TRC

Customer-Focused Solutions

FINAL REPORT

NATIONAL REGISTER OF HISTORIC PLACES ASSESSMENT FOR THE CATAWBA-WATEREE HYDROELECTRIC PROJECT

BRIDGEWATER, RHODHISS, OXFORD, LOOKOUT SHOALS, COWANS FORD, AND MOUNTAIN ISLAND DEVELOPMENTS, NORTH CAROLINA

July 2005

TRC
Customer-Focused Solutions

FINAL REPORT

NATIONAL REGISTER OF HISTORIC PLACES ASSESSMENT FOR THE CATAWBA-WATEREE HYDROELECTRIC PROJECT

BRIDGEWATER, RHODHISS, OXFORD, LOOKOUT SHOALS, COWANS FORD, AND MOUNTAIN ISLAND DEVELOPMENTS, NORTH CAROLINA

FERC Project No. 2232

Submitted to:

DEVINE TARBELL & ASSOCIATES
400 South Tryon Street
Suite 2401
Charlotte, North Carolina 28285

and

DUKE POWER, A DIVISION OF DUKE ENERGY CORPORATION
526 South Church Street
Charlotte, North Carolina 28201

Submitted by:

TRC
3772 Pleasantdale Road, Suite 200
Atlanta, Georgia 30340

Authors: M. Todd Cleveland and Jeffrey L. Holland

July 2005

EXECUTIVE SUMMARY

During April and May of 2004, TRC Garrow Associates, Inc. (TRC), under contract to Devine Tarbell & Associates, Inc. (DTA), conducted an architectural survey and National Register of Historic Places (NRHP) eligibility assessment of 11 hydroelectric developments on the Catawba and Wateree rivers in North and South Carolina. The work was undertaken for Duke Power, a division of Duke Energy Corporation, as part of the relicensing effort for the Catawba-Wateree Hydroelectric Project (FERC No. 2232). This document addresses the six North Carolina developments: Bridgewater, Rhodhiss, Oxford, Lookout Shoals, Cowans Ford, and Mountain Island. A separate document covers the five South Carolina developments. TRC has conducted its work in accordance with applicable federal and state laws, guidelines, and requirements. TRC has also followed the field safety protocols developed by Duke Power and DTA.

The North Carolina developments have been surveyed previously, with the exception of Cowans Ford. That development was completed in 1963, some 41 years ago (a fourth turbine-generator unit came on line in 1967). Because the NRHP process, with few exceptions, only addresses resources that are 50 years of age or older (due to the need to allow time to pass before making an objective eligibility decision), Cowans Ford had not been surveyed and assessed prior to this evaluation. Of the five previously surveyed developments, then, only Bridgewater and Lookout Shoals have had some or all of their components recommended significant and/or eligible for the NRHP.

Based on TRC's work and in accordance with 36 CFR 60.4, the Bridgewater, Rhodhiss, Oxford, Lookout Shoals, and Mountain Island developments are recommended eligible for the NRHP under criteria A and C. The developments have undergone minimal alteration and still appear—for the most part—as they did when first built. Alterations to the facilities have included installation of modern controls, changes made for safety reasons, FERC-mandated upgrades for flood control, and upgrades of generating and transmission equipment. The developments also continue to illustrate the historical associations for which they are significant. Because they are still used for their original purpose, and because the operators have maintained them over the years, the developments retain their integrity and remain good examples of their types.

Cowans Ford is recommended ineligible for the NRHP due to its more recent age. The NRHP process allows resources less than 50 years old to be determined eligible, but they must have "exceptional importance." Although Cowans Ford was the largest of the developments and the last to be constructed, thereby completing the build-out of the river system begun in 1900, it does not meet NRHP Criteria Consideration G as an exceptionally significant resource. It followed a different design, had a much larger capacity, and was built in the post-World War II, modern era—which places it in a different context. However, it is suggested that Duke Power reassess the eligibility of Cowans Ford after it becomes 50 years old.

Since most of the changes to the developments have been mandated by FERC for safety reasons or are day-to-day operational upgrades required for the efficient and profitable functioning of the facilities, it is suggested that Duke Power develop a Programmatic Agreement with the

regulatory agencies to address these ongoing changes. Then, only the most major changes, such as partial or total removal of buildings or structures, would require standard Section 106 review.

ACKNOWLEDGEMENTS

TRC extends special thanks to Brad Keaton of Devine Tarbell & Associates, who served as the primary point of contact in the field and arranged access to each hydroelectric development. He also provided mapping and information on recent upgrades to the facilities. TRC also thanks Jennifer Huff of Duke Power Company for providing information on the relicensing process and for general logistical support. Dennis Lawson of the Duke Power Company archives was extremely helpful, providing source material to TRC staff and helping with their research efforts.

At each development, TRC received assistance from one or more operators and/or managers, who answered questions, provided access to structures, and allowed TRC to review available historic photographs and records. Each of the following is thanked for their time and assistance:

Bridgewater:	Earl Bailey, Donald Kreswell
Rhodhiss:	Dennis Keller
Oxford:	Calvin Ramseur
Lookout Shoals:	Foy Sipes
Cowans Ford:	Alan Putman
Mountain Island:	Dureen Moore, Eddie Rhyne
Operations Managers:	Randy Horton, Sam Powell

Within TRC, Heather Olson and Jeff Holland conducted the background research. Mr. Holland prepared the historical context chapter of this report, with contributions by Todd Cleveland. Mr. Cleveland conducted the field survey and prepared the remainder of the document. Vince Macek produced the report graphics.

CONTENTS

EXECUTIVE SUMMARY ii

ACKNOWLEDGEMENTS iv

FIGURES vii

TABLES xii

I. INTRODUCTION 1

II. HISTORICAL CONTEXT 3
The History and Technology of Hydroelectric Power 3
Historical Development: 1880–Present 3
The Technology of Hydroelectric Power 5
The Development of Hydroelectric Power in the Carolinas: ca. 1893–1955 8
Southern Power Company/Duke Power Company 9
Carolina Power & Light Company 10
Aluminum Company of America (Alcoa) 10
South Carolina Electric and Gas Company 11
Hydroelectric Power and the Development of the Carolina Piedmont 12
Duke Power Company and the Catawba-Wateree Hydroelectric System 16
A Vision Becomes Reality: 1897–1916 16
Struggling to Build an Industry Giant: 1916–1926 21
Duke Shifts Away from Hydroelectric Power: 1927–1959 26
The Last Link in the Chain Begins an Era of Shifting Fortunes for Duke Power: 1958–Present 28

III. STUDY METHODOLOGY 30
Background Research 30
Fieldwork 30
Evaluation Criteria 30

IV. RESULTS 32
Previous Surveys 32
Listing of Dams in the U.S. 32
Fieldwork and Assessment Findings 36
Bridgewater Development 36
Rhodhiss Development 40
Oxford Development 42
Lookout Shoals Development 45
Cowans Ford Development 48
Mountain Island Development 51

V. CONCLUSIONS AND RECOMMENDATIONS 55

REFERENCES CITED 56

APPENDIX 1: FIGURES

APPENDIX 2: LISTING OF DAMS

FIGURES

The following figures are contained in Appendix 1 to this report.

1.1 Map showing location of 11 hydroelectric developments along the Catawba River in North and South Carolina (Duke Power 2004).

2.1 Diagram of a typical hydroelectric system (Duke Power 2004).

4.1 Map showing dams, spillway, and powerhouse at Bridgewater Development.

4.2 Site plan showing dams, spillway, and powerhouse at Bridgewater Development (Duke Energy Corporation 2003).

4.3 Site plan showing Linville Dam and Powerhouse at Bridgewater Development (Duke Energy Corporation 2003).

4.4 Bridgewater Development, Catawba Dam, east side; looking southwest.

4.5 Bridgewater Development, Catawba Dam, spillway; looking west-southwest.

4.6 Bridgewater Development, Paddy Creek Dam, west side; looking southwest.

4.7 Bridgewater Development, Paddy Creek Dam, east side; looking southwest.

4.8 Bridgewater Development, Paddy Creek spillway; looking southeast.

4.9 Bridgewater Development, intake at Linville Dam; looking north.

4.10 Bridgewater Development, Linville Dam, east side; looking northeast.

4.11 Bridgewater Development, Linville Powerhouse; view of office building, powerhouse (behind substation), and substation; looking northeast.

4.12 Bridgewater Development, Linville Powerhouse; view of powerhouse, substation, and office building; looking southwest.

4.13 Bridgewater Development, Linville Powerhouse; view of substation and powerhouse; looking north.

4.14 Bridgewater Development, Linville Powerhouse; view of generator floor, west end; looking northwest.

4.15 Bridgewater Development, Linville Powerhouse; view of generator floor; looking east-southeast.

4.16 Bridgewater Development, Linville Powerhouse; view of basement; looking southwest at exterior of generator base.

4.17 Bridgewater Development, Linville Powerhouse; view of interior of generator base; looking south at generator-turbine shaft and wheel pit area.

4.18 Bridgewater Development, Linville Powerhouse; view of interior of generator base; looking south at bottom of generator and rotor spider.

4.19 Bridgewater Development, Linville Powerhouse; view of warehouse; looking west.

4.20 Bridgewater Development, Linville Powerhouse; view of maintenance sheds and water tank; looking south.

4.21 Map showing dam and powerhouse at Rhodhiss Development.

4.22 Site plan of Rhodhiss Development (Duke Energy Corporation 2003).

4.23 Rhodhiss Development; view of dam, powerhouse, and substation; looking west.

4.24 Rhodhiss Development; view of dam and powerhouse (floodwall improvements visible at south end of dam); looking southwest.

4.25 Rhodhiss Development; view of dam, powerhouse, substation, and warehouse; looking north.

4.26 Rhodhiss Development, Rhodhiss Powerhouse; view of rear intake deck; looking north.

4.27 Rhodhiss Development; Rhodhiss Powerhouse; view of generator floor; looking south-southwest.

4.28 Rhodhiss Development, Rhodhiss Powerhouse; view of generator floor; looking north-northwest.

4.29 Rhodhiss Development, Rhodhiss Powerhouse; view of mezzanine-level control room; looking northwest.

4.30 Rhodhiss Development, Rhodhiss Powerhouse; view of historic governor at generating unit #3; looking south-southwest.

4.31 Rhodhiss Development, Rhodhiss Powerhouse; view of basement; looking northwest at exterior of generator base.

4.32 Rhodhiss Development, Rhodhiss Powerhouse; view of interior of generator base; looking west at generator-turbine shaft and wheel pit area.

4.33 Rhodhiss Development; view of warehouse; looking northwest. The warehouse was demolished in 2004.

4.34 Map showing dam and powerhouse at Oxford Development.

4.35 Site plan of Oxford Development (Duke Energy Corporation 2003).

4.36 Oxford Development; view of substation, powerhouse, and dam with spillway; looking west.

4.37 Oxford Development, Oxford Powerhouse (floodwall improvements visible atop south abutment); looking west-northwest.

4.38 Oxford Development, Oxford Powerhouse; view of rear intake deck (with new decking, railings, and lampposts); looking north.

