land, a portion of which Kieckhefer purchased and gave to the railroads for the construction of spur lines.[3] Thus, the site lay between two major transportation routes.

While the site did provide accessibility to transportation, the low elevation and surrounding swamp resulted in several floods. Until the Kerr Dam was constructed in 1953, the Roanoke River was subject to annual flooding. While the floods were not financially prohibitive to

---

[1]Bailey, Interview, February 26, 1970.

[2]Ibid.

[3]Jenkins, Interview, February 26, 1970.

the Kieckhefer Company, they did cause annual problems in production and maintenance.[1]

One of the most attractive factors in the Plymouth site was not recognized until 1965. Since the site was surrounded by vacant land, the plant grounds could be expanded. In 1965 when the first adequate waste treatment facilities would be constructed, this vacant land would allow for a tremendous savings in the construction of the waste treatment facility. This site, which was satisfactory in 1937, would increase in value as the importance and necessity of waste treatment control increased.

The Historical Development of The Weyerheauser Plant

During the twenty-year period in which the Kieckhefer Company owned the mill, it expanded from a pulp plant to an integrated facility producing linerboard for milk cartons, linerboard for the inner wall of cardboard boxes, and corrugating medium for the inner core of cardboard boxes. The maximum production capacity which the facility reached under the control of the Kieckhefer Company was 800 tons of paper per day.[2] In 1957 the Weyerheauser Company acquired the Plymouth mill through a merger with the Kieckhefer Company.[3]

The rate of production greatly increased under the Weyerheauser management to the current rate of 1,550 tons of paper per day.[4] This production is divided into 850 tons of linerboard, 200 tons of

---

[1] Ibid.

[2] Weyerheauser, "Weyerheauser Strengthens Economy."

[3] Ralph W. Hidy, Frank Ernest Hill, and Allan Nevins, Timber and Men: The Weyerheauser Story, (New York: MacMillian Company, 1963) p. 565.

[4] Bailey, Interview, February 26, 1970.

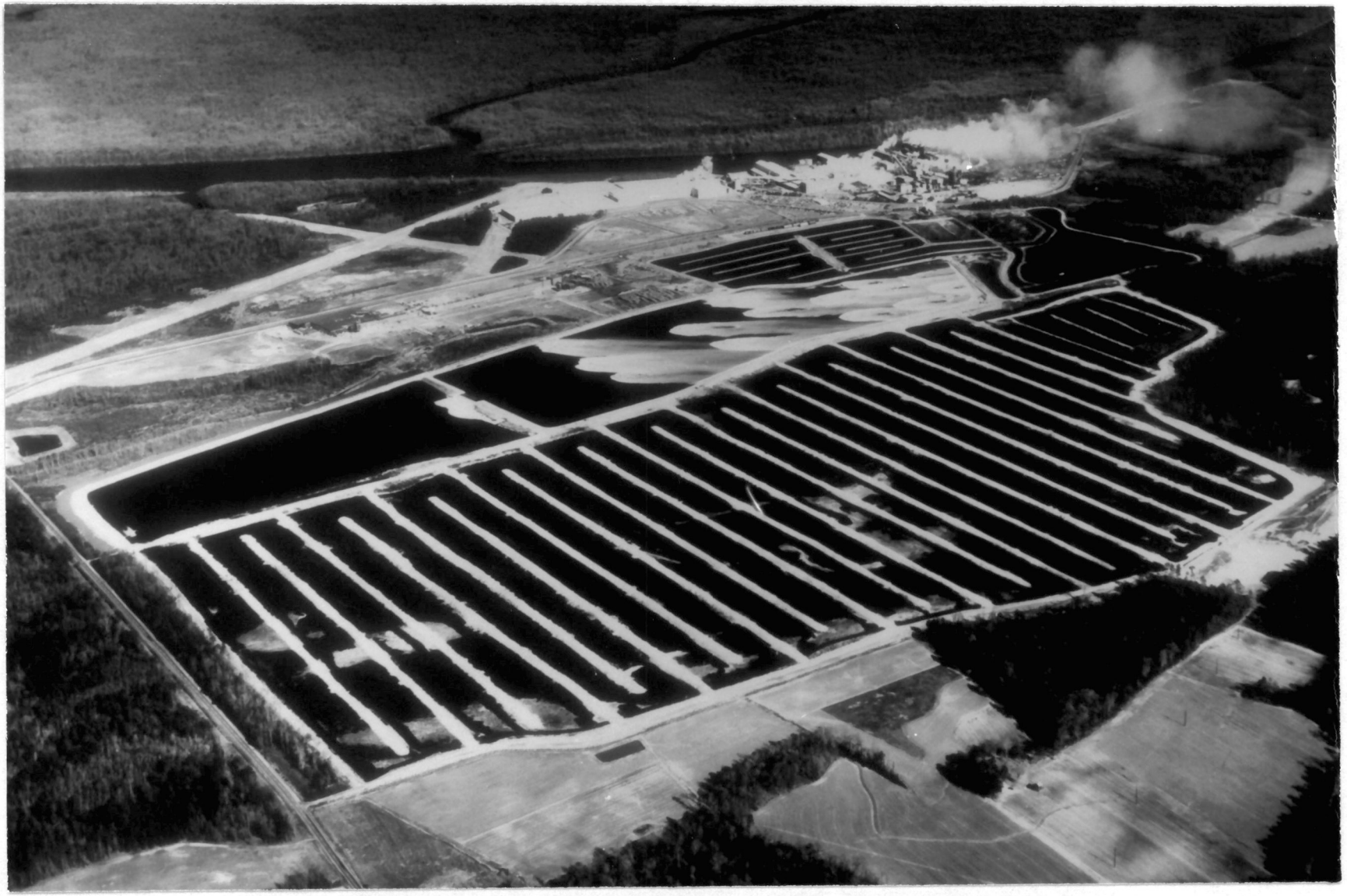


Fig. 7. Since the site was surrounded by vacant land, the plant grounds could be expanded. Aerial Scene at the Weyerheauser Plant.
Source: Weyerheauser Paper Company

corrugated paper, and 500 tons of bleached board daily.[1] None of this paper is processed at the Plymouth plant. Once processed into a final product such as boxes, the paper gains bulk. Therefore, the paper is shipped to market-oriented plants for processing. Distribution of the product is divided with 90 per cent going to Weyerheauser processing plants and the remaining 10 per cent being sold to competitors. Currently, the paper produced is transported predominately by rail, but small amounts are transported by barge and truck.[2]

The production rate requires 2,000 cords of wood per day. Weyerheauser has purchased 570,000 acres of land in Eastern North Carolina for the purpose of forestation.[3] However, this is not enough land to adequately supply the mill with wood. Supplementary supplies are purchased from individuals in Southeastern Virginia and in North Carolina as far west as Charlotte.[4] Transportation is divided with 50 per cent supplied by rail, 45 per cent supplied by truck, and 5 per cent supplied by barge. The amount being transported by barge has declined rapidly in the last fifteen years.[5]

The availability of lumber for the mill will increase in the future. Between 1960 and 1970 almost all counties in Eastern North Carolina showed a decline in population. Weyerheauser has taken

---

[1] G. Sterling Bailey, "Aerated Stabilization Treatment at the Weyerheauser, Plymouth Mill, NCASI, Atlanta, Georgia, August 14, 1969. (Mimeographed).

[2] Jenkins, Interview, February 26, 1970.

[3] Bailey, Interview, February 26, 1970.

[4] Jenkins, Interview, February 26, 1970.

[5] Bailey, Interview, February 26, 1970.

advantage of this decline, acquiring many abandoned farmsteads for the purpose of reforestation.

There are 1,800 people employed at the plant. Out of this total, 200 men devote 10 per cent or more of their time to waste treatment control.[1] This represents more than the normal amount of man hours devoted to waste control and demonstrates Weyerheauser's concern over the problem.

Water Pollution Control

Prior to 1957 there were no waste treatment facilities operated by the Kieckhefer Company at the Plymouth mill.[2] This had resulted in at least one major case of legal action against the mill. In 1941, a group of commercial fishermen sued the company for pollution of the Roanoke River and Albemarle Sound. The case was never settled because inadequate water sampling had not permitted the North Carolina Department of Air and Water Resources to specifically locate the source of pollution which had caused several fish kills.[3] This was the only legal action; but, undoubtedly, the untreated effluents had caused much damage to the quality of the river.

In 1956 when Weyerheauser assumed control of the plant, immediate steps were taken to instigate waste control facilities. This initial attempt at control began a long expensive process which has resulted in excellent control facilities. However, installation of the control facilities cannot be accredited solely to Weyerheauser initiative. One

---

[1] Ibid.

[2] Ibid.

[3] Taylor, Interview, February 12, 1970.

must realize that Federal and State legislation provided a great deal of prompting.

The most important North Carolina legal control is the classification prescribed for a particular water body. The classification, in part, determines the level of oxygen which must be present in the water. The Roanoke River is classified for industrial use, and at Plymouth the water in the river must contain at least three parts per million oxygen.[1] This stipulation is the major problem confronting the Weyerheauser mill. The mill discharges large amounts of tannic acid, color, and resin; but the oxygen-demanding wastes (organic materials coming from the pulp and wood chips) are the most harmful to the ecology of a river. The mill may discharge waste into the river which contains less than three parts per million oxygen. However, the flow of the river must be sufficient to dilute the wastes and maintain the specified oxygen content.[2]

The Weyerheauser Complex uses forty-two million gallons of water daily.[3] This figure would be considerably larger if the process water were not recycled 100 times. The sheer magnitude of this water usage presents considerable waste treatment problems. In 1958, the executives at the mill initially decided on a single retention pond with spraying devices to replenish the oxygen. This approach was used for five years.[4] Many pulp and paper mills have used this type treatment

---

[1] Ibid.

[2] Bailey, Interview, February 26, 1970.

[3] Ibid.

[4] Jenkins, Interview, February 26, 1970.

facility, but Weyerheauser found the method to be inadequate. In 1963, increases in pollution in the river and stricter legal controls forced a change. The decision was made that the most efficient method of treatment would be the installation of a system consisting of settling ponds, aeration ponds, and a retention pond.[1] With the installation of this system, the mill could discharge wastes containing three parts per million oxygen and not depend so heavily on the river for dilution. Not only is this system effective, but it is also relatively inexpensive. The only obstacle is the acquisition of large tracts of land near the plant site.[2]

Weyerheauser was extremely fortunate in that there was a large tract of vacant land adjacent to the plant site. The mill purchased 542 acres of this land. All but a few acres of this land were swamp.[3] Of course, this land was of low elevation and had very little relief, which did present some problems. The area was filled with wastes from an American Cyanamid plant located adjacent to the Weyerheauser mill. In addition to the fill problem, there was a problem of flow. If there had been greater relief in the area, gravity flow could have been utilized to move wastes through the system. As it was, the designers had to install six pumps with a capacity of 12,000 gallons per minute to move the wastes through the system.[4] These were minor problems and did not retard the construction of the system.

---

[1]Jenkins, Interview, February 26, 1970.

[2]Bailey, Interview, February 26, 1970.

[3]Bailey, "Aerated Stabilization Treatment." (Mimeographed)

[4]Jenkins, Interview, February 26, 1970.

The facilities are elaborate and effective, but they cost only two and one-half million dollars to construct and four hundred thousand dollars in yearly maintenance.[1] Land availability was the reason for the low cost. Most other southern mills cannot lay claim to such efficiency and economy.

External Pollution

External pollution is the presence of pollutants in the water taken by the mill from the Roanoke River. As in waste treatment, the problems of external pollution have increased through the years as the number of industries and the size of municipalities on the Roanoke River increased.

The executives at Weyerheauser feel that their improved waste control facilities have decreased their dependence on the river for dilution of wastes. This would permit them to locate a new mill of comparable size on a smaller river.[2]

Plant sites should be selected so that production costs can be kept at a minimum. Any time that the quality of incoming water is lowered, the plant is faced with production cutbacks or additional costs due to external causes. Situations such as this most often occur in heavily industrialized areas or where several large industries depend on a small stream. The Weyerheauser mill has experienced such diseconomies.

In July 1969 the oxygen content of the water which the Weyerheauser plant withdrew from the Roanoke River fell to less than one part per million oxygen.[3] Therefore, the wastes had to be retained longer to

---

[1] Ibid.

[2] Bailey, Interview, February 26, 1970.

[3] Ibid.

replenish the oxygen content (normal retention time is seven days).[1] A tremendous back-up of wastes occurred. If the low content of oxygen in the intake water had continued for two more days, the plant would have had to stop production. The problem, however, had become so serious in the twelve-day period that production had been reduced by one-third. The North Carolina Department of Air and Water Resources never ascertained the specific cause of the lowered oxygen content.[2] But the problem was the result of several industries and municipalities upstream discharging large amounts of waste simultaneously.[3] Stated simply, there was excessive dependence on the Roanoke River for the dilution of wastes.

To protect against external pollution and to improve the natural quality of the water, which is highly colored due to the surrounding swamp, the plant has installed an extensive water treatment system. The system consists of extensive chemical treatment and filtration. In fact, an American Cyanamid plant located adjacent to the Weyerheauser plant grounds was constructed for the sole purpose of supplying allum to the Weyerheauser water treatment system. This treatment system would not be necessary in another location providing clearer water and less possibility of industrial pollution.