4.39 Oxford Development, Oxford Powerhouse; view of generator floor; looking north.

4.40 Oxford Development, Oxford Powerhouse; view of generator floor; looking south.

4.41 Oxford Development, Oxford Powerhouse; view of generating unit #2 from basement level; looking northwest.

4.42 Oxford Development; view of warehouse; looking west-southwest.

4.43 Oxford Development; view of new buttress in front of Oxford Powerhouse; looking west.

4.44 Oxford Development; view of new spillway at north end of dam; looking southwest.

4.45 Map showing dam and powerhouse at Lookout Shoals Development.

4.46 Site plan of Lookout Shoals Development (Duke Energy Corporation 2003).

4.47 Lookout Shoals Development; view of dam, powerhouse, substation, and prefabricated building; looking northwest.

4.48 Lookout Shoals Development; view of dam (floodwall improvements visible at west end of dam); looking southwest.

4.49 Lookout Shoals Development; view of dam, powerhouse, substation, and prefabricated building; looking northeast.

4.50 Lookout Shoals Development, Lookout Powerhouse; looking northwest.

4.51 Lookout Shoals Development; view of dam/intake area to rear of powerhouse; looking west-northwest.

4.52 Lookout Shoals Development; view of crest of dam/intake area; looking west.

4.53 Lookout Shoals Development, Lookout Powerhouse; view of generator floor; looking west.

4.54 Lookout Shoals Development, Lookout Powerhouse; view of generator floor; looking east.

4.55 Lookout Shoals Development, Lookout Powerhouse; view of control room; looking east.

4.56 Lookout Shoals Development, Lookout Powerhouse; view of basement (generator bases at left); looking east.

4.57 Lookout Shoals Development, Lookout Powerhouse; penstock, valve, and turbine housing for synchronous generator; looking southwest.

4.58 Lookout Shoals Development; view of warehouse; looking south-southwest.

4.59 Map showing dam, powerhouse, and dike at Cowans Ford Development.

4.60 Site plan of dam and powerhouse at Cowans Ford Development (Duke Energy Corporation 2003).

4.61 Site plan of Hicks Cross Roads Dike at Cowans Ford Development (Duke Energy Corporation 2003).

4.62 Cowans Ford Development; view of dam, powerhouse, and spillway; looking north-northeast.

4.63 Cowans Ford Development; view of dam and powerhouse; looking east.

4.64 Cowans Ford Development; view of spillway gates; looking north-northeast.

4.65 Cowans Ford Development; view of visitor center/entry point; looking east-northeast.

4.66 Cowans Ford Development; view of interior of visitor center/entry point; looking east.

4.67 Cowans Ford Development, Cowans Ford Powerhouse; view of workroom; looking north.

4.68 Cowans Ford Development, Cowans Ford Powerhouse; view of dam/spillway inspection tunnel; looking east.

4.69 Cowans Ford Development, Cowans Ford Powerhouse; view of generator floor (generator bases at right); looking west.

4.70 Cowans Ford Development, Cowans Ford Powerhouse; view of interior of generator base; looking north at generator-turbine shaft.

4.71 Cowans Ford Development; view of office building; looking northwest.

4.72 Cowans Ford Development; view of warehouse; looking west-northwest.

4.73 Cowans Ford Development; view of tractor shed; looking northwest.

4.74 Cowans Ford Development; view of boat storage building; looking north.

4.75 Cowans Ford Development; view of frame and metal shed; looking east.

4.76 Cowans Ford Development; view of clapboard shed; looking northeast.

4.77 Cowans Ford Development; view of trailer; looking north.

4.78 Cowans Ford Development; view of west embankment; looking north-northeast.

4.79 Cowans Ford Development; view of Hicks Cross Roads Dike; looking southwest.

4.80 Map showing dam and powerhouse at Mountain Island Development.

4.81 Site plan of Mountain Island Development (Duke Energy Corporation 2003).

4.82 Mountain Island Development; view of dam (west abutment), powerhouse, and substation; looking northeast.

4.83 Mountain Island Development; Mountain Island Powerhouse (notice transformer ledge above basement openings and fishing piers at tailrace); looking north.

4.84 Mountain Island Development; Mountain Island Powerhouse; looking west.

4.85 Mountain Island Development; view of east abutment (new floodwall visible at crest and matting visible at ground) and substation; looking northeast.

4.86 Mountain Island Development; view of spillway; looking northeast.

4.87 Mountain Island Development; east and west abutments with intake deck at center; looking east-northeast.

4.88 Mountain Island Development; Mountain Island Powerhouse; view of generator floor; looking east.

4.89 Mountain Island Development; Mountain Island Powerhouse; view of generator floor; looking west-southwest.

4.90 Mountain Island Development; Mountain Island Powerhouse; view of mezzanine showing office/restroom and kitchen/break room; looking west-southwest.

4.91 Mountain Island Development; Mountain Island Powerhouse; view of basement; looking west at exterior of generator base.

4.92 Mountain Island Development; view of warehouse; looking northwest.

4.93 Mountain Island Development; view of open shed; looking northwest.

4.94 Mountain Island Development; view of historic transmission tower; looking west.

TABLES

4-1. Previous Survey Information. 33

I. INTRODUCTION

During April and May of 2004, TRC Garrow Associates, Inc. (TRC), under contract to Devine Tarbell & Associates, Inc. (DTA), conducted an architectural survey and National Register of Historic Places (NRHP) eligibility assessment of 11 hydroelectric developments on the Catawba and Wateree rivers in North Carolina and South Carolina (Figure 1.1). The architectural survey and assessment were undertaken for Duke Power, a division of Duke Energy Corporation, as part of the relicensing effort for the Catawba-Wateree Hydroelectric Project (FERC No. 2232). Six of the hydroelectric developments are located in North Carolina, and five are located in South Carolina. This document addresses the North Carolina developments: Bridgewater, Rhodhiss, Oxford, Lookout Shoals, Cowans Ford, and Mountain Island. A separate document covers the South Carolina developments: Wylie, Fishing Creek, Great Falls-Dearborn, Rocky Creek-Cedar Creek, and Wateree.[1] All work undertaken by TRC was conducted in accordance with applicable federal laws and guidelines, as well as the requirements and guidance of the North Carolina State Historic Preservation Office (HPO). In addition, TRC adhered to field safety protocols developed by Duke Power (*Safe Work Practices*) and DTA while at the developments.

All of the North Carolina developments have been surveyed previously, with the exception of Cowans Ford. That development was completed and brought on line in 1963, some 41 years ago (a fourth turbine-generator unit came on line in 1967). Because the NRHP survey and assessment process, with few exceptions, only addresses resources that are 50 years of age or older (due to the need to allow sufficient time to pass before making an objective eligibility decision), the Cowans Ford development had not been surveyed and assessed prior to this evaluatione. Of the five previously surveyed developments, only Bridgewater and Lookout Shoals have had some or all of their components recommended significant and/or eligible for the NRHP.

Based on TRC's research, field survey, and analysis, and in accordance with 36 CFR 60.4, the Bridgewater, Rhodhiss, Oxford, Lookout Shoals, and Mountain Island developments are recommended eligible for the NRHP under criteria A and C. The dams, powerhouses, and support buildings have undergone minimal alteration and still appear—for the most part—as they did when they were first constructed. They continue to illustrate the historical associations for which they are significant, both to the region and to the South as a whole: the growth of the electric power business; the growth of industry and commerce; changes in employment and improved working conditions; changes in the home and an improved quality of life; changes in rural areas, especially on the farm; and conservation of natural resources. Although the developments have been altered to varying degrees over time, the alterations have been minor and have consisted of installation of modern, computerized control equipment; changes made for safety reasons; FERC-mandated upgrades for flood control; and normal upgrades of generating and transmission equipment. Because the developments continue to be used for their original purpose, and because the operators have maintained the equipment and the structures as they

[1] Although constructed separately, the Great Falls and Dearborn developments are at the same location on the Catawba River and are treated as one overall development. The same holds true for the Rocky Creek and Cedar Creek developments.

have through the years, the developments retain their integrity and their historic design, construction, and use of materials and, thus, remain good examples of their types.

The Cowans Ford development is recommended ineligible for the NRHP due to its more recent age. The NRHP eligibility criteria allow for resources less than 50 years old to be determined eligible, but such resources must demonstrate "exceptional importance." Although Cowans Ford was the largest of the Catawba-Wateree developments and was the last hydroelectric development constructed on the river, thereby completing the build-out of the river system begun in the historic period, it does not meet NRHP Criteria Consideration G as an exceptionally significant resource. Cowans Ford followed a different design, had a much larger capacity than any of the other developments on the Catawba-Wateree system, and was built during a different period—the post-World War II, modern era—which places it in a different context. At that point in time, Duke Power was looking to fossil fuel-powered steam plants, pumped-storage facilities, and nuclear power to meet the electricity needs of the Carolina Piedmont; hydroelectric power generation accounted for only a small percentage of the company's total output.

Because a majority of the changes to the hydroelectric developments have been mandated by FERC for safety reasons or are day-to-day operational upgrades required for the efficient and profitable functioning of the facilities, it is suggested that Duke Power develop a Programmatic Agreement in consultation with the appropriate regulatory agencies to address these types of ongoing changes. Then, only the most major changes, such as partial or complete removal of buildings or structures, would require standard review under the Section 106 compliance process.

This document is organized in the following manner: Chapter II presents the historical context for the six North Carolina developments. Chapter III contains the study methodology. Chapter IV features the results of the fieldwork and NRHP assessment. Chapter V summarizes the conclusions of the document and offers recommendations regarding the resources. Finally, Appendix 1 contains the report figures, and Appendix 2 features a select listing of U.S. dams built between 1821 and 1964.

II. HISTORICAL CONTEXT

Much of the text in this chapter, especially the first three sections, comes from Thomason's (2003) report assessing the eligibility of seven hydroelectric developments in Duke Power's Nantahala system.

THE HISTORY AND TECHNOLOGY OF HYDROELECTRIC POWER

Historical Development: 1880–Present

Thomas Edison's work with electricity in the late 1870s and 1880s spurred the development of waterpower to generate electricity. The earliest hydroelectric plants were direct current (DC) stations built to power arc and incandescent lighting. The first hydroelectric plant for large-scale commercial power generation in the United States was located at Niagara Falls, New York, and is still in use today. A central powerhouse with a Brush dynamo was installed in 1881 to power the city's street lamps (Bureau of Reclamation 2003). By the mid to late 1880s, the number of hydroelectric plants began to grow rapidly in response to the growth of the electric light industry and the development of the electric motor. In 1886, 40 to 50 electric light plants were either on line or under construction in the U.S. and Canada. The largest plants existed at Rochester and Niagara Falls, New York; Holyoke and West Somerville, Massachusetts; Lynchburg, Virginia; Columbus, Georgia; and Laconia, Maine. The *American Electrical Directory* for 1889 listed 560 electric companies in the United States. Two hundred of these companies utilized waterpower for generation of part or all of their current (Hay 1991:15–16).

The true potential of hydroelectric power, however, would not be realized until after the successful commercial demonstration of the use of alternating current (AC) at Niagara Falls in 1895. George Westinghouse won the contract to develop a system for delivering power from Niagara Falls to Buffalo, New York, some 26 miles away. Westinghouse proposed an AC system, over Thomas Edison's proposal for a DC system. Unlike direct current, alternating current allowed electricity to be generated at one voltage, increased through transformers to a higher voltage for transmission, and then decreased through transformers for distribution to consumers. AC was also more economical since it could transmit high voltages via copper wires over long distances. This allowed for the possibility of electrical generation at one source, and the transmission of current to consumers in urban areas or to industrial clients. Thus, household lights that operated at 110 volts could be served by the same power source that provided 240 to 2,000 volts for industrial applications. Although many of the design features of the Niagara plant, such as outward flow turbines and external revolving field alternators, were later abandoned, the practical and financial success of the Niagara plant changed the power generation industry and set in motion the electrical revolution in the U.S. (Hay 1991:22, 24–25).

Westinghouse's "universal" system proved to be the most practical solution to providing hydroelectric power to any location, regardless of the availability of an adequate water source. Before AC electric power, factories required a prime mover, such as a waterwheel or steam engine. This source turned "line shafts" with pulleys and leather belts. The shafts were often three inches in diameter, suspended from the ceiling, and ran the entire length of the building. Power was distributed to other floors via holes in the ceiling. Because these shafts were a fire hazard, many factories opted to build expensive belt towers. The entire system worked continuously throughout the building no matter what machines were in use or disuse. If any problems occurred with the system, a full room of machines or the entire factory shut down until repairs could be made (Devine 1983:352). In addition, regular maintenance of the system was time-consuming.