Marketing Disadvantages Due to Water Pollution Control

There is one final problem connected with the plant's water

---

[1]Jenkins, Interview, February 26, 1970.

[2]Taylor, Interview, February 12, 1970.

[3]Bailey, Interview, February 26, 1970.

pollution control. The Weyerheauser Plymouth plant has suffered a slight marketing disadvantage in competition with firms located in states with laxer legal controls. Stringent controls such as those in North Carolina force the construction of extensive control facilities which raise production costs of the final product. Possibly such a marketing advantage could influence the locational decision for a new plant, but it is doubtful. If the predictions for increasing Federal control prove to be true, interstate variations in legal controls and marketing advantages will disappear and erase marketing advantages. The Weyerheauser executives feel that the interstate variation will be of decreasing significance in waste treatment costs.[1]

Summary

The Weyerheauser Company of Plymouth has been extremely fortunate in both land availability and water supply. The mill has had to combat only one case of external pollution. The availability of land allowed the economical construction of waste treatment facilities which would meet the specified legal requirements and protect the ecology of the river. The residents of the area are pleased with Weyerheauser's efforts. In fact, fishermen report that White Perch may be caught in the river adjacent to the mill site for the first time in fifteen years. The visible effects of any pollution from the mill are negligible. The plant discharges its wastes into Welch Creek 300 yards from the river. There is foam visible at the discharge point, but this breaks up before the water enters the river.

The factors which determined the initial location at Plymouth in

---

[1] Ibid.

1937 did not include considerations of waste control. The Weyerheauser Company was simply fortunate that the site provided land for expansion and low levels of external pollution.

The Albemarle Paper Company

The Albemarle Paper Company is located in Roanoke Rapids, North Carolina, and was owned by the Halifax Paper Company until 1937.[1] In 1906, when the site was selected, there was ample room for expansion. However, in the ensuing years, expansion of the town and industrial development have restricted the possibilities for expansion of the plant site.

The Locational Decision

The location of the Halifax Paper Company at Roanoke Rapids in 1906 was the first attempt at utilizing southern pine for paper production. In 1909, the mill became the first in the United States to use the sulfate process.[2] Pulp produced by this process is used for bags, wrapping paper, and boxes. The initiation of this process, which worked well with southern pine, served as a major example to lure other mills to the South.

Factors Affecting the Regional Location

The mill was a leader in the southern movement of the paper and pulp industry. However, like Weyerheauser, water pollution control was of no concern and did not influence the locational decision. The reasons for its Southern location are the same as those which prompted the Weyerheauser location in the South and the massive expansion of the industry in the South between 1929 and 1941. The locational factors were

---

[1] Gladstone, Interview, February 5, 1970.

[2] Ibid.

increasing land availability for forests, accessibility to raw materials, the long growing season, labor availability, and a plentiful water supply.[1]

However, the Albemarle representatives emphasize one factor which the Weyerheauser people did not. Albemarle felt that the South offered fewer labor problems in 1909 than the Northern sections of the country. They feel that this is still true today.[2] Weyerheauser representatives feel that this would be an important locational factor now but was not a significant factor in the early 1900's.[3]

Site Selection

The Halifax Paper Company was not able to locate at the initial site which they selected. The company had preferred a site at Weldon because the town is at the junction of the Atlantic Coast Line, Air Line, and Seaboard Rail Lines. However, there was considerable sentiment in Weldon against industrial development. Consequently, the mill was located at Roanoke Rapids; and this served as a major factor in the growth of Roanoke Rapids to dominance over Weldon. The site was connected by a spurline to the Seaboard Rail Line. The main line was within one-half mile of the site, and thus the cost of the spurline was not prohibitive.

The consideration of water by the Halifax Company was the most important factor in site selection but had a different orientation than that of Weyerheauser. Of course, an ample water supply was a necessity

---

[1]Gladstone, Interview, February 5, 1970.

[2]Ibid.

[3]Bailey, Interview, February 26, 1970.

for processing and the discharge of effluents; but the factors of power and transportation differed. Until 1937, the plant depended entirely on water for power whereas Weyerheauser had depended on coal. By 1937, the plant had reached a size which prohibited reliance on the river for power; and the plant began to purchase all of its electricity.

The Weyerheauser site had a strong orientation towards water transportation which was not significant at the Halifax site. The location of Roanoke Rapids above the fall zone prevented access to the Intra-Coastal Waterway by barge. Therefore, the Halifax Company relied entirely upon truck and rail transportation of both raw materials and products. Although the railroads were not in direct competition with water transportation at Roanoke Rapids, the Halifax Company still obtained some rate reductions. The major one was a special rate on pulp shipped in a damp state (50 - 55% water) to an Albemarle Paper Plant in Richmond, Virginia.[1]

Minimum requirements were placed on water quality. In 1906, the industrial development on the river had not reached portions which warranted concern over lowered water quality due to industrial effluents. The gradient of the river at Roanoke Rapids caused greater turbidity than that at Plymouth, but the quality was still sufficient for Halifax's production process. The alkalinity was low, and there were no natural chemicals in the water which would have a corrosive effect on machinery. But unforeseen industrial development in the following years seriously impaired the water quality.

The initial site was only 20.5 acres in size. This was an ample

---

[1]Gladstone, Interview, February 5, 1970.

Fig. 8. The initial site was only 20.5 acres in size. This was an ample amount of land in 1906, but the ensuing years brought an expansion of Roanoke Rapids and conflicting industrial development around the site. Aerial at the Albemarle Paper Company.
Source: Albemarle Paper Company

amount of land in 1906, but the ensuing years brought an expansion of Roanoke Rapids and conflicting industrial development around the site. At a later date, when waste control facilities became imperative, the lack of land availability and increased land cost magnified the cost of adequate waste treatment facilities.

The location of the site adjacent to the river solved the problem of process water and waste discharge. But the location of the site on the river flood plain placed the plant in a hazardous position. Frequent spring floods on the Roanoke River were a nuisance. In the spring of 1940, a massive flood occurred which forced a two-month shutdown of the plant. The flood problem was not completely alleviated until 1953, when the John H. Kerr Dam was completed.[1]

The Historical Development of the Albemarle Plant

The production capacity of the Halifax plant only reached eighteen tons per day during the first year of operation. The entire eighteen tons consisted of low grade groundwood wrapping paper.[2] Initiation of the sulfate process in 1909 provided the major impetus for the growth of the facility. The process was not developed by a Halifax employee but rather by a Swedish chemist whom the Halifax Company employed for research.[3] During the first year of operation with the sulfate process, the facility produced twenty-five tons of paper per day.[4]

In 1937, when Albemarle purchased the facility, production had only

---

[1] Ibid.

[2] Floyd Dewey Gottwald, "Albemarle From Pines to Packing," (The Newcomen Society, New York, 1962), p. 13.

[3] Gladstone, Interview, February 5, 1970.

[4] Gottwald, "Albemarle Pines To Packing."

increased to thirty tons of paper per day.[1] However, the Albemarle Company concentrated its efforts on production and rapidly increased it to 100 tons of paper in 1939 and then to 160 tons per day in 1946. In fact, the mill sold surplus pulp on the open market between 1939 and 1946. Since 1946 two paper machines were added, bringing the total to four. These four machines currently produce 500 tons of linerboard and 500 tons of kraft paper per day. Like Weyerheauser, none of the paper produced is processed at the Roanoke Rapids plant but is shipped to market-oriented Albemarle plants for processing. The product is shipped entirely by rail.[2]

The pattern of power production at the plant also emphasizes the growth of the facility under Albemarle control. The immediate expansion of production by Albemarle in 1937 made the reliance upon water power impractical and uneconomical. From 1937 to 1966, the plant purchased all of the electricity it used. This was not the normal procedure for paper and pulp facilities of comparable size, but the Albemarle Company was spending all available money on expansions of production facilities. In 1966, the company began to produce two-thirds of its needed power by steam turbines in the plant. The remaining third is purchased from the Virginia Electric and Power Company.[3]

The current production requires 1,450 cords of wood per day. In 1906, the Halifax Company had obtained all of its wood by truck from forests within a twenty-five mile radius of the plant. The Albemarle Company has greatly expanded the raw material area with forty-five per

---

[1] Gladstone, Interview, February 5, 1970.

[2] Ibid.

[3] Ibid.

cent of the current supply being shipped by truck from within a thirty mile radius and the remaining fifty-five per cent being shipped by rail from within a 200 mile radius. The company has actively engaged in a campaign for the procurement of wood and forests. The Halifax Company had owned only a few acres of forest land, but the Albemarle Company now owns 177,000 acres of forest land in Southeastern Virginia and Eastern North Carolina. The goal of the company is to own enough forest land to enable it to supply fifty per cent of its raw material needs.[1] The decline of population and abandonment of farmsteads in Eastern North Carolina will greatly facilitate the achievement of the goal.

The plant now employs a total of 650 people. The care and maintenance of the waste control facilities are provided for by the Technical Service Department. This department retains two technicians and two maintenance men for control of the waste treatment facility. This compares unfavorably with the Weyerheauser Company in terms of man-hours devoted to waste control facilities.[2]

Water Pollution Control

The Albemarle Paper Company is an excellent example of the problems which can arise from poor planning for waste control facilities. When the site was selected in 1906 and when the Albemarle Company purchased the facility, waste control was non-existent. The wastes were discharged directly into the river without any consideration of the immediate and long-range effects on aquatic life and water quality. The Albemarle Company, as many other water-dependent industries, did not con-

---

[1] Ibid.

[2] Ibid.

struct control facilities until forced to do so by the North Carolina Department of Air and Water Resources.[1]

The flow of the Roanoke River at Roanoke Rapids presently averages 8,500 cubic feet per second.[2] Before the construction of the plant's initial waste treatment facilities in 1963, the plant had depended on the flow of the river to dilute the wastes which the plant discharged. The North Carolina Department of Air and Water Resources prescribed that the segment of the river at Roanoke Rapids must contain at least four parts per million oxygen.[3] The technicians calculated that the river flow was sufficient to dilute the wastes and maintain the specified oxygen level.

The John H. Kerr Dam, completed in 1953; the Roanoke Rapids Dam, completed in 1955; and the Gaston Dam, completed in 1963, caused great fluctuations in the flow of the river.[4] The drops in flow were particularly evident during nights and on weekends. In 1959, after numerous and persistent complaints from industries located downstream, the Army Corps of Engineers, who control the Kerr Dam, and the Virginia Electric and Power Company, who control the Gaston and Roanoke Rapids Dams, guaranteed a flow of 8,500 cubic feet per second under normal conditions.[5]

The second problem associated with the dams was not solved until 1961 when a group of industries, including Albemarle, obtained a court order instructing the Army Corps of Engineers and the Virginia Electric

---

[1]Taylor, Interview, February 12, 1970.

[2]Gladstone, Interview, February 5, 1970.

[3]Taylor, Interview, February 12, 1970.

[4]Ibid.

[5]Gladstone, Interview, February 5, 1970.

and Power Company to raise the oxygen content of the water discharged from the dams.[1] As it was, the intake ducts at the Kerr and Roanoke Rapids Dams were located at the base of each dam; and, therefore, the water taken into the turbines was of the lowest oxygen content possible. Frequently, the water discharged contained less than two parts per million oxygen. Naturally, this affected the ability of the river to dilute industrial wastes further downstream.

As a result of the court order, submerged dams were constructed at the Roanoke Rapids and Kerr Dams to skim off the high quality surface water of the lakes. These submerged dams were constructed in front of the main dam around the intake to the water wheels. Since each submerged dam cost one million dollars, the individuals controlling the facilities were reluctant to build. When the Gaston Dam was designed at a later date, the plans included a submerged dam.[2] After installation of the submerged dams, the oxygen content of the water discharged rose to six parts per million at each dam.[3]

The plant uses twenty-five million gallons of water per day and, consequently, discharges twenty-five million gallons of waste per day. This large amount of water usage left no margin for error. If the flow of the river were reduced significantly or an accidental surplus of waste occurred at the plant, the river would not have been able to sufficiently dilute the wastes. In April 1963, such an accident occurred. A twenty thousand gallon storage tank located adjacent to the river

---

[1]Taylor, Interview, February 12, 1970.

[2]Virginia Electric and Power Company, "Facts About Gaston Dam." (Richmond, Virginia: Virginia Electric and Power Company, 1965).

[3]Gladstone, Interview, February 5, 1970.

containing rosin soap burst, spilling its contents into the river.[1] This spill caused a fish kill in which 20,000 Striped Bass were killed. As a result of the fish kill, the plant was ordered by the North Carolina Department of Air and Water Resources to construct waste treatment facilities.[2]

The Albemarle Company reluctantly constructed waste treatment and control facilities which met the minimum requirements. The facilities consisted of only one forty million gallon, eighteen acre settling pond which cost four hundred thousand dollars.[3] Two aerators were included in the facility. From the point of entry to the point of discharge from the pond, the waste only travels one-half mile. This does not compare favorably with the Weyerheauser treatment facility in which the wastes travel sixteen miles before being discharged.[4]

Albemarle's treatment process removed only a small portion of the organic materials. The wastes discharged into the river still contained much organic material, rosin soap, tannic acid, and color. The main reason for this insufficient treatment was the lack of land. The forty-acre pond consumed all the vacant land at the plant site.[5] In 1963, this site had been surrounded by conflicting land usage. In lieu of making a large investment in additional land, the plant decided to continue to rely on the river flow for the dilution of wastes. This approach met

---

[1]Taylor, Interview, February 12, 1970

[2]Gladstone, Interview, February 5, 1970.

[3]Bailey, Interview, February 26, 1970.

[4]Gladstone, Interview, February 5, 1970.

[5]Ibid.

only the minimum State requirements.

In addition to the settling pond, the North Carolina Department of Air and Water Resources ordered the plant to construct retaining walls around all storage and process tanks which contained material harmful to the river.[1] Similar retaining walls were constructed at the Weyerheauser plant, but Weyerheauser constructed the walls on its own initiative without the prompting of a State order.

The Albemarle Company was fortunate that it had not encountered problems before 1963. The construction of three dams upstream from the plant site seriously affected both the stream flow and oxygen content. The problem was so serious that the West Virginia Paper and Pulp Company decided against locating a fifty million dollar plant at Weldon in 1956 because of the river conditions.[2]

By 1970, the industrial and municipal development on the Roanoke River had increased to the point that the Albemarle Company could no longer rely on the dilution capacity of the river. In June 1967, a major fish kill occurred in that portion of the Roanoke River within Halifax and Northampton Counties. The kill was specific to Striped Bass, but the exact number killed was undetermined.[3] The kill could not be attributed to any one offender but was a result of the cumulative discharge of several industries and municipalities, including Albemarle. Pursuant to the fish kill, Albemarle, along with other industries, was ordered to

---

[1] Ibid.

[2] Taylor, Interview, February 12, 1970.

[3] North Carolina Department of Air and Water Resources, "Fifth Biennial Report, July 1, 1966 - June 30, 1968," (Raleigh: North Carolina, North Carolina Department of Air and Water Resources, 1969), p. B-34.

improve its treatment facilities.[1]

In relation to the improved facilities, the Albemarle Company began to investigate methods for increasing the recirculation of water. By January 1971, the daily intake of process water had been reduced to twenty-three million gallons. When the new facilities begin operation in 1972, the water intake will be further reduced to eighteen million gallons per day.[2]

The new facility will remove eighty-five per cent of the organic material and eighty to ninety per cent of the solid waste in the effluent. However, the color will not be removed.[3] The State does not require this, and color removal would increase the cost of the treatment facility by at least one-third.[4] A mechanical filter for solids removal, a storage pond for removed solids, an aeration lagoon, and a four hundred acre retention pond will be included in the system.[5]

The exact cost of the new facility is not yet known. However, the final investment will be somewhere between three and four million dollars. This figure is almost twice that which the Weyerheauser facility cost. The major reason for the large investment was the acquisition of land. As stated earlier, the plant site had been surrounded on all sides by conflicting land usage. Land which was intended for residential subdivision development had to be purchased for the construction of the

---

[1]Taylor, Interview, February 12, 1970.

[2]J. W. Gladstone, Technical Superintendent, Letter to T. Dale Holland, Albemarle Paper Company, Roanoke Rapids, North Carolina, January 21, 1971.

[3]Ibid.

[4]Gladstone, Interview, February 5, 1970.

[5]Gladstone, Letter, January 7, 1971.

waste treatment facility, and this was the major cost factor.[1]

In terms of waste treatment, the Roanoke Rapids site has proven to be a very poor site. The Albemarle Company has too large an investment in the facility to relocate, but they stated that in future locational decisions more consideration will be given to waste treatment facilities. The main factors of consideration would be the availability of land, constant river flow, and a lack of external pollution from municipal and industrial purposes. The Albemarle plant has not yet suffered from external pollution, but they feel that it will be an increasing problem at their present site.[2] The lack of land and unconstant river flow have been costly problems for the Albemarle Company. The waste treatment factor would not eclipse the other factors involved in a locational decision but will play an increasingly important role.

Marketing Disadvantages Due to Water Pollution Control

The Albemarle Company, like Weyerheauser, has suffered marketing disadvantages because of its water pollution control problems. The disadvantage has not been severe enough to warrant a reduction, but it has raised the cost of their product. The Albemarle representatives feel that the present North Carolina Water Pollution Laws are some of the strongest and most rigidly enforced of all fifty states. However, it is their opinion that increasing Federal control will eclipse the interstate variation in water pollution laws. Perhaps, for this reason, more than any other, they are not worried about the present marketing

---

[1] Gladstone, Interview, February 5, 1970.

[2] Ibid.

disadvantage.[1]

Summary

The Albemarle Company is representative of numerous other industries located in the Roanoke River Basin. The company did not consider water quality or waste control until the consideration was forced upon them. Albemarle acknowledges its long-term neglect of adequate waste treatment. But the company should be commended for the fact that it has learned from its past failures, gaining greater insight into the problems involved in waste treatment and water pollution control. The problems at Albemarle cannot be attributed solely to a lack of foresight. In 1906 and in 1937, it would have been a rather miraculous feat to have predicted the construction of the three dams and the water problem arising from the dams' interference with the normal river flow.

Both Weyerheauser and Albemarle located their plants in the present locations because of the same basic reasons. However, if locating today, the one and one-half to two million dollar saving represented by the Weyerheauser Company's waste treatment facilities would be a strong factor in influencing locational decisions.

The Martin Processing Company

The Martin Processing Company is located adjacent to the Smith River four miles upstream from Martinsville, Virginia. The company will be discussed in less detail than Weyerheauser and Albemarle were discussed. This is not because Martin Processing is less significant but because the company represents several situations which are unique in the Roanoke River Basin and one which is unique in the world. With the exception of

---

[1] Ibid.

a brief locational discussion, the emphasis will be placed on water pollution control.

The Locational Decision

Due to the circumstances under which the plant developed, there is no need to divide the locational analysis into the segments of regional and site selection. The present location of the plant is due entirely to the decision of one man. In the late 1950's, Julius P. Hermes, of Martinsville, began working on a chemical process to dye mylar. The plant had developed a technique which would permanently dye the material. However, after several years of research, Hermes personally developed a successful process which he had patented in 1958.[1]

After obtaining financial backing, Hermes opened the plant in 1961. Since all processing materials and finished products are shipped by truck, the plant could have located anywhere. Having a monopoly on the dyeing of mylar, market orientation was of no significance. This is emphasized by the fact that the Martinsville plant ships products throughout the United States and to Europe, Africa, and Australia.[2] Therefore, the locational decision was dependent almost entirely upon Hermes' decision, and he decided to locate the plant near his home of Martinsville.

Of course, the factors of accessibility, topography, water, and land availability were important in the site selection; and the site chosen satisfies all four criteria. The plant is located three miles from U. S. Route 220, which provides good transportation. The broad flood plain of the Smith River offered flat to gently rolling land upon

---

[1] R. A. Ressel, Plant Manager, Interview, Martin Processing Company, January 8, 1971.

[2] Ibid.

which to build a large facility. The Smith River offered ample water for processing and waste discharge. The Philpott Dam was located twelve miles upstream in 1957 and provided protection against floods. The present location was dependent largely upon Hermes' desires, but he probably could not have found a better location anywhere else.

The Historical Development of The Martin Processing Company

Since 1961, when the plant began operation, the production has rapidly expanded. It is now an international company, having its home offices in New York and a plant comparable to the Martinsville plant located in Belgium. The Belgium plant began operation in 1967.[1]

The production capacity of the Martinsville plant has expanded rapidly. The total production capacity in 1961 was 10,000 pounds of yarn per week. This expanded to 40,000 pounds per week in 1967 and is now at 400,000 pounds per week.[2] The plant currently employs 320 persons. Due to the low per capita income of Southwest Virginia and a shortage of job opportunities, labor supply has never been a problem for the plant.[3] Since the company has a monopoly on its product, the possibilities for expansion are presently unlimited.

Water Pollution Control

The company currently requires 800,000 gallons per day of process water. Consequently, the plant discharges an equal amount of effluents.

---

[1] Ibid.

[2] Bob Griffith, Plant Engineer, Interview, Martin Processing Company, January 8, 1971.

[3] Ressel, Interview, January 8, 1971.

The waste treatment facilities consist of a settling pond and a pond for aeration which contains only one spraying device.[1] The construction cost was one hundred thousand dollars, and the annual maintenance averages seventy thousand dollars. With the current treatment facilities, the effluents discharged are inconsistent in color content, organic materials, and acidity. The two ponds only have a retention period of five days, and this simply is not sufficient to adequately treat the wastes. When the plant began operation in 1961, the treatment facilities were adequate; but they were not expanded as the plant grew. The lag in the expansion of the treatment facilities has caused great problems with the discharge of organic materials. These materials cause a rapid silting of the settling pond and have been very harmful to the oxygen content of the Smith River.[2]

The Martin Processing Company is significant in this study of industrial water pollution because of its attitude toward inter-industrial cooperation in waste treatment, its defiance of State regulations, and the approach it will take to alleviate its waste treatment process.

The Martin Processing Company is located in a heavily industrialized area. Within a two-mile section of the Smith River, there are, including Martin Processing, six water-dependent industries. In 1968, Bassett-Walker Knitting, Bassett Furniture, Stanley Furniture, and Bassett Mirror Company all agreed to cooperate in the construction of a mutual waste treatment facility. This facility would have also served a small community of Bassett, which does not have a sewage plant.

---

[1]Griffith, Interview, January 8, 1971.

[2]Philpott, Interview, January 3, 1971.

This would have been an excellent example of municipal and inter-industrial cooperation, but the financial success of the project was contingent upon Martin Processing's agreeing to cooperate. However, Martin Processing felt that their share of the cost in the project was disproportionate. It would have cost the company two hundred thousand dollars just to connect the plant to the proposed facility.[1] As a result, all of the industries and the Bassett community still discharge wastes independently and inadequately treated.[2]

The same year the company was cited by the Virginia State Water Control Board for excessive waste discharges. However, no fines were levied on the company, and no improvements were made in the plant's waste treatment facilities. The plant continued its lax control and, in September 1970, blatantly ignored the Virginia State Water Control laws. The laws state that, when any plant is going to discharge untreated waste into any stream, the Water Control Board must be notified and have a representative present.[3] The settling pond had filled with sediments from the wastes. In order to clean the pond, the plant discharged its wastes directly into the Smith River for two days.[4] This discharge had a drastic effect on the river and brought immediate complaints from plants and municipalities located downstream. The effect was felt thirty miles downstream at Eden, North Carolina. The wastes not only colored the water highly but also gave it a strong odor and flavor. The town of Eden takes its water supply from the river. The water supply

---

[1] Ressel, Interview, January 8, 1971.

[2] Philpott, Interview, January 3, 1971.

[3] Ibid.

[4] Griffith, Interview, January 8, 1971.

was affected for a week.[1] As a result, the Virginia State Water Control Board took immediate action and ordered the company to construct new waste treatment facilities by the end of 1972.[2]

Because of the legal action, the company has finally taken steps to adequately treat its waste. In fact, the new facilities will far exceed the State requirements. The design of the proposed facility is being done by Langley, McDonald, and Overman, an engineering firm in Norfolk, Virginia. The new facility will be a closed system and cost four hundred thousand dollars. The wastes will not be discharged into the river but will be continuously filtered and recycled.[3] Process water will then be taken from the river only to replace the water which evaporates from the system.

External Pollution

While Martin Processing has created a pollution problem in the Smith River, it has also suffered from natural turbidity and the discharge of effluents and sewage upstream. While the Albemarle plant suffered from its location directly below the dams, the Martin Processing Company has benefited from its location below the Philpott Dam. The Philpott Dam does not maintain a constant flow but discharges water periodically in large amounts. Martin Processing feels that this flushes out the river and alleviates much of the pollution problem. This is because much of the waste in the river is in the form of solid sewage from the Bassett community. This solid waste is taken in with the processing water and

---

[1]J. A. McIntosh, Professor of Biology, Interview, Patrick Henry Community College, Martinsville, Virginia, January 8, 1971.

[2]Griffith, Interview, January 8, 1971.

[3]Overman, Letter, January 29, 1971.

frequently clogs the machinery. Also, the high natural turbidity and the color of the water resulting from the effluents of companies upstream cause problems in the processing water which is used for washing the mylar yarn. The flushing action resulting from the dam periodically cleans the color out of the river. The proposed waste treatment facility will help alleviate the problem of external pollution. Once the initial water is obtained for the production process, very little will be added to replace that which evaporates.[1]

Summary

The Martin Processing Company was the only one of the three industries which began operation with waste treatment facilities. While the facilities were initially adequate, the failure to coordinate the expansion of the waste treatment facilities with the production process resulted in pollution control problems. These problems have caused the plant executives to be dissatisfied with their present location. On the basis of their experiences, they would prefer to have the plant located within a municipality. This would have allowed them to use municipal water and waste treatment facilities.[2] Of course, the process water would have cost more; but they feel that the overall cost would have been less than the cost for pollution control has been in the present location.