Hydroelectric projects were constructed at a rapid pace following the successful application of alternating current, and the pace continued up until the beginning of World War I, as new developments were introduced and demand increased. By 1896, there were as many as 300 AC plants operating in the United States (Hay 1991:20). However, at the turn of the century, most factories still depended on costly and cumbersome power from steam or coal, which was sometimes used to power electric motors. These power sources adversely affected the size, location, and design of factories and machines using electricity. Only four percent of manufacturing power came from electricity. However, by the 1920s, more than half of industry used electricity (Woolfe 1982:230), and manufacturing used more power than municipalities, business, and homes combined (DuBoff 1967:510). During this period, about 40 percent of the electricity in the U.S. was generated hydraulically.

With the possibility of U.S. involvement in the war in Europe looming, President Woodrow Wilson recognized the potential benefits of hydroelectric power for military purposes and promoted the government-sponsored construction of a dam on the Tennessee River at Muscle Shoals, Alabama, to power nitrate plants there. Between World War I and World War II, dam construction for mixed use and power generation continued, with increased standardization. New Deal legislation in the wake of the Depression was of particular significance to the future of large-scale hydroelectric projects. The Tennessee Valley Authority (TVA), created in 1933, began an ambitious plan to harness the waterpower of the entire Tennessee River and its tributaries, bringing inexpensive electrical service to industries, towns, and residents of the South, where it had previously only been available in limited areas. At the same time, private electrical companies, which had formed piecemeal prior to World War I to serve individual manufacturers or local governments, were being consolidated into large entities such as Duke Power and Georgia Power. These companies were developing networks to share power across systems for greater efficiency and were involved in transportation and manufacturing in addition to utility service. At the same time, industry fears of government regulation and nationalization of utility services discouraged large investments in hydroelectric projects (Hay 1991:xii).

On the eve of America's entry into World War II, the share of U.S. electrical power from hydroelectric generating facilities had dropped to about one-third. Yet the industry would play a key role in the country's efforts during the war. Fontana Dam in western North Carolina, Douglas Dam in eastern Tennessee, and other power projects were rushed to completion to supply vital industries with the power necessary to produce war materiel and conduct nuclear power research. After the war, U.S. efforts to maintain military superiority over the Soviet Union and its allies contributed to a further expansion of hydroelectric capacity, both nationwide and in the Southeast. The increased demand for power after the war eventually outstripped the available supply of practical hydroelectric power, accelerating the shift that had begun in the 1930s toward coal- and gas-powered plants as major sources of electricity in the United States. In 1964, Parr Nuclear Station in South Carolina, a joint venture of four utility companies in the Carolinas and

Virginia, including Duke Power, became the first nuclear-powered generating station in the Southeast. More nuclear power stations were constructed in the 1970s and 1980s to meet increasing demand and reduce American reliance on foreign oil.

The Technology of Hydroelectric Power

Hydroelectric systems consist of a variety of components and equipment that work together to produce energy. Among these are dams, intake structures, water delivery systems, and prime movers (Figure 2.1). Water delivery systems can be canals, flumes, tunnels, pipelines, or penstocks. Plants with high heads also typically have surge tanks, stand pipes, and relief valves. The term "head" refers to the amount of water pressure exerted to provide energy. The higher the head, the greater the water pressure that drives the prime movers. Prime movers are the water turbines or impulse wheels, which drive electrical generators. This equipment usually is enclosed in a powerhouse, which also contains the control and switching equipment (Hay 1991:43).

The water from the storage reservoir behind the dam flows through a delivery system, such as a penstock. Adjustable valves or gates control the rate of water flow. After entering the turbine, the water exits via the draft tube and tailrace. A turbine is a rotary engine that converts the energy of moving water into mechanical energy by driving the axle or shaft of an electric generator. Within the generator, electric current is produced by the movement of the conductor (usually copper) through a magnetic field (Jackson 1988:44). The turbine is equipped with paddles, propellers, blades, or buckets that are turned by the tangential force of water. The design of the turbine depends on the available head of water; generally, high heads require a Francis-type turbine, while low heads use a Kaplan or propeller turbine.

As Hay (1991:43) points out in his work on the history of hydroelectric power, the design, arrangement, use, and combination of the various elements within a hydroelectric system "varies enormously from site to site and often is a product of the time during which a particular plant was designed." The technology of dam construction, delivery systems, and prime movers evolved as the industry developed and demand for electricity increased. Power plants built before World War I exhibit more variation, as engineers sought to improve the efficiency, durability, and dependability of the plants, while reducing costs. Improvements continued to be made in the 1920s, but there was more standardization in the industry, and effective designs were often repeated at different sites (Hay 1991:xi–xii).

Dams come in one of two basic types. Diversion dams do what their name implies and divert water from a river or stream into a manmade canal or waterway. The diverted water is then utilized at another site. This type of dam is usually small in size and can redirect either the whole flow of water or a portion of the flow. Often, a diversion dam is designed to be overtopped during flooding. Storage dams, on the other hand, retain water for the long term. These larger dams collect seasonal runoff and utilize it throughout the year (Jackson 1988:41).

Dam construction is one of the largest and most expensive undertakings in the development of a hydroelectric plant. Early hydroelectric plants often used existing dams for their projects. Dams constructed in the nineteenth century included those made of masonry, earth, and timber. As hydroelectric power became a viable enterprise, dams were constructed solely for this purpose. The first large masonry dam built for a hydroelectric plant was the Austin Dam across the Colorado

River in Austin, Texas. Completed in 1893, the dam was 1,300 feet long and 65 feet high. Floodwaters, however, caused the structure to collapse in 1900. Concrete and timber dams were also constructed in the late nineteenth century for use at hydroelectric plants. In 1897, an 800-foot-long concrete dam was completed at Mechanicville, New York. Also during the 1890s, timber crib dams were constructed in New Hampshire, Maine, and Montana. Although less permanent, timber dams were less expensive to build than those of stone or concrete (Hay 1991:45–46).

In the decades that followed, dam building technology was fueled by the desire to lessen the expense of dam construction. Efforts focused on using smaller volumes of material and on designs that employed less costly materials and fewer skilled laborers. Arch dam designs reduced the volume of required construction materials by transferring thrusts to the abutments, which meant the dam itself could be thinner. The first such dam constructed was the 1885 Bear Valley Dam near San Bernardino, California. The masonry dam was slender for its time with a twenty-foot thick base, and it was able to withstand a 65-foot static head. The use of steel in dam construction also came into play in the late nineteenth century but did not come into general use (Hay 1991:47–48).

Innovative designs in dam construction appeared in the early twentieth century with the work of Nils Frederick Ambursen and John S. Eastwood. In 1903, Ambursen patented a slab and buttress design for a reinforced concrete dam, in which the weight of the water was distributed across an inclined upstream face. The design called for a row of triangular buttresses that supported cast-in-place reinforced concrete slabs. In 1904, Ambursen patented a curved sloping downstream spillway to carry water from the crest. This design created a "shell-dam" with a hollow core between the buttresses. Some power companies who used this design elected to install the facility's powerhouse inside the dam's hollow interior rather than build a separate structure (Hay 1991:48–50). In the early twentieth century, John S. Eastwood developed a multiple arch dam that featured "a series of reinforced concrete cylinder sections (arches) set at an angle . . . joined at their edges, and resting on triangular buttresses reminiscent of those used by Ambursen" (Hay 1991:51). This design greatly reduced the amount of material, as the arches were very thin.

Engineers also explored various laborsaving devices to reduce dam costs. Advances in earthmoving equipment encouraged the construction of rockfill and earth dams. Hydraulic fill dams were developed in the late nineteenth century. These were built by shooting high-pressure streams of water at hillsides near a dam site. The wet fill was then carried via sluices to the site, where it was allowed to settle and dry. Semi-hydraulic dams were built using dump cars on parallel, elevated trestles. The cars transported fill from nearby borrow pits and dumped it at the front and rear edges of the dam. As the two outer layers of dry fill grew in height, the center space was filled with wet fill washed from adjacent hillsides. This fill, after the excess water drained away, created a more solid core of earth between the two dry layers (Hay 1991:52–54).

An important development in dam technology was the invention of Tainter gates to control water flow. Jeremiah Burnham Tainter (1836–1920) developed this gate in 1886 while working at a lumber mill in Wisconsin. Tainter improved on the basic design of a common radial or paddle gate, which had been patented in 1827. Refinements of the radial gate occurred over the years, with Tainter's design proving to be the most superior. The Tainter gate employed the force of gravity and the movement of the water to help open and close the device. The gate thus operated with a minimum of manpower, was easy to manipulate, and was more efficient than previous models. The Tainter gate consists of two arched girders connected by a metal sheet. The gate is supported by trunion arms that rotate along an axis when the gate is lowered and raised. The arched gate is convex on the upstream side, and the rush of water helps to open and close the gate (Lynch and Russell 1996). The Tainter gate system came to be used in dams and locks throughout the world. Over time, stronger and more rigid models of the Tainter gate were developed, including submersible versions.

The water delivery systems that carry water from dams and associated reservoirs include canals, flumes, tunnels, pipelines, and penstocks. With the development of hydroelectricity, only subtle changes occurred in the construction of canals and flumes, which had been in use for irrigation and other purposes for centuries. Changes focused on streamlining and efficiency. Rectangular timber flumes were common, and manufacturers began to offer semicircular flumes constructed of wood and sheet metal. Some concrete flumes were produced, but were cost-prohibitive. In the eastern United States, closed conduits were more common than flumes. Plank-lined and later concrete-lined pressure tunnels enabled companies to connect streams, storage reservoirs, and power plants while bypassing ridges and other obstacles (Lynch and Russell 1996:54–56).

Pipelines and penstocks transfer water to the turbines. Pipelines are defined as "pressure conduits that run from a dam or the foot of a canal to the surge tank or standpipe" (Lynch and Russell 1996:57). Pipelines are connected to turbine cases by penstocks. Penstocks typically have steep slopes and are able to withstand high pressures. Pipelines and penstocks are often confused, and it is not uncommon for the entire system to be referred to as a penstock. Throughout the late nineteenth century, wood stave pipelines were used in hydroelectric facilities to carry water along gentle slopes. Plate steel penstocks then delivered the high headwater to the turbines. It was found that rivets in the penstocks weakened the steel plate and caused internal surface friction, so welded steel versions became the norm. A few pipelines and penstocks were constructed of pre-cast or cast-in-place reinforced concrete; however, the material could not withstand pressure without seepage and so was not widely used (Lynch and Russell 1996:57–58).

Pressure within long pipelines and penstocks often called for relief devices or venting in the system. Early hydroelectric systems installed safety valves, known as standpipes, to relieve pressure along the lines. Intense surges and rising pressure forced water to spill out of the top of the standpipes. Larger and taller pipes created simple surge tanks to conserve this water. In 1911, the differential surge tank was introduced. This tank contained a riser, similar in diameter to the pipeline, which was enclosed by a much larger diameter tank. It featured ports midway up the riser that helped to prevent oscillations within the tank and conduit (Lynch and Russell 1996:58–59).

Prime movers of a hydroelectric system are the impulse wheels or turbines. The design of impulse waterwheels changed little from the 1880s to the 1920s. Pelton wheels, as they were commonly called, revolved around horizontal shafts that could be connected directly to generators. Early versions were connected with flexible rawhide. In the 1890s, overhung waterwheels avoided misalignment problems by connecting directly to an extension of the generator shaft (Lynch and Russell 1996:60). Control mechanisms such as needle valves and jet deflectors were also common features at high head installations.

Low and medium head developments turned to water turbines in the late nineteenth and early twentieth centuries. Turbines are reaction wheels that are driven by the flow and pressure of water that moves against vanes or buckets. Early turbines were either outward or inward flow units, which are distinguished by the path of the water as it travels through the unit. "Inward flow runners receive water through guide vanes mounted around their periphery and discharge it at their centers" (Lynch and Russell 1996:62). Axial units force water along a path parallel to the runner shaft.