The plant has not encountered problems with the availability of land. This is due to the approach the plant will take with its proposed facilities. The recycling of process water will involve an

---

[1]Griffith, Interview, January 8, 1971.

[2]Ressel, Interview, January 8, 1971.

expansion of equipment but will not require additional land. The plant could purchase additional land and construct waste treatment facilities at a lower cost than will be required for the proposed process. But this approach would not have alleviated the problem of external pollution. In view of its relatively small water usage, the more expensive approach was taken to prevent the possibility of future problems. If the water requirements had been equal to those of Weyerheauser and Albemarle, the complete recycling of wastes would have been impossible; and additional land would have been required for expansion.[1]

In view of Martin Processing's product, the plant has not suffered any marketing disadvantages due to pollution control. However, R. A. Ressel, Plant Manager, stated that the cost of their product has been significantly raised due to the cost involved in pollution control. In other words, the consumer is paying for the construction of water pollution control facilities. This is also true at Weyerheauser and Albemarle. If the plant were in competition with other companies, the additional cost could cause a marketing disadvantage.[2]

Martin Processing, Weyerheauser, and Albemarle exemplify problems involved in industrial water pollution control. Land availability, external pollution, river flow, and legal controls affect all water-dependent industries within the Roanoke River Basin. All three industries have found acceptable solutions to the problem. However, only Weyerheauser finds itself in a completely acceptable location. Both

---

[1]Griffith, Interview, January 8, 1971.

[2]Ressel, Interview, January 8, 1971.

Martin Processing and Albemarle would prefer different locations. The best overall solution to the regional problem of water pollution control was refused by Martin Processing when it declined to cooperate in the inter-industrial and municipal approach in 1968.[1]

---

[1] McIntosh, Interview, January 28, 1971.

CHAPTER IV

THE ROLE OF INDUSTRIAL WATER POLLUTION AS A LOCATIONAL FACTOR

Water pollution is a problem of growing concern to the water-dependent industries within the Roanoke River Basin. In past decades, water has been considered a free resource by most water-dependent industries. However, this attitude began to change during the last decade. In some cases, the concern is over an adequate quantity of clean water to meet existing and projected needs, while in other cases the industries are concerned over the existing and potential waste treatment problems within the Roanoke River Basin.

The major use of water by industry within the river basin has been as an effluent carrier. This long-term use of the basin's streams to carry wastes has produced serious effects which are manifested by increased operating costs, industrial-municipal cooperation, changes in locational decisions and plant site development, and the impaired marketing ability of several plants.

While water pollution is affecting industry in various ways, the main concern of this study is the role of industrial water pollution as a locational factor. All water-dependent industries will attest to the fact that increasing federal and state pollution control regulations and decreasing water quality are significantly increasing costs of obtaining clean water. Similarly, the costs of treating and disposing of effluents are climbing. Any raw or processing material which

is costly will exert an influence in an industrial locational analysis. Therefore, in the future, regional and site selections for the location of water-dependent industries should be increasingly influenced by the costs of obtaining clean water and of treating industrial effluents.

Water Pollution As An Economic Deterrent

It is a relatively simple matter to delineate those industries which are responsible for discharging wastes into a water body. However, when there is more than one plant discharging effluents into the same body of water, it is difficult to determine the effect which any one plant's effluent is having on water quality. Therefore, when attempting to define the amount of water pollution in any water body, one must consider the cumulative effect of all the pollutants introduced into the water. There is no single plant or municipality within the Roanoke River Basin which is discharging wastes of such strength and quantity to prohibit the development of additional water-dependent industries within the basin. However, the cumulative effect is decreasing the attractiveness of the river basin for the location of water-dependent industries. This is due to the fact that legal controls, the cost of treating wastes, and the cost of obtaining clean water have increased to the point that it is not economically feasible for large water-dependent plants to locate in the following areas of the river basin: the Smith River, Smith Mountain Lake, the Lower Dan River, and the Roanoke River at Roanoke Rapids. (See Fig. 6., page 37.)

The least important economic factor is the cost of obtaining clean water. However, this cost may be increased as a result of water pollution and has created serious problems for some water-dependent plants

in heavily industrialized areas such as the Hudson, Delaware, and Ohio River Basins. The Smith River is the only area of the Roanoke River Basin in which the presence of water pollution is serious enough to prevent the location of certain types of water-dependent industries.

The quality of water available from the river has seriously affected the Martin Processing and Fieldcrest Mills Companies. Fieldcrest's Fieldale plant was located on the Smith River in 1918 where there was little industrial development adjacent to the river. The plant's engineers believe that the company would not now select a site on the Smith River as a suitable location.[1] The existing industrial and municipal developments along the river have discharged enough wastes to significantly lower the quality of the river's water and forced the Fieldcrest plant to extensively treat its process water prior to use. This treatment process requires sedimentation, chlorination, and charcoal filtering which would not be necessary if clean water were available. As discussed in Chapter II, the Martin Processing Company faces a similar problem of obtaining clean intake water.

The problem of obtaining clean water is only experienced by industries such as textile, dyeing, food processing, and high-quality paper plants which require large quantities of clean water.[2] The duPont Nylon Plant, which is adjacent to the Smith River in Martinsville, Virginia, has not had any problems obtaining clean water. This is simply because the question of what constitutes clean water is relative. Most of the

---

[1] David E. Simmons, Vice-President Engineering, Interview, Fieldcrest Mills, Incorporated, Fieldale, Virginia, September 29, 1971.

[2] Dana W. Lewis, Pollution Control Coordinator, Interview, duPont Nylon Plant, Martinsville, Virginia, September 29, 1971.

water required by duPont is used for cooling and requires no prior treatment. Therefore, duPont has not experienced and does not foresee any problems with the quality of water available.[1] However, industries dependent on high-quality process water will not find the Smith River to be a suitable location.

The only possible solution to the problem would be the use of ground water, and this is not a promising alternative for water-dependent industries considering a location along the river. The United States Soil Conservation Service has determined that the water table in the Smith River Valley is dropping continuously but at an undetermined rate.[2] The Bassett-Walker Knitting Company is the only industry on the Smith River which relies on a subsurface water supply. This dependence on ground water has resulted in problems of obtaining adequate quantities of water.[3]

From 1940 to 1969, the Bassett-Walker Knitting Company had its dyeing process located at its Bassett plant. When the plant began operation in 1940, the water table was only ten to twelve feet below the earth's surface. By 1969, the water table had dropped to 150 feet below the surface. This drop in the water table forced the company to seek an alternate water supply. The company decided not to use the Smith River as a water supply due to the presence of industrial and municipal pollutants which would have necessitated costly treatment of the intake water. In lieu of using the river as a water source, the company decided to

---

[1] Ibid.

[2] Dwight Towler, Area Conservationist, Interview, United States Soil Conservation Service Offices, Martinsville, Virginia, September 26, 1971.

[3] L. D. Walker, President, Interview, Bassett-Walker Knitting Company, Bassett, Virginia, September 30, 1971.

move the dye process to a new plant which was located adjacent to the Smith River south of Martinsville.[1] The quality of the water supply was not improved at the new location; however, the relocation allowed the plant to obtain water from four wells. The water table at the new site is dropping, but each of the wells presently provides a flow of 200 gallons of water per minute. If the water table drops enough to reduce the quantity of the water supply, the plant may obtain water from nearby city water lines.[2]

The majority of the water-dependent industries in the river basin do not presently rely on wells as a source of water. However, the Bassett-Walker relocation exemplifies a trend in locational decisions which may become increasingly important within the river basin. Unless the volume of wastes discharged into the river is reduced, plants requiring clean intake water may rely on wells as a source of water. If this should become established as a trend, the Smith River Basin will be even less attractive for the location of water-dependent plants requiring large quantities of water.

That portion of the Roanoke River directly below Roanoke Rapids, North Carolina, is the only other area in the river basin in which obtaining high-quality water is an economic problem for water-dependent industries. As discussed in Chapter III, this situation has resulted in at least one plant's deciding not to select a plant site in the vicinity of Roanoke Rapids. However, the availability of well water should provide an alternate source of water for small water-dependent plants desiring to locate in the Roanoke Rapids area. The added costs of

---

[1] Ibid.

[2] Ibid.

extensively treating processing water make the selection of a plant site in either the Smith River or Roanoke Rapids sections of the basin economically unattractive for plants requiring large volumes of water.

The Lower Dan River and Smith Mountain Lake areas of the river basin are the remaining areas in which water pollution is reducing the potential for the development of water-dependent industries. However, in these areas the reduced development potential is due to the stringent water pollution control requirements which are being enforced by the Virginia State Water Control Board. This agency will not allow any industry which will increase the level of water pollution to locate in the Smith Mountain or Dan River areas of the river basin. The Water Control Board has taken the position that additional discharges of wastes which are not completely void of pollutants will seriously harm the areas' environment, affect potable water supplies, and increase the operating costs of existing industries.[1] In addition, these requirements are being applied to existing industries. The result has been a large increase in operating costs for existing plants and any plants considering locations in the two areas.[2]

The increased production costs are the result of a multiplier effect. This multiplier effect may be considered an external diseconomy; that is, the pollution control requirements are an external factor which force an increase in total production costs.

The cost of activity X (any industrial activity which is water-

---

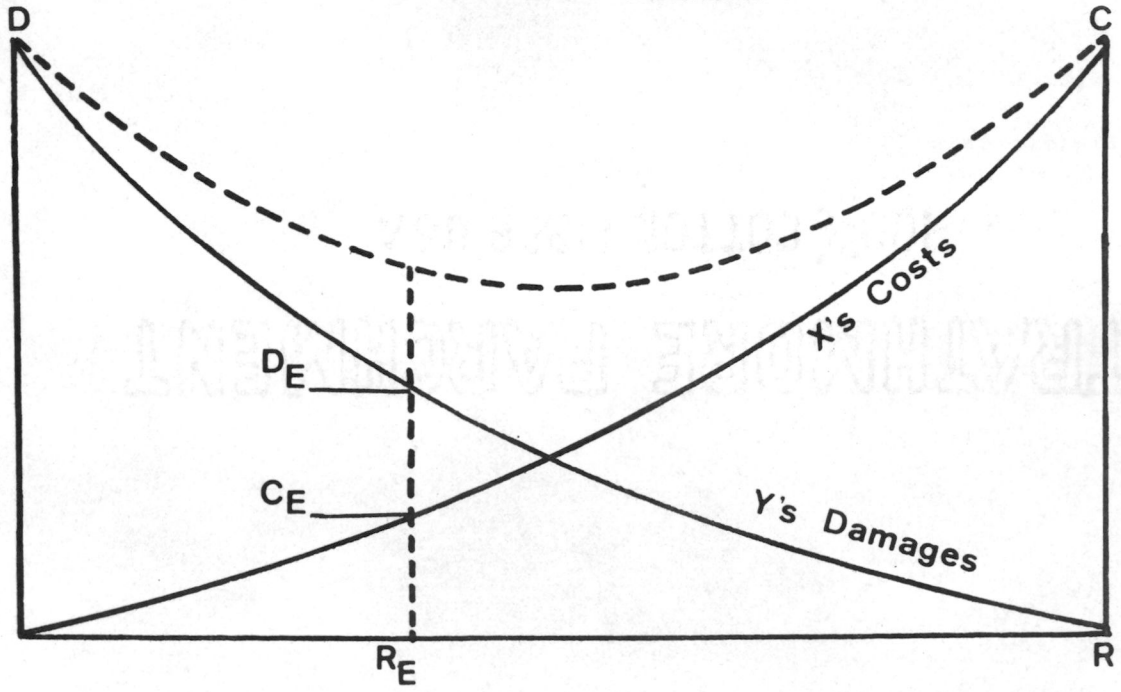
[1] Bob Jennings, Director of Planning and Grants Division, Interview, West Piedmont Planning District Commission Offices, Martinsville, Virginia, June 9, 1971.

[2] T. A. Goodson, Vice-President of Production, Interview, Dan River Mills, Incorporated, Danville, Virginia, September 30, 1971.

dependent) and the total damages incurred Y (adverse effects on water quality and the operation of other water-dependent plants) are both a function of waste removal R. X's cost will rise with increased anti-pollution requirements and will reflect the combinations of waste reduction and the increased input of labor and capital used to reduce the waste. Thus, the total production cost is raised through waste removal processes. This may be shown in the following graph.[1]

TABLE 2

PRODUCTION COST INCREASES
DUE TO EFFLUENT TREATMENT



[1] William R. Walker, Economics of Air and Water Pollution (Blacksburg, Virginia: Virginia Polytechnic Institute Water Resources Research Center, October 1969), pp. 40-44.

R represents the removal of all wastes from the effluents of activity X. D is the level of pollution when no removal measures are practiced. With no governmental intervention, the dollars per year in damages would be greater; thus, the D value would be larger on the graph. Complete removal of wastes would result in an expenditure of C dollars. R_E is the point at which the degree of removal will cost C_E and leave pollution damages D_E. At this point, the sum of the costs and damages will be at a minimmum.[1]

This chart exemplifies some of the effects which water pollution is having on industry within the river basin. The ideal situation would be for all water-dependent plants to operate at point R_E. However, the existing laws and pollution problems will not always allow this. Plants located in the Lower Dan River and Smith Mountain sections of the basin must spend large sums on control facilities and incur costs greater than those at point R_E. In some cases, the costs would go as high as point C for complete waste removal. Operation under such conditions is not economically feasible and thereby discourages industrial location in these sections of the river basin.

External Economies

External economies are savings in production costs which accrue to a plant which is located adjacent to advantageous facilities or in a favorable monetary or political environment.[2] Such economies are available to water-dependent industries via municipal-industrial or inter-industrial cooperation. Through cooperation in the construction

---

[1] Ibid.

[2] Gunnar Alexandersson, Geography of Manufacturing, (Englewood Cliffs, New Jersey: Prentice-Hall, Incorporated, 1967) p. 8.

of waste treatment facilities, industries and municipalities may save great sums of money. Within the Roanoke River Basin, there have been four instances of municipal-industrial cooperation, while there have not been any developments of inter-industrial cooperation.

The municipal-industrial approach is the most popular because it offers the greatest cost advantage to industries and the least responsibility for the discharge of wastes. This is the only approach by which individual industries are currently able to benefit from federal grants for the construction of waste treatment facilities.[1] While money does not accrue directly to the individual industries from federal and state grants, there are very definite cost advantages to be obtained through industrial-municipal cooperation.

Dan River Mills of Danville, Virginia, is the best example of such cooperation within the river basin. Increasing pollution in the Dan River and the conflicting use of the river by landlocked Striped Bass for a spawning ground have caused the federal and state water pollution control agencies to exert pressure on the plant to treat its wastes.[2] At present, all of the process water discharged by the plant is untreated. The plant was faced with either constructing its own waste treatment facilities or persuading the City of Danville to treat its wastes. In order for the city to treat the plant's wastes, it would have necessitated an expansion of the treatment facilities. Such an expansion would have been beyond the financial means of the city.[3]

---

[1] William R. Walker, Economics of Air and Water Pollution, pp. 56-76.

[2] James C. Pangle, "An Approach to Stream Pollution Abatement," p. 125.

[3] Guynn Marchman, Chief of Planning, Interview, Danville City Planning Department, Danville, Virginia, April 14, 1971.

However, the city was able to obtain a grant of eight million dollars from the Environmental Protection Agency and the Virginia State Water Control Board which financed 80 per cent of the construction costs for the treatment facility. This grant enabled the city to construct a facility which would adequately meet the expanding sewage needs of the urban area in addition to treating ten million gallons of waste per day from Dan River Mills. The availability of the municipal facility will save the plant an initial financial investment of several million dollars. Engineers at the plant also project a substantial savings in annual maintenance costs. The operation of its own facility would have cost the plant approximately $850,000 per year, while the connections with the municipal system are estimated to cost $500,000 per year for fees and minor maintenance. Thus, the federal and state grants to the City of Danville have enabled Dan River Mills to save several million dollars in initial investment and approximately $300,000 per year in operating costs.[1]

The composition of the municipal and industrial wastes was also a factor in the cooperative venture. If the wastes had been incompatible, treatment in one facility would have been impossible.[2] Compatibility of wastes requires that the wastes discharged from the industrial source be uniform in composition and flow. Variation in either could disrupt the chemical balance necessary for the effective treatment of municipal and industrial wastes. In this case, the municipal and industrial wastes complemented each other. The chemical compositions were such that the two types of effluents reacted on each other, increasing the

---

[1] Goodson, Interview, September 30, 1971.

[2] Ibid.

reduction of the biological oxygen-demanding materials. This reduced the cost of treating the wastes and offered a further cost reduction to both the city and the company.[1]

The J. P. Stevens Company at Roanoke Rapids, North Carolina, has never operated its own facility but relied entirely on the Roanoke Rapids municipal facility for the treatment of its wastes. In 1956, the Stevens Company purchased the Roanoke Rapids complex from the Simmons Company.[2] At that time, the Simmons Company operated its own waste treatment facility which also treated domestic waste from the surrounding municipal area. Until this time, the City of Roanoke Rapids had been known as a "mill town" and was largely controlled by the Simmons Company. The J. P. Stevens Company did not want to perpetuate this paternalistic attitude regarding the city. Therefore, the company donated the waste treatment facilities to the town with the stipulation that the municipality would continuously operate the treatment system at a capacity sufficient to treat the plant's effluents.[3] This situation represents a unique approach to municipal-industrial cooperation within the river basin. In no other case have industrial resources completely financed the construction of municipal-industrial facilities. In view of increasing federal aid, it is doubtful that this situation will occur again in the river basin.

The Fieldcrest Mill at Fieldale expects to save substantial sums of money by utilization of a treatment plant to be constructed by Henry

---

[1] Ibid.

[2] Paul Barrett, Public Relations, Letter to Timothy Dale Holland, J. P. Stevens and Company, Incorporated, Greenville, South Carolina, May 18, 1971.

[3] Gladstone, Interview, February 5, 1970.

County. The company had initially planned to upgrade its existing primary system to a secondary system. However, the plant will now rely on the county-operated system to treat its wastes. This will save the Fieldcrest Company approximately one-half million dollars in construction costs. In addition, reliance on the public facility will allow the company to eliminate expenditures on annual maintenance. The only expenditure by the company will be a sewage charge adjusted to the amount of effluent discharged by the plant.[1]

Reliance on the county system is particularly appealing to the Fieldcrest Company because of future county plans. Henry County's Water and Sewer Plan calls for the Fieldale systems to be upgraded to tertiary treatment.[2] This is the same level of treatment which the plant had planned to install as soon as financially feasible. Tertiary treatment would meet all projected federal requirements and remove all polluting materials from Fieldcrest's effluents. The county's construction of a facility capable of adequately treating industrial wastes will save Fieldcrest Mills approximately one million dollars. As in the construction of the Danville facility, a federal grant was necessary to provide sufficient funding for the construction of the facility.[3]

The arguments for municipal-industrial cooperation are embodied in the above examples of such cooperation. The major argument against this approach to waste treatment is expressed by duPont's objection to

---

[1] Simmons, Interview, September 29, 1971.

[2] Langley, Overman, and McDonald, Henry County Water and Sewer Plan (Norfolk, Virginia: Langley, Overman, and McDonald, Engineers, January 1971) p. 40.

[3] Simmons, Interview, September 29, 1971.

the approach. The opinion of the duPont Environment Section was that the desirability of municipal-industrial cooperation decreases as the size of the plant increases. It was felt that it would be advantageous for industries discharging millions of gallons of waste per day to operate independent facilities. Of those industries within the river basin which were interviewed, only duPont, Weyerheauser, and Albemarle objected to a cooperative approach. The remaining industries all felt that municipal-industrial cooperation offered the most profitable approach. In fact, representatives of Martin Processing, Bassett-Walker Knitting, and Fieldcrest Mills all stated that, if their plants were locating now, they would select a site which had access to municipal treatment facilities.

Adept Regional Plant Location

Industrial location analysts may be able to partially alleviate pollution problems and treatment costs via the coordinated location of two or more water-dependent industries. Plants whose wastes neutralize each other may select adjacent sites and thereby provide one another with natural non-mechanical treatment facilities. This approach to pollution abatement was accidentally discovered at Onondaga Lake near Syracuse, New York. An Allied Chemical plant which discharged chlorine, calcium chloride, and lime water wastes was closed for several weeks due to a strike. The Syracuse municipal treatment plant also discharged wastes into the lake and continued its operation while the Allied Chemical plant was closed. As a result, the lake developed an odor which persisted until the chemical plant resumed operation.[1]

---

[1]Marshall I. Goldman, Controlling Pollution: The Economics of A Cleaner America, (Englewood Cliffs, New Jersey: Prentice-Hall, Incorporated, 1969) p. 36.

Situations such as that which occurred at Lake Onondaga cannot be expected to occur frequently, even when industries are receptive to the approach. The most feasible arrangement would be the organization of industrial parks designed specifically for water-dependent industries. Precise chemical and biological planning could produce a plan which would specify the size and type of water-dependent industries desired for location in such an industrial park. This arrangement would be more desirable for small, independently operated plants which have limited financial resources and a more defined and uniform discharge of effluents.[1]

The major obstacle to the establishment of industrial parks for water-dependent plants will be inter-industrial cooperation. There has been only one attempt to establish industrial cooperation within the river basin, and it failed. This was the attempt of Martin Processing, Bassett-Walker Knitting, Stanley Furniture, Bassett Furniture, and Bassett Mirror. Although the primary reason for the failure of the effort was Martin Processing's lack of interest, each of the companies believe there were cost inequities in the proposed system.

Industrial cooperation in the development of industrial parks and the construction of waste treatment facilities may provide a lucrative solution to industrial waste problems, but only when such development is approached systematically. The expenditures required of all participants and the benefits accruing to all must be equal and yet individually advantageous.

Pollution-Induced Diseconomies

The existence of pollutants in a water supply may also exert an

---

[1]Lewis, Interview, September 29, 1971.

influence on production costs by forcing expensive treatment of intake water. The additional costs and problems involved are directly proportionate to the quality of process water required by a particular plant. For example, the thirty-six million gallons of water required daily for cooling by duPont does not require pretreatment and could withstand large concentrations of dissolved and small suspended impurities. The situation is the reverse at the Weyerheauser plant which extensively pretreats process water to obtain impurity-free water for the washing of high-quality paper. Other plants facing major problems in obtaining clean process water from surface supplies are the Albemarle Paper Company, the Martin Processing Company, and Fieldcrest Mills.

The problem of pollution-induced diseconomies in the river basin will decrease during the next decade as industrial and municipal water pollution controls improve. Of course, this improvement is a direct result of action by the Federal Water Quality Administration, the Department of Housing and Urban Development, the Virginia State Water Control Board, and the North Carolina Air and Water Pollution Control Board to increase water pollution control and planning requirements. Additional costs resulting from the increased control requirements will be felt by all water-dependent industries. These additional costs will be for the construction of treatment facilities or for increased fees levied for the use of improved municipal facilities. Higher quality surface water will be available as a result of the improved treatment facilities and thereby will permit many plants to reduce their expenditures on the purification of intake water. This may permit some individual plants to offset increased control expenditures by reductions in their costs for treating process water. However, the effect will not

be a reduction in total production costs to industry within the basin but rather a cumulative increase as a result of the magnitude of additional expenditures which will be required for control facilties.

The Smith River, Lower Dan River, and Roanoke Rapids areas of the river basin are those in which pollution-induced diseconomies have presented the greatest problems. These are also the areas which will benefit most from improved pollution control. This is particularly true of the Fieldcrest Mills Company, the Martin Processing Company, and the Dan River Mills plant, all of which have experienced major problems of municipal and industrially produced impurities in their water supplies. Most of these impurities should be removed during the next decade.[1]

Changing Plant Site Development

One of the most significant changes in locational decisions resulting from expanded pollution control requirements is that of plant site selection. However, this change is affecting only those plants which require huge quantities of water and provide their own waste treatment facilities. For these plants, the availability of land becomes the dominant factor in the economical disposal of waste. When extensive tracts of land are available, a company may use retention, aeration, and settling processes. Although time consuming and space demanding, this procedure is more economical and cost effective than any other treatment process yet developed.[2] The validity of this idea is demonstrated by the savings which accrued to the Weyerheauser Paper Company because of the availability of a large tract of low-cost land suitable

---

[1]Philpott, Interview, January 3, 1971.

[2]Bailey, Interview, February 26, 1971.

for the construction of a waste treatment facility. Before Dan River Mills consummated an agreement with the City of Danville, the executives of the company considered constructing their own treatment facility. The primary factor which discouraged the development of a private facility was a lack of land. Each of the Dan River Mills plant sites within the city had been hemmed in by intensive urban development. This was primarily commercial development, and high land values prevented the acquisition and clearance of the surrounding land. Thus, Dan River Mills had to take the second most economical approach--that of contracting with the city for waste treatment.[1]

The requirement for large tracts of land will not manifest itself in or tangent to urban areas. The concept will be developed in rural areas which offer extensive tracts of land. In addition, areas of low relief will be desirable to reduce the necessity for expensive and maintenance-demanding pumping facilities.

In the upper reaches of the Roanoke River Basin, large water-dependent industries will be limited to location in the river valleys which offer the largest areas of level land. However, location in such areas places industry in competition with other intensive land uses for the use of such flat valley areas. The availability of level land increases as one moves down the river basin toward the coastal areas. In addition, many coastal pocosin areas may be filled and developed for waste treatment facilities, while development for other uses may be impossible. Of course, the construction of waste treatment facilities and the discharge of wastes in such areas must be carefully controlled. If not, serious damage could be done to the aquatic life in the river

---

[1]Goodson, Interview, September 30, 1971.

basin's coastal areas.