The majority of hydroelectric plants in the U.S. have what are known as Francis, or mixed flow, turbines. These units combine inward and axial flow. Several patented versions of the mixed flow turbine were introduced in the late nineteenth century; however, less precise but less costly stock pattern turbines were installed in most plants. Turbines were arranged in either vertical or horizontal configurations and were enclosed in cylindrical plate iron cases. Multiple runners per shaft also made duplex, triplex, and quadraplex installations common (Hay 1991:62–66).

Stock pattern turbines, however, could not meet the needs of large-scale hydroelectric facilities that developed in the twentieth century. These installations required custom designed turbines to fit their specific needs. Impulse wheels continued to be used at sites of 1,000 feet or more at the turn of the century, but Francis turbines became the norm for moderate to high head developments in the twentieth century. A key factor in this change was the development of the Kingsbury thrust bearing, an oil film pressure wedge bearing connecting the turbine and generator and allowing vertical suspension of the turbine-generator unit. Invented by Albert Kingsbury in 1898, it was first used in a commercial hydroelectric plant in 1912. The design did not require pumps or other external pressure equipment, and the bearing had the capacity to carry vertical reaction turbines of great size. This greatly altered power plant design. The Kingsbury bearing and variations on the design were commonplace by 1915, and large-scale plants were being built with vertical reaction turbines, which hung from the new bearings. By 1920, vertical Francis turbines were built with up to 60,000 horsepower at heads over 600 feet (Hay 1991:71–76; Lynch and Russell 1996:72).

Propeller turbines were first used in low head hydroelectric facilities in 1916. Several versions of the design emerged that were "smaller, lighter, and less prone to damage from passing ice and debris than their Francis counterparts" (Hay 1991:79). The propeller runners also operated at high speeds and were more economical. The design was perfected by Dr. Viktor Kaplan, who invented a propeller turbine with blades "that were continuously adjustable in synchrony with wicket gate angles" (Hay 1991:80). Kaplan units first appeared in the U.S. in 1929 at a plant in Texas.

The six hydroelectric developments addressed in this document reflect much of the history of the growth and development of hydroelectric technology. The dams are of concrete and earth fill construction. The powerhouses contain vertical Francis turbines, except at Cowans Ford, where there are four vertical Kaplan units. Full descriptions of these facilities can be found in Chapter IV.

THE DEVELOPMENT OF HYDROELECTRIC POWER IN THE CAROLINAS: CA. 1893–1955

In the late nineteenth century, electrical power in the Carolinas was limited to small DC dynamos and generators used to power individual homes and businesses. The earliest use of large-scale hydroelectric power in the region was at Columbia Mills on the Broad River, near Columbia, South Carolina. Sidney B. Paine, a salesman with General Electric, designed an AC system that powered a series of motors and lights in the textile mill. The mill began operation in 1894 and was the first cotton mill in the U.S. to use an AC system. Its success had an immediate impact on the industry.

By 1900, nearly all new mills were equipped with AC electrical systems, which provided several advantages, including more reliable and steady current, independent operation of different parts of the system, and less fire hazard (Hay 1991:32–34). In 1897, a young engineer named William C. Whitner completed a hydroelectric plant at Portman Shoals near Anderson, South Carolina. The plant used specially built generators capable of producing 10,000 volts, the highest capacity commercial generators then in operation. The plant, regarded as something of an experiment, soon provided power to Anderson Cotton Mills and the City of Anderson and proved that high voltages could be carried long distance to a variety of customers (Durden 2001:7–8, 12).

In North Carolina, the first significant hydroelectric facility was the Idols Hydroelectric Plant on the Yadkin River, constructed in 1898 by the Fries Power and Manufacturing Company. The facility powered textile mills, streetcars, and small manufacturing plants in the nearby towns of Salem and Winston. When it was constructed, the plant transmitted electric power 13.5 miles to a substation in Salem (North Carolina Department of Cultural Resources [NCDCR] 1974:5–6).

The Portman Shoals and Idols plants were the first of dozens of hydroelectric facilities that would be built in the Carolina Piedmont over the next several decades. Numerous companies were formed to build dams and power plants in these years with varying degrees of success. The Duncan Hay study of *Hydroelectric Development in the United States, 1880–1940* (1991) documents the existence of 40 non-Duke Power hydroelectric plants built in the Carolinas prior to 1940. Some plants operated only for a short period before they proved uneconomical and went out of business. Others were eventually purchased by or consolidated with emerging larger utility companies such as Duke Power, Carolina Power & Light (CP&L), and South Carolina Electric & Gas (SCE&G).

Southern Power Company/Duke Power Company

Duke Power's roots lay with North Carolina tobacco heir James Buchanan (Buck) Duke, engineer and physician Dr. W. Gill Wylie, and South Carolina engineer Dr. William States Lee. Wylie and William C. Whitner organized the Catawba Power Company in 1900. Whitner left the company in 1902, and Wiley hired Whitner's assistant on two previous projects, William States Lee. Lee completed the company's first hydroelectric project at India Hook Shoals on the Catawba River in 1904 (commonly known as the Old Catawba development). The station supplied power to the Victoria Cotton Mills at Rock Hill (Duke Power Company 2004; Durden 2001:10). By the end of the year, transmission lines had been extended to the South Carolina towns of Rock Hill, York, Clover, Fort Mill, and Pineville, and to Charlotte, North Carolina.

In the meantime, Buck Duke formed the American Development Company to acquire land and water rights on the Catawba River and other water sites in the Carolinas. Duke met with Wylie and Lee and organized the Southern Power Company in 1905, with Duke raising the majority of the funding and Wylie and Lee providing the technical expertise. The company was founded on the idea of developing an entire river valley into a hydroelectric system that would feed a transmission network, serving customers throughout its territory (Durden 2001:18; Lee 1987:8–9; Maynor 1980:13–14).

Southern Power completed its first hydroelectric station at Great Falls, South Carolina, in 1907. In 1909, the plant began to supply power to the city of Greenville, South Carolina, via a 143-mile, double-circuit, 100,000-volt transmission line—the first in the country. That same year, a plant was brought on line at Rocky Creek, two miles below Great Falls. Less than two years later, the Ninety-Nine Islands station on the Broad River was completed. At the end of 1915, the first Southern Power hydroelectric plant in North Carolina, the Lookout Shoals development in Iredell County, was put into service (Duke Power Company 2004; Maynor 1980: 13, 32).

Southern Power also constructed hydroelectric facilities through its subsidiaries, beginning in 1916 and continuing into the 1920s. In 1919, the Western Carolina Power Company completed the Bridgewater development in Burke County, North Carolina, at the upper end of the Catawba River system. In the same year, the Wateree Power Company began operations at the Wateree development near Camden, South Carolina, at the lower end of the system. Five more facilities and two additional powerhouses (one each at Great Falls and Rocky Creek) were constructed between Bridgewater and Wateree by Southern Power subsidiaries between 1923 and 1928. Meanwhile, in 1924, Southern Power was renamed Duke Power Company in honor of its most significant benefactor (Duke Power Company 2004; Durden 2001).

Carolina Power & Light Company

Carolina Power & Light Company (CP&L) was formed in 1908 with the mergers of the Raleigh Electric Company, Cape Fear Power Company, and Consumers Light and Power Company. This was accomplished with the backing of the Electric Bond and Share Company (EBASCO), a holding and management company that had previously been owned by General Electric. EBASCO's first transaction was the purchase of the securities of the Raleigh Electric Company in 1905, followed by the purchase in 1906 of Cape Fear Power and Consumers Light and Power. The three companies were consolidated as Carolina Power & Light, and improvements to and construction of transmission lines began immediately, giving the company more flexibility. Raleigh Electric had constructed a hydroelectric plant on the Neuse River near Melburnie in 1903, and Cape Fear Power had just completed its first project, Buckhorn Dam, but was struggling financially. CP&L connected Buckhorn to Raleigh, Sanford, and Jonesboro, North Carolina, and rebuilt the Buckhorn to Fayetteville transmission line, ensuring the plant's success. Other plants in the system included a 1,000-kilowatt steam plant in Raleigh and a 75-kilowatt plant at Sanford (Riley 1958:32, 38–40, 42, 44–47, 57–58, 63).

CP&L also began acquiring smaller electric companies in the state. In 1911, the Oxford Electric Company was transferred to CP&L. That same year the North State Hydro Electric Company, financed by EBASCO, was formed to build transmission lines. It was soon obtained by CP&L. In 1912, CP&L acquired Asheville Power & Light Company and the electric system at Goldsboro, North Carolina. Four years later, it acquired the Manchester hydroelectric plant on the Little River, which supplied the town of Fayetteville. As power demands increased in the state, CP&L directors authorized the acquisition of sites on the Yadkin and Rocky rivers. By 1918, CP&L had become a sizable company, supplying electric light and power to a number of cities in North Carolina. In 1926, CP&L had 19,800 customers (Riley 1958:70, 73, 86–87, 90).

Aluminum Company of America (Alcoa)

A major demand for hydroelectricity in the Southeast developed as a result of advances in the mass production of aluminum made by Charles Martin Hall and the Pittsburgh Reduction

Company. Refining operations for making aluminum required tremendous amounts of power, and hydroelectric power proved to be the best choice for this highly consumptive type of manufacturing. In 1895, the Pittsburgh Reduction Company moved to Niagara Falls, becoming the first customer of the hydroelectric plant located there. Renamed the Aluminum Corporation of America (Alcoa) in 1907, the company began to expand to other hydroelectric sites. It was important to locate the aluminum reduction facilities near sources of hydroelectric power because it was found to be cheaper to bring the raw materials to the source of power than to construct long-distance transmission lines to bring the power to the raw materials (Carr 1952:88–90, 92; Smith 1986:94–95).

Beginning in 1910, Alcoa started to acquire property in North Carolina and Tennessee for its planned hydroelectric developments. The company focused on the Little Tennessee River and its tributaries in the Great Smoky Mountains region, including the Tuckasegee, a large river in North Carolina with terrain that was ideal for a high head plant. Alcoa gained riparian and power rights along the mountainous waterways by purchasing the Knoxville Power Company and Union Development Company in Tennessee, and the Tallassee Power Company in North Carolina. In 1914, Alcoa began operations at its new smelting plant at Alcoa, Tennessee, the largest aluminum plant in the country (Carr 1952:93–94; Smith 1986:96). Alcoa continued to build its own dams and power stations along the Little Tennessee and its tributaries in order to provide additional power to its Tennessee smelting plant. These developments included the Cheoah Dam (1919), the highest overfall dam in the world to date, the Santeetlah Dam (1928), and the Calderwood Dam (1930) (Carr 1952:95–96, 106).

In 1915, Alcoa purchased the floundering Southern Aluminum Company of North Carolina. The company had initiated a smelting operation and waterpower site at Badin on the Yadkin River, located in the Piedmont area of North Carolina. Alcoa completed a dam and powerhouse, and the plant began operating in 1917. Later dams were constructed at Yadkin Falls in 1919 and High Rock in 1927. In 1929, the Nantahala Power & Light Company (NP&L), a wholly owned Alcoa subsidiary, was formed. NP&L served as a public utility company that provided electric power for residential and commercial use in the Great Smoky Mountains area of North Carolina. At the time the company was formed, fewer than 2,000 people had electric service in the region. NP&L developed existing sites of the Tallassee Power Company, which Alcoa had purchased in 1914, and built and operated the Glenville and Nantahala dams and power stations (Carr 1952:94–95, 100–102; McRae 1992:1–2; NP&L 1999; Smith 1986:96; Thorpe 1939).

South Carolina Electric and Gas Company

The first company to successfully provide electric lighting in Charleston was the Charleston Electric Light Company in 1886. The following year, the Congaree Gas & Electric Company formed to generate and distribute electricity in Columbia. Initially formed to provide electricity for lighting, these companies soon were supplying power for electric streetcar systems that came to typify urban public transportation in the 1890s. The Columbia Street Railway Company debuted its electric streetcars in 1893, and Charleston had a system by 1897. These electric car companies were major customers for the electric utilities, who created and promoted different entertainment events to increase ridership. Patrons could choose oceanside concerts on the Isle of Palms or weekly vaudeville performances at a casino in North Columbia. The streetcars reached their zenith during World War I, but by the mid to late 1930s, they were viewed as obsolete and were abandoned in both Columbia and Charleston. In the meantime, industries along the Broad River in Columbia had emerged as the main customers of the power companies. In 1894, Columbia Water Power Company's powerhouse on the Columbia Canal supplied the power for the world's first electrically powered textile mill (SCANA Corporation 2004). The success of Columbia Mills led to the rapid electrification of factories after 1900.

After World War I, several large companies emerged as leaders in supplying electric power in South Carolina. In the northern part of the state, Southern Power Company had constructed several large dams and powerhouses on the Catawba and Broad rivers and had linked the stations together to supply power to the Piedmont region of the Carolinas. Farther south on the Broad River at Columbia, the Broad River Power Company was organized in 1924 as a subsidiary of General Gas & Electric Corporation. The next year it bought the electric and gas properties of Columbia Railway Gas & Electric Company. The new company immediately set out on a program to add electric generating capacity (SCANA Corporation 2004).

South Carolina Power Company formed in 1926 when several smaller companies consolidated in Charleston. In 1928, Commonwealth & Southern Corporation purchased controlling interest in South Carolina Power. It then merged with the Augusta-Aiken Railway & Electric Company, Georgia-Carolina Power Company, and the Edisto Public Service Corporation, bringing 13 new counties into the company's service territory (SCANA Corporation 2004).

During the next two decades, the growth of both Broad River Power and South Carolina Power helped fuel expansion of the state's economy. In 1927, the Lexington Water Power Company received a license to build a dam on the Saluda River northwest of Columbia. Saluda Dam, which would create the 50,000-acre Lake Murray, was the largest manmade barrier built for power production in the world when it was completed in 1930. In addition, the project provided desperately needed jobs in the lean years leading up to and beyond the stock market crash of 1929 and the beginning of the Great Depression (SCANA Corporation 2004).

In 1937, the Broad River Power Company became South Carolina Electric & Gas Company (SCE&G). Lexington Water Power Company merged with SCE&G in 1942. Throughout the difficult economic times of the 1930s and early 1940s, private utility companies, including SCE&G, fought unsuccessfully to prevent the creation of public power companies that competed against them, particularly for supplying electricity to rural areas. SCE&G is now the principal subsidiary of SCANA Energy Corporation (SCANA Corporation 2004)

Hydroelectric Power and the Development of the Carolina Piedmont

While the South may have lagged behind the North in industrial output in the postbellum era, it was certainly not lacking in innovators and progressive thinkers. Putting their faith in the potential for industrialization to pull the South out of the grips of a monolithic and outdated agricultural economy, political and business leaders in Southern cities such as Atlanta, Charlotte, and Birmingham sought capital and know-how to bring technological innovation to their cities. While the persistent presumption has been that most of this money and knowledge came from Yankee carpetbaggers, many of those on the forefront of the movement were native Southerners. Moreover, these promoters were not blind to the power of electricity to turn their visions into reality. The first electric streetcar system in the nation went into operation in Richmond in 1887, and the second in Asheville in 1889. Columbia Mills, the first fully electric cotton mill and one of the first factories in the country to use hydroelectric power, opened in Columbia in 1894.

The Southern states experienced a significant boom in manufacturing between 1880 and 1900, fueled in large part by the establishment of textile mills along the fall line from Virginia to Georgia. Wages, capital, and value of products were all increasing at an exponential rate (265 percent, 325 percent, and 196 percent, respectively). That increased value was being spread among a work force that had increased by only 165 percent and a population that had increased only 43 percent. Still, the South at the turn of the century was less urbanized and less industrialized than the Northeast and was suffering the ill effects of a depressed cotton market in the 1890s. In the Piedmont of North Carolina and South Carolina, cotton and tobacco dominated the agricultural economy, but the region was not possessed of the old money aristocracy of the coastal regions. The *Charlotte Observer* described the Piedmont in 1937 as "an agricultural section—and not a particularly favored agricultural section—with a scattering of small industrial plants, mostly neighborhood grist mills, small wood and metal shops and a few cotton mills" (quoted in Maynor 1980:30).

This may have been a slightly exaggerated description, but it certainly reflected the feelings of rapid change experienced in the region since the beginning of the twentieth century. The growth in manufacturing that began in the last two decades of the nineteenth century reached even greater proportions during the first quarter of the twentieth century. From 1900 to 1925, total wages, capital invested, and value of products grew more than four fold, while the work force increased by only 90 percent and the population increased by 47 percent (Brooks 1929:9–13). The textile industry led the way in this industrialization, passing the New England states in amount of cotton used in 1913, value of product in 1923, and total number of spindles in 1927 (Durden 2001:56–57).

The Piedmont Carolinas benefited even more from the boom than did the Southern states as a whole. Unlike the Black Belt areas of the Lower South, the Piedmont was unencumbered by a strict social structure, large unskilled African-American population, and conservative business atmosphere. It was also rich in natural resources, cheap labor, and potential waterpower, which attracted a flood of textile and other manufacturers. These manufacturers typically located their factories in small or medium-sized towns where waterpower and cheap white labor could be found. The ability to transmit electricity over great distances to sites where waterpower was not available helped attract industries to the South, because of the lower cost of constructing an initial power source and the ability to locate on inexpensive land in areas where employment opportunities were welcomed. The power lines also encouraged a dispersed pattern of industrialization. Hoping to boost the local economy, small towns throughout the Piedmont competed for the attention of investors looking to establish factories. The result was a proliferation of low-wage jobs and a lack of labor unions to protest the situation. Efforts to raise wages were generally met with anger from both local officials and workers, who feared the industries would abandon the area for a more supportive locale. North Carolina was the most vociferous state in the South in its opposition to labor unions, and while it succeeded in leading the South in percentage of population employed in manufacturing, it also topped the list of lowest paid laborers in the United States (Cobb 1993:33, 37–38). Certainly, the success of the textile industry in North Carolina was a mixed blessing.

The efforts of various organizations in the South to promote the benefits of locating industry in the Piedmont Carolinas in particular touted the hard-working character of the region's Anglo-Saxon stock and the lack of a large, disaffected black population. Writing in 1927, Thorndike Saville, a professor at the University of North Carolina, stated that one of the main reasons for the development of the "Power Province" in the South was cheap, non-unionized, white labor. A pamphlet produced by the University of Georgia's Bureau of Business Research in 1929 made it clear that the African-American population of the South was a debilitating presence that only undermined its progress. "The colored man ... will probably continue to operate as a drag on Southern progress and will serve to exaggerate the South's relatively low standing in such matters as per capita wealth, income, and literacy" (Brooks 1929:4–5). The smaller proportion of blacks in the general population of the Piedmont region was cited as a possible reason for the success of manufacturing in the area. Efforts to downplay the African-American population in promotional materials continued after World War II. A review of industry in the South in 1949 barely mentions black labor, stating only that blacks generally work in unskilled jobs (National Planning Association 1949). Although it was apparently not publicized, Southern Power utilized the contributions of African Americans in its dam construction program, which employed many such workers in unskilled and semi-skilled positions. Photographs in the Duke Power archives show many black workers at the construction sites, and Dennis Lawson, archivist with the company, has suggested that the dams were constructed almost entirely by African-American laborers (personal communication 21 April 2004).

The construction of hydroelectric plants in the 1910s and 1920s played a significant role in the development of industry in the Carolinas. A water and power census in 1922 noted that since 1910, North Carolina had moved from twenty-third to tenth place in the value of its industries, and from nineteenth to fourth place in crop value. The state produced a total of 360,000 horsepower, divided primarily among Southern (Duke) Power, Carolina Power & Light, Alcoa, Blue Ridge Power, and North Carolina Power. Most of the power went directly to industry rather than residential and commercial customers. Thirty-two percent of the power was transmitted for use out of state, and thirty-one percent went for the reduction of aluminum at Alcoa's Badin plant. Another 12.5 percent went to other manufacturing establishments within the state, leaving approximately one-fourth of the total generated power for general use (Saville 1922:5). By 1924, North Carolina ranked fourth in the United States in the amount of developed waterpower (Saville 1924:4–6).

The 1922 census further estimated that at the current rate of growth and power usage, North Carolina would have to increase its hydroelectric power capabilities. To further utilize the water resources of the state, the census also observed that it would be vital to develop water storage facilities, steam auxiliary plants, and interconnection of power units. Storage reservoirs were vital for water supply in times of drought, for flood control, and for river navigation. Since there was a deficiency of water storage facilities, steam power would be used in times of hydroelectric power shortage. To further avoid power shortages, power units would be interconnected to distribute excess power to other plants in times of need (Saville 1922:8–9, 13–14).

The census predicted that the rate of power produced in the state would increase in the coming years because the larger utility companies planned to construct several new waterpower developments, including Southern Power projects on the Catawba River, horsepower upgrades at Badin and Cheoah, and new plants on the Little Tennessee River by Tallassee Power Company. In addition, the North Carolina Geological and Economic Survey had investigated several potential sites for hydroelectric power facilities in Wilkes, Surry, Clay, Cherokee, Randolph, Stokes, and Moore counties. The survey had also determined that large, undeveloped power sites could be found on the Hiwassee, Nottely, French Broad, Watauga, Toe, and New rivers in western North Carolina and on the Yadkin, Deep, Haw, Dan, and Cape Fear rivers in the central part of the state (Saville 1922:8, 10, 12).

North Carolina did continue to show a tremendous increase in the power and transmission industry in the years following World War I. By 1924, North Carolina hydroelectric plants were producing 540,500 total horsepower. Tallassee Power Company (Alcoa), with the Badin, Yadkin, and Cheoah plants, was the largest producer. Southern (Duke) Power followed with the Bridgewater, Lookout Shoals, and Mountain Island developments. CP&L, which operated the Blewett Falls and Buckhorn Falls plants, was the third largest provider. Smaller companies included Blue Ridge Power Company (Tuxedo and Turner plants), North Carolina Electric Power (Ivy, Marshall, and Weaver plants), Sandhill Power (Carbonton plant), Deep River Power Company (Lockville plant), and Roanoke Rapids Power (Roanoke Rapids plant) (Saville 1924:4–6).

From 1919 to 1923, the amount of energy produced by hydroelectric power in North Carolina increased nearly 60 percent, although the percentage of total output from hydroelectric sources decreased in proportion to that produced by fuels from 93 percent in 1919 to 82 percent in 1923. The total output of electrical energy increased nearly 80 percent, and the total output for 1923 exceeded one billion kilowatt hours. In South Carolina, hydroelectricity continued to dominate fuel-powered generation during the same period. The amount of power produced by fuel-powered plants saw no significant increase and accounted for only six to eight percent of the total. The increase in hydroelectric power was considerably smaller than in North Carolina, growing only 23 percent between 1919 and 1923 (Saville 1924:13–16).

By the end of the 1920s, the South had emerged as a leading producer of hydroelectric power in the country. Electric power production in the South increased by more than 700 percent from 1912 to 1929, while electric power in the rest of the country increased by 400 percent. North Carolina remained fourth in the country in hydroelectric development, with Alabama, South Carolina, and Georgia ranking third, sixth, and seventh respectively (Thomason 2003:22).