The significant factor is that the desirability of large plant sites will make the Piedmont and coastal areas of the basin more attractive for the location of large water-dependent plants. Location in these areas also provides larger volumes of surface water than that available in the head water areas of the basin. The larger water volumes provide a greater assimilative capacity, thereby increasing a river's capability to absorb large quantities of effluents without adverse environmental effects. This assimilative capacity enables plants to retain wastes in settling and aeration ponds for lengthy periods and subsequently discharge large quantities of effluents which have been retained to receive extensive treatment. This also provides a safeguard for periods of low river flow. During periods of reduced river flow, the assimilative capabilities of a river are impaired.[1] Therefore, effluents, unless totally purified, must be retained until the flow of the river is again sufficient to handle the wastes. Such retention requires large areas of land for the construction of large retention ponds. In locations where the river flow is controlled by the release of water from dams, the discharge of effluents should be coordinated with such releases. A situation similar to this exists at Roanoke Rapids, North Carolina, and is partially responsible for the high construction costs at the Albemarle plant.

New site development requirements will be one of the most visually recognizable changes to occur because of industrial efforts to control pollution. This will become apparent as the plant sites increase in size. The per cent of the site devoted to production will decrease in relation to the area of the site which is devoted to the non-productive

---

[1] Jenkins, Interview, February 26, 1970.

process of waste treatment. In order to reduce the additional costs, the larger industries will tend to locate in rural as opposed to urban and suburban areas.

The Effect of Pollution Control on Industrial Marketing Ability

During the last decade, there have been numerous complaints about marketing disadvantages for those plants confronted with large expenditures for water pollution control facilities. These complaints stemmed from inequities in state and international control requirements. For example, Alabama was lax in its control requirements and, with a few exceptions, offered industry uncontrolled utilization of surface waters as effluent carriers. Concurrently, states such as Virginia, North Carolina, and Washington were requiring waste treatment and, in some cases, the operation of expensive facilities.[1] The result was an increase in the total production costs for some plants and a proportionate rise in the price of the company's product. Therefore, many companies were forced to market products in competition with products of comparable quality produced in other states at lower costs.[2] The only plants within the river basin to complain about marketing disadvantages were those in the textile and paper and pulp industries.

The reasons for the marketing disadvantages have now been eradicated within the United States and will soon be erased on the international level. The passage of the Federal Water Quality Act of 1965 and the 1970 interpretation and enforcement of the Refuse Act of 1899 have

---

[1]Taylor, Interview, February 12, 1970.

[2]Goodson, Interview, September 30, 1971.

eliminated interstate variations in water pollution control requirements.[1] Thus, no state can offer production cost advantages to water-dependent industries. Prior to 1965, both North Carolina and Virginia had control requirements which increased the production costs of most water-dependent industries. This inequity in requirements made location in the Roanoke River Basin less desirable than location in a comparable watershed in a state offering less stringent legal controls.

Until 1965, most companies considered the question of marketing disadvantages in their locational decisions.[2] In some cases, such disadvantages may have been considered jointly with other locational factors to make location within the Roanoke River Basin less attractive than an alternate area. However, the problem never became significant enough to cause any plant within the river basin to consider relocation or to cease operation. At most, the marketing disadvantages were an influence and not a decisive factor in locational decision.

Pollution Control Laws

The significance of pollution control laws as an influencing factor in industrial location decisions has decreased during the last six years. Prior to the Water Quality Act of 1965 and the Clean Waters Restoration Act of 1966, water pollution control was primarily a state matter.[3] There existed many variations in individual state requirements; and the Federal Government could only intercede when water pollution adversely affected the people, wildlife, or environment of two or more

---

[1] Ibid.

[2] Bailey, Interview, February 26, 1970.

[3] Taylor, Interview, February 12, 1970.

states. However, both North Carolina and Virginia enacted anti-pollution legislation during the 1940's and 1950's which made industrial locations in one of these states less desirable than alternate locations in states having less stringent controls or, in some cases, no controls at all.

Although the State of North Carolina has established sound control measures, the state devoted little attention to the pollution of its streams by industrial wastes until enactment of the Stream Sanitation Law in 1951. This act created a Stream Sanitation Committee and required it to do the following: develop water quality standards for classification of the state's waters as to "best usage," make comprehensive pollution studies of the waters, assign each water body a classification which will best suit the state's public interest, and execute a stream pollution control program to improve the quality of the state's waters.[1]

Under Article 21, Chapter 143, General Statutes of North Carolina, classification and water quality standards and regulations applicable to the surface waters of North Carolina were adopted by the State Stream Sanitation Committee on November 19, 1953, and subsequently amended on January 30, 1968.[2] As a result, each stream in North Carolina has been assigned a classification.

The basic regulation governing the discharge of wastes is that there can be no impairment of the primary usage for which a body of water is classified. The following are the five classifications

---

[1]Kenneth B. Pomercy, North Carolina Lands, (Washington: The American Forestry Association, 1964) p. 174.

[2]North Carolina Department of Air and Water Resources, Classifications and Water Quality Standards Applicable to the Surface Water of North Carolina, (Raleigh, North Carolina: North Carolina State Government Printing Office, 1965) p. 1.

established within North Carolina: A-1, source of water supply for drinking or food processing purposes; A-11, source of water supply for drinking after approved treatment; B, bathing; C, fishing and wildlife propagation; and D, agricultural purposes.[1] Failure to comply with the quality specifications for each classification will result in strict monetary penalties. In order to establish a method of enforcement, the North Carolina General Assembly established the Department of Water and Air Resources in 1959 and assigned it the responsibility of enforcing the state pollution control laws and of planning and implementing programs for the beneficial use of North Carolina's water resources.[2]

Each violation of the anti-pollution laws is considered to be a misdemeanor, and each day of violation is considered to be a separate offense. The penalty for such violations was set at no less than one hundred dollars nor more than one thousand dollars for each violation. The Board of Water and Air Resources was impowered in 1959 to conduct investigations and levy fines.[3] Thus, for the last twelve years, the State of North Carolina has attempted to control the discharge of industrial effluents with the threat of financial penalty. Within the Roanoke River Basin, the state has never charged an industry with a misdemeanor. However, firms such as Albemarle Paper Company have been charged damages for fish kills when the responsibility for the kill could be determined.[4]

---

[1] Ibid.

[2] Pomercy, North Carolina Lands, p. 174.

[3] Ibid.

[4] Gladstone, Interview, February 5, 1970.

While the North Carolina pollution control laws were not enforced rigidly, they were more stringent than those of most states and the Southern states in particular. The degree of control was sufficient to be a factor in at least one company, the West Virginia Paper and Pulp Company, not selecting a site in the North Carolina portion of the river basin.[1]

There are several Virginia statutes which have the control of pollution in the state's water bodies as a primary or secondary purpose. These statutes are the Sanitation Districts Law of 1946, the Fish Law, and statutory provisions which prohibit the placing of certain materials in water courses. The most important of the laws for general pollution control and for industrial control in particular is the State Water Control Law, enacted in 1946 by the Virginia General Assembly.[2]

The purpose of the 1946 law was to maintain the state's waters in such a condition as to permit all reasonable public uses and to support the propagation of aquatic life, to safeguard clean waters against pollution, and to reduce existing levels of pollution. One of the more important provisions in the law was the establishment of the State Water Control Board and the adoption of regulations governing the procedure of the board.[3]

The State Water Control Law took effect as to the operation of industry on 1 July 1946. At that time, all plants which were discharging wastes were required to apply to the State Water Control Board for a

---

[1]Gladstone, Interview, February 5, 1970.

[2]William R. Walker and William E. Cox, Water Resources Laws for Virginia, (Blacksburg, Virginia: Virginia Polytechnic Institute Water Resources Research Center) p. 19.

[3]Ibid.

permit to continue discharging wastes. The only additional stipulation as to those industries already in operation was that the State Water Control Board could require a company to adopt measures for improving the quality of the effluent discharged.[1] Within the Roanoke River Basin, such action was taken against the Martin Processing Company, the Roanoke Steel and Electric Company, and the Norfolk and Western Shops in Roanoke,

After 1 July 1946, all companies constructing, enlarging, or reopening any establishment which would cause pollution of state waters was required to provide facilities for the treatment of industrial wastes. The 1946 General Assembly established penalties for the violation of the state pollution control laws or any special order of the Water Control Board. The penalty was set at a fine of not less than fifty dollars nor more than five hundred dollars for each violation. Each day of continued violation after conviction constitutes a separate offense.[2] This provided the State of Virginia with a method of enforcement. However, until 1967 the State Water Control Board was understaffed with professionals, and rigid enforcement was difficult.[3] Frequently, reported fish kills would not be investigated until several days after the complaint was filed.[4]

In order to refine the Virginia water pollution control requirements, the State Water Control Board adopted a classification system for Virginia's water bodies in July 1966. The classifications were detailed, specifying such things as specific oxygen requirements,

---

[1]Walker and Cox, Water Resources Laws for Virginia, p. 23.

[2]Ibid.

[3]Jenkins, Interview, February 26, 1970.

[4]Philpott, Interview, January 3, 1971.

ph requirements, and other chemical stipulations.[1] This system is more complicated than that adopted by the State of North Carolina and too technical to adequately explain herein. In most cases, the result was a complication of the situation. The staff of the State Water Control Board was not staffed to enforce the controls.

The Virginia fines were lower than those enforced in North Carolina. In addition, the framework for enforcement was weaker in Virginia than in North Carolina. However, this discrepancy cannot account for the fact that there are more water-dependent industries located in Virginia than in North Carolina. The majority of the plants were located prior to 1946. Although the Virginia enforcement was weaker than that in North Carolina, it was significantly stronger than that in the remaining Southern states. In 1969, Virginia began a program to improve the enforcement of its statutes. This effort has centered on an expansion of the State Water Control Board staff.[2] Sufficient time has not elapsed to permit a valid evaluation of the expanded program. However, the local and state officials and industrialists are of the opinion that the expanded effort is producing positive results.

The major factor in water pollution control laws has been the increasing involvement of the Federal Government. Since 1965, the Federal control has rapidly increased.[3] As a result, water-dependent industries cannot obtain economic advantages by locating in a state with lax controls. The United States Congress has enacted legislation which forces

---

[1] Ibid.

[2] Ibid.

[3] Citizens Advisory Committee on Environmental Quality, Community Action for Environmental Quality, (Washington, D. C.: United States Government Printing Office, January 1970) p. 24.

uniform national pollution control requirements.

The first Federal legislation related to water pollution was the Refuse Act of 1899. This law had definite language which would have permitted Federal control of pollution, but the law was not enforced until 1970. It was not until after the House Committee on Public Works was established and considered the problem of water pollution control. In 1948, the first comprehensive legislation aimed at pollution was enacted. This act allowed for grants and loans to finance the construction of water pollution studies but did not provide for the control of effluent discharges. The establishment of a national water pollution control program did not occur until 1956 when Congress adopted Public Law 84-660, which provided comprehensive legislation and permitted Federal participation in a wide variety of activities.

The major item in the law was the stipulation which permitted the Federal Government increased control of interstate waters. In 1961, the water pollution control program was accelerated by the enactment of Public Law 87-88. The law incorporated several measures designed to improve municipal treatment facilities. However, industry was significantly affected by the extension of Federal pollution abatement procedures to navigable interstate and coastal waters.

In addition, the Department of Health, Education, and Welfare was designated as the Federal pollution control agency and was impowered to bring court suits to require an offender to cease activities causing pollution in interstate waters without seeking permission of the state. In cases of pollution of intrastate navigable waters, state permission had to be obtained prior to court action.

The Water Quality Act of 1965 was the first Federal legislation

designed to establish uniform national pollution controls. Under the legislation, the states were permitted the opportunity of adopting water quality standards for their interstate waters and plans to implement and enforce the standards prior to 30 June 1967. If a state failed to adopt sufficient criteria, the Department of Health, Education, and Welfare was authorized to establish Federal standards.[1] Both North Carolina and Virginia had already adopted controls which were acceptable to the department.

The Clean Water Restoration Act of 1966 did not directly affect industry. The legislation simply authorized increased Federal expenditures for municipal waste treatment facilities. Of course, a relatively few industries within the country did benefit via the use of municipal facilities. The legislation did not have any noticeable effect on industry within the Roanoke River Basin.

The most important and recent Federal pollution control legislation is the 1970 Water Quality Act. This legislation dealt specifically with oil pollution from vessels and on-shore and off-shore facilities, Federal permits and licenses for discharge, and hazardous substances discharged into the water of the United States. In addition, one of the most important provisions was the creation of the Office of Environmental Quality to furnish staff support for the enforcement of environmental legislation.[2]

---

[1] Committee on Public Works, United States House of Representatives, Laws of the United States Relating to Water Pollution Control and Environmental Quality, (Washington, D. C.: United States Government Printing Office, July 1970) pp. 1-3.

[2] Ibid.

The 1970 legislation made it unlawful to discharge almost any refuse matter into navigable waters of the United States or tributaries of navigable waters unless a certificate has been granted by the Corps of Engineers. This method of implementation was specified in the Refuse Act of 1899. This nineteenth century law provides a means of implementing the 1970 legislation.[1] Enforcement of these two public laws eradicated all interstate inequities in pollution control requirements and now prevents economic advantages for those water-dependent industries locating in states with lax controls.