Privately owned and operated utilities such as Duke Power, CP&L, and SCE&G had originally provided power primarily to industry, while various municipalities had developed their own small companies to supply power for stores, residences, and street lights. However, the larger companies took over these smaller operations, and as mill owners began to include electricity in worker homes as an incentive to attract workers, the large power companies began to see residential power as a lucrative market. Southern Power began to put considerable effort into attracting residential customers, and increasing their usage, by promoting the use of electrical household appliances. One of the first of these appliances powered by electricity was the iron:

> A Southern Power employee strapped a supply of them [electric irons] on the back of his bicycle and sold them door-to-door. He was the first appliance salesman for the company, and his success with the electric iron was the beginning of a whole new area of marketing (Maynor 1980:36–37).

In 1910, electricity was available in about 10 percent of households in the United States, steadily increasing to 70 percent in 1930 (Nye 1990:4).

By the end of the 1920s, North Carolina had passed Massachusetts as the leading producer of textiles in the United States. At the same time, there were signs of trouble ahead. Increased international competition, labor-reducing machinery, and overproduction led to a depression in the textile industry, resulting in layoffs and plant closings (Tullos 1989:285). With the coming of the Great Depression, little new construction of hydroelectric plants occurred in the state in the 1930s, as demand for power decreased for the first time in the century.

The outbreak of World War II and U.S. assistance to the Allied powers in the late 1930s led to a gradual turnaround in the economy. Power demands for military-related manufacturing spurred the construction of both the Thorpe and Nantahala hydroelectric plants for Alcoa. Following the war, several additional dams and reservoirs were built in the state to provide both hydroelectric power and flood control. With the completion in 1963 of the Cowans Ford Dam impounding Lake Norman, the potential waterpower of the Catawba River had been completely utilized. Increasing costs for land acquisition and construction also slowed the harnessing of waterpower from other rivers in the Carolinas. By the mid 1950s, other forms of energy, such as steam power and nuclear power, came to be favored over hydroelectric power. These new forms of electrical generation would surpass hydroelectric power to the point that by the mid 1970s, hydroelectricity provided only about five percent of Duke Power's output. Growing environmental concerns over the continued damming of the state's rivers and streams also became a concern. The trend away from construction of hydroelectric plants in the Carolinas continued to the end of the century.

DUKE POWER COMPANY AND THE CATAWBA-WATEREE HYDROELECTRIC SYSTEM

A Vision Becomes Reality: 1897–1916

Although it operated plants throughout the Piedmont of North and South Carolina, Duke Power's origins lay in the development of the Catawba River valley, as envisioned by the company's founders, James Buchanan (Buke) Duke, Dr. Gill Wylie, and William States Lee. Lee, one of the top engineers in the country, had comported himself well as an assistant to William C. Whitner on two of the earliest large-scale hydroelectric projects in the Southeast. The Portman Shoals development near Anderson, South Carolina, was completed in 1897 and was one of the first high-voltage, long-distance transmission projects. Wylie and his brother, both physicians with a number of interests including hydroelectric power, had invested in the Portman Shoals project and had purchased the land on which it was built. After this, Whitner and Lee went on to build what was then the largest hydroelectric plant in the country at Columbus, Georgia. The success of these projects spurred interest in potential waterpower sites in the Southeast.

The 700-foot drop of the Catawba River through the Carolina Piedmont, with the emerging regional center of Charlotte, North Carolina, at its midway point, was recognized as a prime resource for waterpower. Among those seeking to invest in the area were Buck Duke and his older brother Ben, who had acquired a vast fortune by securing a virtual monopoly on the lucrative tobacco industry. In 1897, Ben Duke received a letter from a North Carolina entrepreneur discussing the potential of using the Yadkin and Catawba rivers for waterpower (Maynor 1980:14). Duke was primarily interested in encouraging textile mill development in the

Southeast and was well aware of the potential of hydroelectric power within that industry. In 1899, Buck and Ben Duke organized The American Development Company to acquire land and water rights on the Catawba River and other water sites in North and South Carolina (Duke Power Company 2004; Durden 2001:8, 15–16; Maynor 1980:13).

Whitner, meanwhile, had left Lee in Columbus to finish the project there while he scouted the Catawba River around Charlotte for a site for his next large-scale project. He found that site at India Hook Shoals near Rock Hill, South Carolina, about 18 miles from Charlotte. After securing options on the property, Whitner then went to Wylie to seek funding for the project. Wylie and his brother invested $50,000 in the project and joined Whitner in forming the Catawba Power Company in 1900. Wylie was well aware of the Duke brothers' interest in hydroelectric power, and when he served as Ben Duke's physician for an appendectomy in 1899, he took the opportunity to ask the elder Duke to invest in the Catawba project. Ben Duke bought a small stake in the project, and he pitched in again in 1902 when the project hit a financial snag. This was a minor investment for the Dukes, however, and when their own engineer had visited the facility, he had advised Duke not to pursue the venture. The American Development Company did make an important purchase around this time, when it secured the rights to Great Falls, located about 33 miles below the Catawba Power Company's project at India Hook Shoals (Durden 2001:8–10; Maynor 1980:13–15).

The construction of the dam at India Hook Shoals was delayed in 1901 due to floods. During the delay, Wylie made some changes to the dam's design, creating a "gorge dam" by diverting overflow through a natural channel in the old riverbed. This allowed normal head to be used even in high water. The design change may have led to a disagreement between Wylie and Whitner, although this is not known for certain. In any case, Whitner left the project in 1902 and took the job of chief engineer for the Virginia Railway and Power Company (Durden 2001:8–9; Maynor 1980:11–12).

The project again ran out of money in 1903, illustrating all too well the pitfalls of a hydroelectric project of such size. Nevertheless, Wylie was able to secure backing from a group of Philadelphia capitalists, using some of the money to purchase a large share of the original bonds authorized on the project. Wylie then sought a replacement for William Whitner. He found one in W. S. Lee, Whitner's assistant and a brilliant engineer. Wylie assured Lee that the Catawba project had the potential to make the young engineer's reputation. The project was finally finished in 1904 and began supplying power to its only customer at the time, the Victoria Cotton Mills in Rock Hill. The power plant was connected to the mill by an 11,500-volt wire strung on poles that operated a 300-horsepower motor driving the mill machinery (Durden 2001:13). Soon after, similar lines were strung to Rock Hill, York, Fort Mill, and Clover, South Carolina, and Pineville and Charlotte, North Carolina (Sampson 1936). The Catawba plant had a capacity of 6,600 kilowatts by 1907. The generators of this plant were of historical interest, as the horizontal turbines powered the generators by means of rope drives. When the Catawba plant was redesigned in 1924, the equipment was removed from the powerhouse and the new facility was placed on top of the old (Duke Power Archives 1927b; Duke Power Company n.d.; Wray 1961).

When Wylie brought Lee on to the Catawba project, he explained to him his larger plan for a string of dams along the river (Maynor 1980:13). If it was Wylie's imagination that envisioned a series of dams and powerhouses on the Catawba River, it was certainly Lee's abilities that brought the vision to reality. Although Wylie may have had a sense of it, it seems that it was Lee who formulated the plan to link the powerhouses into an interconnected network. Such a network would provide more flexibility and economy by sharing power and taking into account the available supply and demand in different parts of the network. This important development promised to mitigate to some extent the uneven flows that were inevitable along such a large river system. This variability had discouraged the manager of Duke's textile operations, William A. Erwin, who had been investigating the potential of the Catawba. Indeed, the Wylies' earlier project at Portman Shoals had experienced problems with water flow. The board of directors of Anderson Cotton Mills, the primary customer for the power from Portman Shoals, in 1905 expressed "regret that circumstances over which we had no control prevented our making the amount of profit for the year we would have made under other conditions" (quoted in Durden 2001:12). The loss was due to low water flows, but the mills also had to shut down in 1901, when a flood damaged the Portman Shoals dam.

Lee began surveying "every yard of the Catawba River" and planning for dams at Great Falls and Wateree, South Carolina, and at Mountain Island, North Carolina, even before the Catawba project was finished and before he had any idea how such a grand scheme would be financed. "It had even occurred to me," he wrote, "that I might not realize anything out of it. But what interested me more than anything else was the practicability of the thing" (quoted in Maynor 1980:28). "It was something that just *had* to be done, and was a job for some man who would give his heart and soul [and a large chunk of his money] to it" (quoted in Durden 2001:11–12).

Buck Duke would turn out to be the man with the money. When Wylie had the chance to serve as Buck Duke's physician in 1904, he mentioned the work of his brilliant engineer and his grandiose scheme (Lee 1987:8–9; Maynor 1980:28). With the Catawba plant in successful operation for about nine months, Duke had become more interested in the potential of hydroelectric power to drive the "mill a mile" that he envisioned along the river (Maynor 1980:43). Duke had Wylie bring Lee to New York, and Lee laid out his plans to the great financier. Despite Lee's concerns that the project's $8 million price tag would be prohibitive, Duke was undeterred by the cost. Indeed, its scale likely appealed to Duke's empire-building aesthetic. He asked Wylie to match an immediate $50,000 contribution to acquire the necessary land and rights for the first phase of the project at Great Falls, a site that Duke's American Development Company had already begun to acquire (Durden 2001:15).

Lee's plan to connect all of the power plants along the system appealed to Buck Duke's sense of scale and meshed with his idea of attracting industry by first developing the power sources, rather than building the power sources when establishing the factories (Maynor 1980:15–16, 28–29, 31–32). Duke was among a handful of men in the country who could finance the anticipated $8 million project. In 1905, Duke, Wylie, and Lee formed the Southern Power Company, the predecessor to Duke Power, with Buck Duke, his brother Ben, Dr. Wylie and his brother Robert, and three others as the first board of directors. The company had an authorized capital stock of $7.5 million, most of which came from Buck Duke and his brother. Southern Power was an operating company for a number of entities involved in the development of hydroelectric power on the Catawba River. Before the Southern Power Company was formed, Duke began to purchase the properties and franchises of the Catawba Manufacturing and Electric Power Company, which had been formed as the successor to the Catawba Electric Power Company founded by Wylie in 1893. The Catawba Power Company, another Wylie holding formed to construct the India Hook Shoals facility at Rock Hill (later called the Catawba project and now the Wylie development), continued to construct dams as a subsidiary of Southern Power. Other subsidiaries also built dams and hydroelectric stations along the river (Maynor 1980:32)

In 1905, Southern Power began construction of its first hydroelectric station at Great Falls, South Carolina, about 40 miles downstream of the Catawba plant. The unique design of the project was described in great detail in *The Electrical Journal.* It consisted of two concrete dams whose spillways directed water into a canal. The dams, however, were located in the main bed of the river, over a mile from the powerhouse. The bulkhead at the powerhouse had no spillway. (Maynor 1980:32). By 1907, the project was delivering power, although it was not completed until later. The plant had a capacity of 24,000 kilowatts and cost over $1.6 million. The dam and powerhouse were impressive, and a reporter for the *Charlotte Observer* called the project a "work of massive beauty." He wrote that the engineers had designed the system "to turn every drop of water that the river affords into the canal and delivering same with an even flow to the eight massive turbine water wheels" (quoted in Durden 2001:20). He also commented on the massive spillway that would divert flow from the turbines in case of high water. Although Buck Duke was not able to convince Cannon Mills, one of North Carolina's largest textile producers, to locate their mill at Great Falls, a mill was established at the site with financial help from the Dukes (Durden 2001:21).

The Great Falls project also represented the company's first foray into land conservation, which would become another part of Duke Power's legacy in the Piedmont Carolinas. Southern Power had acquired 9,500 acres for the dam and lake, and because much of the land was unsuitable for agricultural leases, the company planted pecan trees on some of the acreage in hopes of deriving revenue from the land while protecting the lake from soil erosion (Durden 2001:20).

In anticipation of the completion of the Great Falls plant, transmission lines were constructed to Catawba Station, giving the two plants a combined capacity of some 30,000 kilowatts. The lines were mounted on twin steel towers designed by the Aermotor Company of Chicago, which had designed windmills. Transmission lines linked the Great Falls plant first to Charlotte, and later, as municipalities sought to modernize, to Gastonia, Shelby, Clover, Mount Holly, Dallas, Newton, Kings Mountain, Statesville, Davidson, Concord, and China Grove (Sampson 1936).

Meanwhile, Lee had begun work on the next project in the Catawba system, Rocky Creek, just below Great Falls, and on a separate project, Ninety-Nine Islands, on the Broad River. Work at Rocky Creek began in 1906 and was completed in 1909. The design of the project was much simpler than Great Falls. The concrete dam with spillway spanned 1,000 feet and was 90 feet high. Its powerhouse was identical to that at Great Falls and produced 10,000 horsepower. Less than a year after the completion of Rocky Creek, Ninety-Nine Islands added 24,000 horsepower to the company's output (Duke Power Company 2004; Maynor 1980: 13, 32).

To handle the additional power from Rocky Creek, Southern Power built the first double-circuit 100,000-volt transmission line in the country in 1909. The 143-mile line connected Great Falls to High Point, North Carolina, and Greenville, South Carolina. The transmission lines were carried on 75-foot-high steel towers (Duke Power Company 2004; Sampson 1936). The long distance lines illustrated the viability of Southern Power's plan to harness the power of the Catawba River along its length and contribute to the development of the whole region. The completion of Rocky Creek and Ninety-Nine Islands added to the reliability and flexibility of Southern Power's service, and in the period between 1910 and World War I, the company's reach expanded considerably. Although converting to electric power at a textile mill cost money up front, investors began to recognize the long-term value of electricity, which was cheaper and required less maintenance than an on-site steam plant. James Cannon told Buck Duke of his plans to build a new mill at Kannapolis, North Carolina, north of Charlotte, and asked Duke to extend his lines there. Duke had not intended to expand beyond Concord, a few miles south of Kannapolis, but he constructed the lines and in quick succession picked up contracts in Salisbury, Greensboro, and Durham, acquiring interest in competitive plants and buying them out, and investing in industries that were customers of Southern Power. By 1911, the line to Durham had been extended 12 miles to connect to the Carolina Power Company, and in 1913 a line was built to connect to the Tallulah Falls plant of the Georgia Power Company. Southern Power purchased 2.5 million kilowatt hours from Georgia Power to supply Clemson, Pendleton, Seneca, and Westminster, South Carolina. Between 1914 and 1917, textile mills sprang up throughout the Piedmont, due in large part to the availability of inexpensive power (Cocke 1963).

Even as these first hydroelectric plans were transmitting electric power through miles of lines to mills and towns, many textile mill owners were reluctant to convert to electric power. Through a clever bit of propaganda by Thomas Edison and his allies, who advocated the use of direct current, alternating current had gained notoriety as being the source of power used in legal executions. Some mill owners therefore feared the use of electricity in their operations. The Duke brothers attacked this problem on two fronts. First, they continued to invest in mills throughout the Piedmont, predicating their financial backing on the use of electricity in the plants. Through these investments, the Dukes succeeded in promoting the union between the textile industry and the hydroelectric companies, as "[n]ew sources of power spawned new mills, and the South began to hum with its newfound industrial activity" (Maynor 1980:34). Second, the company extended its reach into the retail sector to encourage the use of its product. In 1910, the Dukes created the Mill Power Supply Company to act as a purchasing agent and to sell equipment and supplies to textile mills in an effort to convert them from steam to electric power. Mill Power Supply Company was able to offer generous credit terms on its equipment, because the eventual sale of power to the mills would benefit the entire operating company. In 1913, the company created another subsidiary, Southern Public Utilities Company (SPUC). SPUC's role was to acquire smaller utilities that provided electricity, gas, water, and streetcar service in the Piedmont Carolinas, thereby further integrating Duke Power into the local utilities markets. SPUC also promoted the benefits of electricity in the home and sold electric appliances and lighting equipment for the home (Duke Power Company 1935, 2004; Durden 2001:33; Maynor 1980:34–35). This policy of controlling many aspects of the industry contributed to the company's rapid growth and influence in the region during the first half of the twentieth century.

Although Southern Power was concentrating on the development of hydroelectric power, primarily along the Catawba River as envisioned by W. S. Lee, increasing demand for power and the need for emergency backup and peak-load power prompted the construction of steam plants in the company's service region. The first coal-fired steam plant put into service was the Greenville Steam Station in Greenville, South Carolina in 1911. Other steam plants completed prior to World War I were the Greensboro station in North Carolina (1911), the Mount Holly station in Belmont, North Carolina (1913), and the Eno station in Orange County, North Carolina (1915). These auxiliary plants played a vital role in 1916, when floods destroyed a number of the hydroelectric facilities along the Catawba River, and in 1925, when a drought lowered water levels along the river, and the steam plants were forced to make up the shortfall in generating capacity (Duke Power Company 2004).

At the end of 1915, the first Southern Power hydroelectric plant in North Carolina, the Lookout Shoals development in Iredell County, was completed. Located on the east side of the Catawba River, it was the first plant to use vertical-shaft turbine-generator units (Duke Power Company 2004). It had a concrete dam with a head (height of falls) of 76 feet and a generating capacity of 18,720 kilowatts (Duke Power Archives 1927b). Transmission lines with a carrying capacity of 100 kilovolts were constructed from Lookout Shoals to Greenville, Spartanburg, Chester, and Lancaster, South Carolina, and to Monroe, Albemarle, Salisbury, Lexington, Thomasville, High Point, and Greensboro, North Carolina (Sampson 1936). Work also began in 1915 on the Fishing Creek hydroelectric facility, just a few miles above the Great Falls station. Fishing Creek Lake is a long, narrow impoundment on the border between Lancaster and Chester counties, South Carolina. The Fishing Creek Station began operation in late 1916 with a capacity of nearly 30,000 kilowatts. This was the first project of the Wateree Power Company, a subsidiary of Southern Power. Wateree Power Company was created in 1909 to acquire land and water rights for the Wateree project, the largest dam in the planned Catawba system.

In July 1916, a hurricane swept into the western Carolinas from the Gulf coast of Alabama, soaking the soil and filling streams and rivers. Then just a few days later, the remnants of another hurricane moved through North Carolina from the Atlantic coast, dropping as much as 19 inches of rain on the already saturated headwaters of the Catawba in just a 24-hour period. Flooded streams and rivers jumped their banks, causing widespread devastation throughout the region. Floods on the Yadkin and Catawba rivers and their tributaries washed out bridges, dams, and knocked down power lines, bringing electrical service to a halt. The Rocky Creek development was the hardest hit, as debris came over the dam and landed on the roof of the powerhouse, allowing water to pour through the building. The Catawba plant at India Hook Shoals was put out of commission for six months, and other plants were out of service for up to two months. A rebuilding program by Southern Power began right after the flood, with crews working around the clock to bring the power back on line (Maynor 1980:41–42).

Struggling to Build an Industry Giant: 1916–1926

The destruction caused by the Flood of 1916 sent Duke engineers scrambling to redesign their dams and powerhouses to withstand the worst that nature could dish out. Buck Duke did not want a similar scenario happening again, and he demanded that his engineers come up with a plan to control flows along the river. Engineers working on recent FERC-mandated reinforcement projects for the dams in the Catawba system have noted the high quality of construction in the period after the floods, finding it superior even to the construction at Cowans Ford, built many years later.

W. S. Lee, his assistant C. I. Burkholder, and their team of engineers went to work quickly and came up with a plan for a large reservoir on the upper reaches of the Catawba that would serve as storage for excess water. The reservoir would also serve to maintain better downstream flow during periods of drought. The engineers chose the site for the project—known as Bridgewater, after a nearby railroad station of that name in Burke County, North Carolina—due to its large upstream drainage (380 square miles) and the heavy rainfall that fell on the eastern slopes of the Blue Ridge Mountains. Because the Southern Railway paralleled the Catawba River at

Bridgewater, it was determined that a dam across the river would be impractical at this site. Instead, the engineers determined that three dams could be constructed, one spanning the Catawba River, and the other two on the Linville River and Paddy Creek, creating a single impoundment known as Lake James (named for James B. Duke) behind a five-mile long barrier of dams and natural elevations, just 2.5 miles from the railroad station at Bridgewater. Construction began on the project in August of 1916, just a month after the floods (Durden 2001:35–36).

Lee and a young engineer named Richard Pfaehler supervised the construction of the Bridgewater project and reported on their extraordinary efforts in several engineering journals. The conditions at the site precluded the use of concrete dams, so earthen dams were used, one of which was among the highest in the world when completed. The Catawba Dam does contain a concrete core wall and concrete overflow spillway section, however. To be certain that the dam could withstand a massive flood, the spillway was designed to have a capacity twice that of the 1916 flood that had proven so destructive. A tunnel and steel penstock in the Linville Dam led to the powerhouse, which contained two 13,200-horsepower turbines driving two 10,000-kilowatt generators. The Bridgewater dam has by far the highest head (net effective) in the Catawba system at 135 feet. The project was completed in 1919, and the design proved successful in 1940, when water levels exceeded those in 1916 but downstream flows were significantly lower. At Morganton, North Carolina, the downstream flow was 14 feet lower than in 1916, and at the southern end of the system near Camden, the water was 9 feet lower than in 1916, despite an upriver volume that was twice that of the earlier flood. The reservoir at Bridgewater also effectively maintained downstream flows during low water, although the dry summer of 1925 tested even this design. Under normal conditions, water is released from the dam at periodic intervals and is used to generate power at each successive site downstream, with the load shifting to each plant as the water reaches it (Durden 2001:36–37; Federal Power Commission 1958; Waddell 1932).

Due to problems during construction, the Bridgewater project was the last to use outside contracting firms. In 1924, along with renaming the company for its principal financier, Duke Power created its own construction department through which it was better able to manage procurement, schedules, and quality control. The result was that Duke Power's construction costs were among the lowest in the industry, and it was able to pass on the savings by way of lower rates (Dennis Lawson, personal communication 21 April 2004; Durden 2001:95–97). The Bridgewater project also marked the beginning of a series of hydroelectric projects carried out by subsidiaries of Southern Power/Duke Power between 1916 and 1927. Bridgewater was constructed by the Western Carolina Power Company, which had been incorporated in 1909 as the Horseford Power Company. Southern Power purchased all of the issued and outstanding stock in the company in 1909 for $35,000. Western Carolina Power had already acquired about 750 acres on the Catawba River in Catawba, Burke, and Caldwell counties. In 1915, the company began to acquire land in Burke and McDowell counties where the Bridgewater project was to be built. The plant was operated by Southern Power under a lease and then purchased by Duke Power in 1927, along with the Rhodhiss plant (Duke Power Archives 1927b; Duke Power Company n.d.).

One year after construction began on the Bridgewater project at the upper end of the Catawba, Wateree Power Company began construction of the Wateree project near Camden, South Carolina, at the lower end of the river. (The dam is technically on the Wateree River, which begins at the junction of Wateree Creek and the Catawba River some 16 miles upstream of the dam.) This was the largest station in the system to that point and generated 90,000 horsepower and 56,000 kilowatts of power, representing about a third of the system's total capacity. The project cost over $5 million. The earthen and concrete dam impounded an area of 11,500 acres when full. W. S. Lee oversaw the design for the project, and A. C. Lee, his younger brother, was the resident engineer. C. O. Lenz of New York City served as a consulting engineer. The Wateree development began operation in late 1919 (Durden 2001:38; Lee and Pfaehler 1920).

The Wateree Electric Company was incorporated in 1917 in New Jersey and was a separate entity from the Wateree Power Company. This company began to acquire the power companies created by the Dukes, including the Great Falls Power Company and the Wateree Power Company. In 1924, it was the Wateree Electric Company that became Duke Power Company. The Southern Power Company continued to operate under that name until 1927, when it also became part of Duke Power. Southern Public Utilities Company merged with Duke Power in 1935. This merger combined the generating and transmission operations with the retail distribution arm (Duke Power Company 2004; Durden 2001:37).