The Bassett-Walker plant of Martinsville, Virginia, is the only industry within the river basin which has had a suit filed against it. The suit is a result of the company's having failed to file for a permit to discharge wastes into the Smith River as required by the Refuse Act of 1899.[2] It is not anticipated that there will be any additional Federal action against industries within the river basin. All other industries within the basin are complying with the requirements of the Environmental Protection Agency. This compliance should insure a long-term improvement of water quality within the river basin. In addition, the legislation has alleviated any national marketing disadvantages which industries within the basin may have been previously experiencing.

---

[1]Committee on Public Works, United States Senate, "Hearing Before the Subcommittee on Air and Water Pollution of the Committee on Public Works, United States Senate Ninety-First Congress Second Session," (Washington, D. C.: United States Government Printing Office, April 1970) pp. 22-23.

[2]Walker, Interview, September 30, 1971.

CHAPTER V

CONCLUSIONS

Industrial development has been adversely affected by water pollution in the Roanoke River Basin. However, the problems encountered by industry have not been experienced throughout the river basin in the same degree of seriousness nor have all such problems been continuous long-term situations. In the majority of the river basin, increases in state and federal control and an increasing awareness among industrial management of environmental problems will result in an improvement in water quality for most of the river basin. However, many problems will persist and changes result from the effects of water pollution. These have been manifested and will continue to be manifested by the development of pollution problem areas, changes in plant site development, increased municipal-industrial cooperation, a greater emphasis on pollution control in locational decisions, and attempts to develop inter-industrial solutions for waste treatment problems. These changes have altered man's relationship to his environment and his utilization of resources within the river basin. This chapter reviews the significance of pollution-induced changes in the river basin. It also attempts to forecast, in a general way, the future trends in development for water-dependent industries.

Water Pollution Problem Areas

The four major water pollution problem areas were identified in Chapter II. These were: the Smith River, Smith Mountain Lake, the

Lower Dan River, and the Roanoke River at Roanoke Rapids. (See Fig. 6, page 37.) These areas have developed as a result of both industrial and municipal effluent discharges. In no case can one plant or group of plants be held solely responsible for creation of the water pollution problem areas. However, these areas will exert a greater effect on the growth and location of industry than on that of municipalities. National and state land use control and development policies have not attained a level of sophistication which will permit control of the location and growth of municipalities. Consequently, the population in any one area may continue to increase and produce an increased discharge of domestic sewage. Currently, the only solution is to provide adequate waste treatment. In the four areas identified, adequate treatment will be the construction of tertiary facilities. Such treatment is planned for the Virginia Cities of Roanoke, Martinsville, and Danville.

Each of the four identified areas is heavily industrialized and has large concentrations of water-dependent industries. The control of existing industrial discharges and the prevention of additional industrial waste discharges in the four areas are the primary means by which the pollution problems may be controlled and eventually eliminated. The Environmental Protection Agency, the Virginia State Water Control Board, and the North Carolina Department of Air and Water Resources can control the location and development of industry by the issuance of permits for the discharge of wastes. This option will be rigidly enforced in each of the four areas.[1] It is not the desire of the Federal and state agencies to prohibit the development of new plants or the expansion of

---

[1]Jenkins, Interview, February 26, 1970.

existing ones. The objective will be to prohibit the discharge of any effluents which will increase the level of pollution in those areas which are on the brink of becoming saturated with pollutants. In fact, portions of the Smith River will only sustain sludge worms.[1] Such rigid control would require large investments for waste treatment facilities by water-dependent plants considering location in one of the four areas. Such investments would be for non-productive purposes and would be prohibitive. Consequently, it is unlikely that additional development of water-dependent industries will occur in the above-mentioned areas.

Each of the concentrations of pollution is located in a more highly developed area of the Roanoke River Basin where the streams have been overloaded and pollution control has not kept pace with industrial and urban development. The result has been a rapid decline in water quality, an adverse effect on rock fish spawning in the Roanoke and Dan Rivers, a decline in the trout population in the Smith River, and the serious impairment of Smith Mountain Lake as a recreational area.

In the future, water-dependent industries desiring to locate within the river basin will be dispersed into the rural areas where there is little or low-intensity development. The objective of such distribution will be to keep pollution levels within the assimilative capacity of a water body. Low concentrations of treated wastes can be diluted by a river and thereby prevent pollution problems. The existing problems in the river basin have arisen as a result of the assimilative capacity of several water bodies being exceeded. The distribution of water-dependent

---

[1]Lewis, Interview, September 29, 1971.

industries will assist in preventing the creation of additional concentrations of pollution.

Plant Site Development

The most noticeable effect which water pollution is having on industrial development is to change the requirements for plant site development. This is evidenced by a demand for the availability of larger tracts of land at the plant sites. The primary reason for this is that industrial effluents may be treated more efficiently and economically in large complexes of settling, aeration, and retention ponds. The major cost factor is the availability of inexpensive land. For those plants selecting a site, the cost of land will be the major pollution-related factor.[1]

The result of the search for low-cost land will be the dispersion of those plants desiring to construct their own waste treatment facilities. Normally, the most expensive land is that situated in the urban areas of the river basin. When a company requires several hundred acres of land for a treatment facility, location in an urban area becomes prohibitive. Therefore, many of the urban amenities such as proximity to major transportation facilities and fire and police protection will have to be sacrificed for the availability of cheap land. This is only valid for those industries whose wastes are of a nature which prohibits treatment in municipal facilities or which produce quantities of effluents in excess of the capacity of existing municipal facilities.[2] The inability

---

[1]Bailey, Interview, February 26, 1970.

[2]Goodson, Interview, September 30, 1971.

the distribution of additional water-dependent plants to rural areas and, in most cases, the construction of individual treatment facilities. In such cases, industry will desire to locate on land which, for reasons of permeability, topography, and substructure, is not suitable for uses other than the treatment of wastes. This is exemplified by Weyerheauser's construction of a treatment facility in an area which was predominantly swampland.

Municipal-Industrial Cooperation

Municipal-industrial cooperation has been limited to agreements among municipalities and small industries. It is impossible to define the limits of such cooperation in terms of quantity or types of wastes to be treated. Rather, each individual case must be analyzed and the benefits to be derived from cooperation considered. There have been three instances within the river basin in which large industry found it advantageous to cooperate with a local government in the construction or financial support of a treatment facility. These were: the J. P. Stevens Company at Roanoke Rapids, North Carolina; the Fieldcrest Mills plant at Fieldale, Virginia; and the Dan River Mills plant at Danville, Virginia. It is anticipated that such cooperation will be limited in the future. This is due to three basic reasons. First, large industry is reluctant to become directly tied to local government. There is a wide-spread feeling that this would create undue friction with local authorities. Secondly, there is the fear that dependence on public facilities would subject the company to unexpected rate increases. Finally, such cooperation is contingent upon the industrial wastes being compatible with the municipal system. Almost all of the large

industries within the river basin and, in particular, the chemical and paper and pulp manufacturers support these reasons.[1]

Within the Roanoke River Basin, the major increase in municipal-industrial cooperation will occur among local governments and the smaller independent plants in the food, textile, and wood categories. These groups operate with relatively small profit margins and cannot withstand large expenditures for waste treatment facilities on which there will be no profit return. Since their wastes are primarily organic in nature and compatible with municipal treatment facilities, dependence on such public systems is the best solution to a costly problem. The net result of this is that small firms with organic wastes should be attracted to urban areas, while the larger plants and those with incompatible inorganic wastes should be discouraged to locate in the urbanized areas.

Inter-Industrial Cooperation

In an effort to solve the problem of waste treatment, many approaches have been tried. One of these is inter-industrial cooperation in the construction of large micro-regional waste treatment systems. To date, attempts to successfully establish and operate such systems have met with failure. The most numerous occurrences of such attempts have been in the European countries. All of those efforts were accompanied by problems of incompatible wastes and simple inter-industrial agreement.[2]

As discussed in Chapters III and IV, there was one attempt at inter-industrial cooperation on the Smith River. It failed because of the

---

[1]Lewis, Interview, September 29, 1971.

[2]Goodson, Interview, September 30, 1971.

inability of the firms involved to agree on engineering design, the incompatability of wastes, and disagreements over financial contibutions.[1] The Smith River area was the only location in which the topography and the proximity of several water-dependent plants would have permitted the construction of a large treatment system to serve existing plants. Any further attempts at an inter-industrial approach will have to be generated by new plants locating in the river basin. This would require the location of several water-dependent plants in one small area which would discharge compatible wastes. It is unlikely that this will happen.

Plant Location

The process of plant location focuses primarily on regional location and secondly on the selection of a specific site. If one considers the drainage basin limits as the parameters of a region, then the Roanoke River Basin provides a region within which additional water-dependent industries can locate economically and without adversely affecting the environment. This is the exception of the four pollution problem areas previously identified.

There are sufficient supplies of clean intake water available and numerous locations at which adjacent rivers can adequately assimilate wastes. In fact, by virtue of the establishment of uniform national water pollution control requirements, the Roanoke River Basin is more appealing to companies involved in the location process. Legal controls will still influence industrial location by encouraging the rural distribution of future plants. However, this will benefit industry in the

---

[1]Philpott, Interview, January 3, 1971.

long run by improving the basin's water quality, thereby making the region a more desirable location for water-dependent industries.

Prospects for the Future

When one considers the entire Roanoke River Basin, the prospects for future industrial development are bright. This is, however, with the exception of the four sections of the basin identified as water pollution problem areas. While these four areas are not completely dead, they can only be returned to an acceptable quality by extensive improvements in industrial and, in some cases, municipal waste treatment facilities. Scattered and normally isolated water pollution problems have occurred in almost all portions of the river basin. Usually these have been short-lived and manifested by minor fish kills. Such occurrences have decreased during the last decade as state and federal regulations have increased. In fact, it is believed that, as a whole, water quality in the river basin has improved during the last ten years. This trend should continue but at an increased rate during the 1970's. State and federal legislation and regulation, public interest, and an increasing concern for environmental quality by plant management have been responsible for the improvements in the river basin. These same factors, but on a more intensive plain, may eliminate the four major problem areas. If and when these four areas are elevated to a level of quality commensurate with the total river basin, the region will be one affording tremendous appeal for the expansion of existing water-dependent plants and the addition of new plants. At such a time and with appropriate regional water pollution planning, the streams and rivers in the basin could effectively assimilate substantial amounts of additional effluents. In fact, this condition could be achieved in

the early 1980's. However, only increased state, federal, industrial, citizen action can produce such a result.

BIBLIOGRAPHY

Alexandersson, Gunnar. Geography of Manufacturing. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1967, pp. 105-106.

Altavista Journal. "Klopman to Build Costly Plant to Control Effluent." Altavista, Va.: Altavista Journal. April 16, 1970. p. 8.

Anderson, Walt. Politics and Environment. Pacific Palisades, Cal.: Goodyear Publishing Company, Inc., 1970.

Bailey, G. Sterling. "Aerated Stabilization Treatment at the Weyerheauser, Plymouth Mill." NCASI, Atlanta, Ga., August 14, 1969. (Mimeographed.)

Bailey, G. Sterling. Director of Environmental Resources. Interview, Weyerheauser Company. Plymouth, N. C. February 26, 1970.

Barrett, Paul. Public Relations. Letter to Timothy Dale Holland. J. P. Stevens and Company, Inc. Greenville, S. C. May 18, 1971.

Behrman, A. S. Water Is Everybody's Business. Garden City, N.Y. Doubleday and Company, Inc., 1968.

Buckley, Elton V. Chief Chemist. Questionnaire. Piedmont Manufacturing Company, Altavista, Va. April 17, 1971.

Citizens Advisory Committee on Environmental Quality. Community Action for Environmental Quality. Washington, D. C.: U. S. Government Printing Office, January 1970.

Committee on Public Works, United States House of Representatives. Laws of the United States Relating to Water Pollution Control and Environmental Quality. Washington, D. C.: U. S. Government Printing Office, July 1970.

Committee on Public Works, United States Senate. "Hearing Before the Subcommittee on Air and Water Pollution of the Committee on Public Works, United States Senate Ninety-First Congress Second Session." Washington, D. C.: United States Government Printing Office, April 1970. pp. 22-23.

Dawson, Herbert M. Superintendent of Water Production. Letter to Walter E. Mather. Water, Gas, and Electric Departments. Danville, Va. March 31, 1971.

Denison, J. A., Colonel. Commander of the Wilmington District, Army Corps of Engineers, Meeting of the Roanoke River Basin Association. 4-H Center. Smith Mountain Lake, Virginia. May 21, 1971.

Eckenfelder, W. Wesley and Gloyna, Earnest F. Advances in Water Quality Improvement. Austin, Tex.: University of Texas Press, 1968.

Ettridge, Don Erwin. An Economic Study of the Effect of Municipal Sewer Surcharges on Industrial Wastes. Raleigh, N.C.: Water Resources Research Institute of the University of North Carolina, November 1970.

Federal Security Agency, Public Health Service. Southeast Drainage Basins. Washington, D. C.: U. S. Government Printing Office, 1951. p. 40.

Federal Water Quality Administration. Clean Water for the 70's. Washington, D. C.: U. S. Government Printing Office, 1970.

Gladstone, J. W. Technical Superintendent. Interview. Albemarle Paper Company, Roanoke Rapids, N. C. February 5, 1970.

Gladstone, J. W. Technical Superintendent. Letter to T. Dale Holland. Albemarle Paper Company. Roanoke Rapids, N. C. January 21, 1971.

Goldman, Marshall I., ed. Controlling Pollution. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1967.

Goodson, T. A. Vice-President of Production. Interview. Dan River Mills, Inc. Danville, Va. September 30, 1971.

Gottwald, Floyd Dewey. "Albemarle from Pines to Packing." New York: The Newcomer Society, 1962. p. 13.

Graham, Jack B., ed. Water for Industry. Washington: American Association for the Advancement of Science, 1956.

Griffith, Bob. Plant Engineer. Interview. Martin Processing. Martinsville, Va. January 8, 1971.

Gunnoe, C. O. President. Questionnaire. Gunnoe's Sausage Company. Goodes, Va. April 1, 1971.

Halacy, D. S. The Water Crisis. New York: E. P. Dutton and Co., Inc., 1966.

Hare, F. Kenneth. "How Should We Treat Environment?" Science, 23 January 1970, pp. 352-355.

Healy, John D. and Hamric, Herbert N., III. Environmental Plus or Minus? Lynchburg, Va. Central Virginia Planning District Commission. August 1970.

Hidy, Ralph W., Frank Ernest Hill, and Allan Nevins. Timber and Men: The Weyerheauser Story. New York: MacMilliam Company, 1963, p. 565.

Hoffman, Jack. Chief of Fish Division of the Commission of Game and Inland Fisheries. Meeting of the Reservoirs Regional Committee. Bedford, Va. April 14, 1971.

Hines, William N., and Willrich, Ted L. Water Pollution Control and Abatement. Ames, Iowa: Iowa State University Press, 1965.

Institute of Government University of North Carolina: Industrial Water Use in North Carolina, 1964. Chapel Hill, N. C.: University of North Carolina, 1964.

James, G. V. Water Treatment. London: Technical Press Ltd., 1966.

Jenkins, Scott H. Technical Director. Interview. Weyerheauser Company. Plymouth, N. C. February 26, 1970.

Jennings, Bob. Director of Planning and Grants Division, Virginia State Water Control Board. Interview. West Piedmont Planning District Commission Offices. Martinsville, Va. June 9, 1971.

Kiepe, J. C. President. Questionnaire. Virginia Crafts, Inc. Keysville, Va. April 7, 1971.

Klein, Louis. River Pollution I. Chemical Analysis. London: Butterworths, 1959.

Langley, Overman, and McDonald. Henry County Water and Sewer Plan. Norfolk, Va.: Langley, Overman, and McDonald, Engineers. January 1971. p. 40.

Lewis, Dana W. Pollution Control Coordinator. Interview. duPont Nylon Plant. Martinsville, Va. May 7, 1971.

Lewis, Dana W. Pollution Control Coordinator. Interview. duPont Nylon Plant. Martinsville, Va. September 29, 1971.

Lewis, Dana W. Pollution Control Coordinator. Questionnaire. duPont Nylon Plant. Martinsville, Va. January 8, 1971.

Marchman, Guynn. Chief of Planning. Interview. Danville City Planning Department. Danville, Va. April 14, 1971.

McGinty, A. J. Plant Manager. Interview. E. I. duPont de Nemours. Martinsville, Va. December 15, 1970.

McIntosh, J. A. Professor of Biology. Interview. Patrick Henry Community College. Martinsville, Va. January 28, 1971.

Mouzon, Olin L. "The Southern Pulp and Paper Industry, Its Past, Its Significance, Its Future." Southern Pulp and Paper Manufacturer. IV, October 1, 1941. p. 22.

Nilolaieff, George A. The Water Crisis. New York: The H. W. Wilson Company, 1967.

North Carolina Employment Security Commission. Employment Security Commission Quarterly. "Halifax, First in the United States to Use the Sulfate Process." Raleigh, N. C.: North Carolina Employment Security Commission. VI, No. 1. Winter 1948.

North Carolina Department of Air and Water Resources. Significant Sources of Waste Discharged, Municipal and Industrial Roanoke River Basin. Raleigh, N. C.: State Government Printing Office, January 13, 1971. (Mimeographed.)

North Carolina Department of Air and Water Resources. Chemical and Physical Character of Surface Waters of North Carolina, 1965-1966. Raleigh, N.C.: State Government Printing Office, 1967.

North Carolina Department of Air and Water Resources. Classifications and Water Quality Standards Applicable to the Surface Waters of North Carolina. Raleigh, N. C.: State Government Printing Office, 1965.

North Carolina State Stream Sanitation Committee. Comprehensive Pollution Abatement Plan for the Roanoke River Basin. Raleigh, N. C.: State Government Printing Office, 1957.

North Carolina Department of Air and Water Resources. Fifth Biennial Report, July 1, 1966-June 30, 1968. Raleigh, N. C.: State Government Printing Office, 1967.

North Carolina Department of Conservation and Development, Division of Water Resources and Engineering. Hydrologic Data on the Roanoke and Tar River Basins, 1871-1945. Raleigh, N. C.: State Government Printing Office, 1952.

North Carolina Department of Labor. North Carolina Directory of Manufacturing Firms 1968. Raleigh, N. C.: North Carolina Department of Labor, 1968.

North Carolina State Stream Sanitation Committee. "Report of Proceedings at Public Hearing Relating to Application Filed by Carolina Power and Light Co., Raleigh, N. C., Requesting Reclassification of Hyco River and Certain Tributaries in the Roanoke River Basin." Raleigh, N. C.: State Government Printing Office, 1963.

North Carolina State Stream Sanitation Committee. "Report of Proceedings at Public Hearing Relating to Application Filed by the Town Board of Commissioners, Draper, N. C., Requesting Reclassification of Certain Waters in the Roanoke River Basin." Raleigh, N. C.: State Government Printing Office, 1965.

North Carolina State Stream Sanitation Committee. "Report of Proceedings at Public Hearing Relating to Application Filed by the Washington Mills Co., Mayodan, N. C., Requesting Reclassification of Certain Waters in the Roanoke River Basin." Raleigh, N. C.: State Government Printing Office, 1965.

North Carolina State Wildlife Resources Commission. Survey and Classification of the Roanoke River and Tributaties, Vol. 2. Raleigh, N. C.: State Government Printing Office, 1964.

North Carolina State Stream Sanitation Committee. "The Roanoke River Basin, A Study of Existing Pollution...Together with Recommended Classifications of Its Waters." (Pollution Survey Report No. 4). Raleigh, N. C.: State Government Printing Office, 1956.

North Carolina Department of Conservation and Development. Water and Power Development in North Carolina. Raleigh, N. C.: State Government Printing Office, 1951.

Overman, William C. Engineer. Questionnaire. Langley, McDonald, and Overman Consulting Engineers. Norfolk, Va. January 29, 1971.

Padgett, Hach. Plant Engineer. Questionnaire. Stanley Furniture Company. Stanley, Va. January 15, 1971.

Pangle, James C. "An Approach to Stream Pollution Abatement." Danville, Va.: Research Division, Dan River Mills, Inc., January 1969.

Pangle, James C., Jr. Director of Environmental Research. Questionnaire. Dan River, Inc. Danville, Va. January 8, 1971.

Parker, W. A. President. Interview. W. A. Parker Canning Company. Thaxton, Va. April 12, 1971.

Philpott, A. L. Virginia State Representative, 37th District. Bassett, Va. January 3, 1971.

"Plymouth Awakes." The State. August 28, 1937, p. 2.

Pomercy, Kenneth B. North Carolina Lands. Washington, D. C.: The American Forestry Association, 1964.

Ressel, R. A. Plant Manager. Interview. Martin Processing. Martinsville, Va. January 8, 1971.

Rubin, Sidney. Plant Manager. Questionnaire. Perfect Packed Products Company, Inc. Henderson, N. C. April 8, 1971.

Simmons, David E. Vice-President. Interview. Fieldcrest Mills, Inc. Fieldale, Va. September 29, 1971.

Stone, W. O. Division Vice-President. Questionnaire. Fieldale Towel Mill of Fieldcrest Mills, Inc. Fieldale, Va. January 6, 1971.

Tallison, J. B. Vice-President and General Manager. Letter to T. Dale Holland. Klopman Mills, Inc. Altavista, Va. January 11, 1971.

Tallison, J. B. Vice-President and General Manager. Questionnaire. Klopman Mills, Inc. Altavista, Va. January 11, 1971.

Taylor, Julian R. Chief of Stream Monitoring Branch. Interview. North Carolina Department of Air and Water Resources. Raleigh, N. C. February 12, 1970.

Towler, Dwight. Area Conservationist. Interview. United States Soil Conservation Service Offices, Martinsville, Va. September 26, 1971.

U. S. Federal Power Commission. "Roanoke River Basin, Virginia--North Carolina; Planning Status Report, Water Resource Appraisals for Hydroelectric Licensing." Raleigh, N. C.: U. S. Government Printing Office, 1964.

U. S. Department of the Interior. Water Resources of the Neuse River Basin North Carolina. (Geological Survey Water--Supply Paper 1914). Raleigh, N. C.: U. S. Government Printing Office, 1957.

U. S. House of Representatives Committee on Public Works. Law of the United States Relating to Water Pollution Control and Environmental Quality. Washington: U. S. Government Printing Office, 1970.

Virginia Department of Water Resources. Municipal and Institutional Wastes Discharges: Henry. Richmond, Va.: Virginia Department of Water Resources, January 1971. (Mimeographed.)

Virginia Division of State Planning and Community Affairs. Data Summary, Campbell County. Richmond, Va.: Division of State Planning and Community Affairs, December 1970. p. 13.

Virginia Division of State Planning and Community Affairs. Data Summary, Henry County. Richmond, Va.: Division of State Planning and Community Affairs, December 1970. p. 12.

Virginia Electric and Power Company. "Facts about Gaston Dam." Richmond, Va.: Virginia Electric and Power Company. 1965.

Virginia State Water Control Board. Factor Related to Water Quality of the Roanoke River and Smith Mountain Lake. Richmond, Va.: Virginia State Water Control Board.

Walker, L. D. President. Interview. Bassett-Walker Knitting Company. Bassett, Va. September 30, 1971.

Walker, L. D. President. Questionnaire. Bassett-Walker Knitting Company. Martinsville, Va. April 14, 1971.

Walker, William R. and Cox, William E. Water Resources Laws for Virginia. Blacksburg, Va.: Virginia Polytechnic Institute Water Resources Research Center.

Walker, William R. Economics of Air and Water Pollution. Blacksburg, Va. Water Resources Research Center Virginia Polytechnic Institute, 1969.

Water Resources Research Center Virginia Polytechnic Institute. Generalized Initial Conditions for the Stochastic Model for Pollution and Dissolved Oxygen in Streams. Blacksburg, Va.: Virginia Polytechnic Institute Press, 1969.

Water Resources Research Center Virginia Polytechnic Institute. Public Perception of Water Resource Problems. Blacksburg, Va.: Virginia Polytechnic Institute Press, 1969.

Water Resources Research Center Virginia Polytechnic Institute. Some Water Quality Aspects of the Upper Roanoke River Basin with Special Emphasis on Temperature. Blacksburg, Va.: Virginia Polytechnic Institute Press, 1969.

Water Resources Research Institute of the University of North Carolina. Water Resources of North Carolina. Chapel Hill, N. C.: University of North Carolina, 1968.

Water Resources Research Institute of the University of North Carolina. Water Resources Problems and Research Needs of North Carolina, March 1, 1967. Chapel Hill, N. C.: University of North Carolina, 1967.

Wayne, Ollie. Plant Manager. Questionnaire. International Telephone and Telegraph Company. Roanoke, Va. March 16, 1971.

"Weyerheauser Plymouth Complex Strengthens Economy in Eastern North Carolina." Weyerheauser Company. 1965. (Mimeographed.)

Wright, Jeffery. Plant Superintendent. Interview. American Furniture Company. Martinsville, Va. January 5, 1971.

TIMOTHY DALE HOLLAND
Biographical Sketch

Timothy Dale Holland was born on January 9, 1947, in Durham, North Carolina. He lived in Portsmouth, Virginia, until the age of thirteen, when his family resettled in Durham. He attended Durham High School from 1963 to 1965. During high school, his interests focused on outdoor activities of hunting, camping, fishing, and sports. It was this outdoor interest which provided a basis for his interest in the academic discipline of Geography which developed later.

He selected Geography as his field of study in his freshman year at East Carolina University. However, at that time, he was interested in pursuing geography in a pure academic sense with the goal being a position in the teaching profession. During his sophomore year, his interest expanded to include the area of urban and regional planning. At that time, he decided to pursue a career in the planning profession. After completing the requirements for a Bachelor of Arts Degree in Geography, Dale Holland entered graduate school in East Carolina University's Geography Department. His major interests were in economic and industrial geography. The objective of his graduate work was to apply his knowledge in the field of regional planning.

In December 1970, he was employed by the West Piedmont Planning District Commission, Martinsville, Virginia. He is responsible for providing regional planning for a four-county area in the functional fields of transportation, land use, and environment. The knowledge of man's relationship with the physical environment has been a useful tool which he utilizes daily in the field of planning.