In 1919, Southern Power began a struggle over rate hikes with the Corporation Commission that had been granted regulatory power over electric utilities in 1913. J. B. Duke had not intended Southern Power to be the source of his personal wealth, but instead to support his other investments and to finance the Duke Endowment, a philanthropic venture that he planned to finance using his stock holdings in the company. Facing inflation after World War I and a demand for power requiring increasing investment of profits in new facilities, Duke felt that a rate increase was necessary. In 1919 he informed the North Carolina Public Service Company of Greenville that the price of wholesale power supplied to them would be increased from 1.1 cents per kilowatt hour to 1.5 cents. The Public Service Company took the issue to the North Carolina Supreme Court, which ruled that Southern Power must submit the rate increase to the Corporation Commission for approval. Hostility toward Duke's monopolistic empire was fierce in the press and among some members of the state legislature, and in 1921, the Commission voted only about half of the requested increase (Durden 2001:44–49).

With the partial rate increase, Duke authorized the construction of two new hydroelectric facilities for the Catawba system. A new station operated by the Great Falls Power Company, known as Dearborn Station, was completed at the existing Great Falls dam in 1923. This was followed later that year by the Mountain Island Station, built in Gaston County, North Carolina, and operated by the Catawba Manufacturing & Electric Power Company.

The Dearborn development at Great Falls was simply an additional powerhouse constructed adjacent to the Great Falls Station. Construction began in 1921 and was completed in 1923. The facility consisted of a concrete gravity intake and powerhouse structure extended from the east end of the Great Falls dam. The powerhouse contained three 17,000-horsepower vertical turbines driving three 15,000-kilowatt generators. The total cost of the project was about $1.5 million (Duke Power Company 1971; Federal Power Commission 1958).

Just a few months after construction began on the Dearborn Station, crews began work on the Mountain Island development at the upper end of Lake Wylie, near Charlotte, North Carolina. Catawba Manufacturing & Electric Power Company (CM&EP) had acquired the dam site and water rights in 1904, and these transferred to Southern Power when they purchased CM&EP in 1905. Acquisition of land for the lake did not begin until 1913, and construction did not start until

1921. The project was built by CM&EP using over $5 million in funds provided by Southern Power. The Mountain Island Station was equipped with four vertical turbine-generator units with a capacity of 15,000 kilowatts each. The Southern Public Utilities Company purchased the dam at its completion in 1923 for a total of $6.3 million in stocks and cash, and Southern Power operated it under lease. CM&EP merged with Duke Power in 1932 (Duke Power Company 1935).

Still facing revenue shortfalls, J. B. Duke once again went to the Corporation Commission to ask for the remainder of the rate increase requested in 1921. In 1923, in a rare public statement, Duke threatened to cease construction of new facilities in North Carolina if the increase was not approved; the Commission acquiesced the following year. This cleared the way for the establishment of the Duke Endowment and gave the go-ahead to a second powerhouse at Rocky Creek, two new developments in the Catawba system (the last until the late 1950s), and an overhaul of the system's oldest facility, the Catawba dam and powerhouse. These projects were constructed by Southern Power subsidiaries. The creation of these subsidiaries limited Southern Power's liability and, in the case of Wateree Power Company, allowed it to operate in South Carolina with eminent domain (Duke Power Company 2004; Durden 2001:37, 50–54).

In 1924, Wateree Power Company returned to the first project in the Catawba system at India Hook Shoals. With eight units generating less than 10,000 kilowatts, it was the least powerful facility in the system and had one of the lowest dams with only 25 feet of head. By raising the dam, the reservoir was increased in size to 12,455 acres, and the head was increased by 45 feet. The old powerhouse was partially removed and then filled with concrete (once the old equipment had been taken out). That area was then incorporated into the spillway of the new dam, which had two gated areas separated by an uncontrolled overflow spillway. A new powerhouse was constructed on the opposite bank of the river, and the old rope-driven generators were replaced by four vertical-shaft turbine-generator units with a total capacity of 60,000 kilowatts. The new powerhouse began commercial operation in 1925 "without the loss of a single day of station operation" (Duke Power Company 1971; Federal Power Commission 1958; Nabow 1934).

The Great Falls Power Company, which had constructed Dearborn Station at Great Falls, was also responsible for constructing a second powerhouse at the Rocky Creek development, beginning in 1925. The Cedar Creek development was completed in 1926. Like Dearborn, the Cedar Creek powerhouse contained three vertical turbine-generator units generating 15,000 kilowatts apiece. The intake structure included two vertical lift floodgates (Duke Power Company 1971).

The final two impoundments constructed on the Catawba River in the 1920s powered the Rhodhiss and Oxford hydroelectric stations, completed in 1925 and 1928, respectively. Both dams were constructed by the Western Carolina Power Company. Rhodhiss Dam created Lake Rhodhiss, while Oxford Dam created Lake Hickory. The two projects were located on the upper Catawba between the Bridgewater and Lookout Shoals projects, in Caldwell, Burke, Catawba, and Alexander counties, North Carolina.

The Rhodhiss project consisted of a rolled earth embankment dam with a concrete gravity overflow spillway section, two concrete non-overflow sections, and a concrete intake and powerhouse section. Three 14,140-horsepower vertical-shaft turbines were installed to drive generators with a capacity of 8,500 kilowatts each. The plant began commercial operation in 1925 (Duke Power Company 1971; Federal Power Commission 1958). Oxford Dam was also of earthen and concrete construction. Work began on the site in early 1927 and was completed by the middle of 1928. The concrete spillway is gravity fed, with 10 Stoney type gates to maintain full pond elevation. The powerhouse was equipped with two turbines, each powering a generator with a capacity of 18,000 kilowatts. Lake Hickory, the impoundment behind the dam, provides water to the towns of Hickory and Longview (Duke Power Company 1975; Wanzer 1956).

Two engineers, David Nabow and C. T. Wanzer, came to prominence during the construction of these projects. David Nabow was a Russian-born Jew who immigrated to the United States as a child. He came to work for Southern Power in 1916 after graduating from Columbia University, where he attended on a Pulitzer scholarship. He was a draftsman and designer on the Bridgewater and Wateree projects. In 1919, he began to work on specialized hydraulic and structural designs to be used in future projects. During his tenure, he invented a butterfly-type headgate design that was used on all later Duke hydroelectric projects. In 1921, he was appointed Designing Engineer for all Duke power plants under Chief Engineer W. S. Lee. Charles Tice Wanzer came to the company in 1918 and served as assistant resident engineer to A. C. Lee on the Wateree project. When Lee became Division Engineer in 1919, Wanzer served as resident engineer on the Dearborn, Mountain Island, Rhodhiss, and New Catawba projects. In 1927, he moved up to Division Engineer and supervised the construction of the Oxford development, as well as "extensive additions ... to several other plants" (Durden 2001:38; Lee 1934; Nabow 1934; Wanzer 1934).

For two decades, Southern Power's emphasis was on hydroelectric power, with steam plants built mainly for peak loads and emergency backups. A severe drought in 1925 showed that it was unwise to depend on the rivers in the Piedmont to supply the electricity required by the region. The drought of 1925 essentially spelled the beginning of the end of Duke Power's reliance on hydroelectricity, and Lee immediately began plans for Buck Steam Station, by far the largest steam plant in the system (Duke Power Company 2004; Durden 2001:55, 63; Maynor 1980:49, 63). During the 1910s, engineer Lee had been integrating fossil fuel steam stations into the Southern Power system. These included stations at Eno, Tiger, Mt. Holly, and Greenville, South Carolina. The stations played a major role in the 1925 drought crisis. A few weeks before his death, in 1925, Buck Duke authorized the construction of a massive, primary component steam plant, and in 1926 the Buck Steam Station began operations. The plant burned pulverized coal, a first in the Southeast (Lee 1987:9; Maynor 1980:43).

The Buck Steam Station marked the beginning of a transition to fossil fuel generation of electricity. Hydroelectric facilities eventually came to be use primarily for peak load power delivery, as steam plants had once been used. With no new hydroelectric plants planned, many of the employees of Duke Power that specialized in hydroelectric power retired or left the company. No more hydroelectric stations were constructed on the Catawba River for 30 years.

The years between World War I and the Depression were marked by impressive construction and engineering accomplishments on the Catawba system, and the emergence of Southern Power as a major force in the transformation of the Carolina Piedmont. It was during this period that electricity became a familiar force in the lives of those living in the Southern Power service area. Southern Power and its subsidiaries, and later Duke Power, changed their marketing strategy to reflect the changing role of electricity in the Piedmont, as electric power moved from factories to urban homes to farms and rural households. At times, the company seemed to respond slowly to these changes, perhaps reluctant to neglect the industrial and commercial markets responsible for its initial success. The first residential power was provided to mill worker houses as a courtesy to industrial customers. As more and more residents of the South came to see the advantage of electricity and could afford to have it installed in their homes, demand grew and service was increasingly marketed to residential users (Maynor 1980:67–68).

The shifting marketing priorities reflect not only the changing demands for electricity, but also the interests and concerns of the period. These changes are reflected in the articles and advertisements that appear in the company's magazines, *Southern Public Utilities Magazine* and *Duke Power Magazine*. *Southern Public Utilities Magazine* was published by the retail subsidiary of Southern Power from ca. 1915 until the merger with Duke Power in 1935; *Duke Power Magazine* was published from 1935 to ca. 1998. In its early years, the magazine focused on electric trolleys, commercial lighting, and the power supplied to the textile mills and other industries. By the early 1920s, however, articles and ads began to focus on electrical appliances for the home. In 1922, SPUC began its annual "Electric Range Sale," a campaign that took place in the spring of each year. The latest ranges by Hot Point, refrigerators by Kelvinator, water heaters, and other appliances were displayed in SPUC offices in the region. In the fall, there was an annual Mazda Lamp Campaign to sell light bulbs, with prizes and awards to the top salesmen. The role of electricity in the modern household and lifestyle was showcased in Electric Houses, models built for display that were powered entirely by electricity. The extent to which Duke Power had embraced the retail aspect of its industry is reflected in articles showing how best to display Christmas lights and in the introduction of "Ready Kilowatt," a company mascot that taught people how to use electricity, live safely, and be efficient.

Another important focus of SPUC and Duke Power was the promotion of better lighting for better health. Numerous articles featured doctors warning against bad lighting, which was said to promote blindness, and asserting instead that the warmth of lights aided digestion after a meal (among other health benefits) and contributed to an overall healthier, safer, more efficient, and convenient lifestyle.

Duke Shifts Away from Hydroelectric Power: 1927–1959

In 1927, the newly created Duke Power Company had a total operating capacity of 897,200 horsepower from its 19 major hydroelectric and steam plants. The power was distributed to industries and communities over 3,000 miles of transmission line (Duke Power Company 1927:21–22). As Buck Duke had always envisioned, there were 300 textile mills receiving power from the Duke system along with twenty Carolina cities (Lee 1987:16). With the industrial boom in the Piedmont showing no signs of stopping, Duke Power continued to plan for the addition of new plants. The Riverbend Steam Station was completed and had just begun operation in October of 1929 when the Stock Market crash occurred (Maynor 1980:66, 69).

The Depression of the 1930s significantly reduced Duke Power's revenues, as mills and other customers shut down and laid off workers. The company was also struggling against a tide of public sentiment for government intervention in the crisis and more public control of utilities. The Federal Water Power Act of 1920 had given the federal government considerable power to regulate private utilities operating at government power sites, and was the basis for the construction of federally funded dams on major rivers in the West. In 1933, President Roosevelt authorized the TVA, which would carry out many of the functions on the Tennessee River that Duke Power had been doing privately on the Catawba River. Duke Power also received competition from the Rural Electrification Administration (REA), another New Deal agency charged with facilitating the distribution of transmission lines into rural areas. Although the economic conditions forced Duke Power to halt its expansion program during the 1930s, an increased push to sell power to residential, municipal, and small business customers kept it financially solvent until the crisis was over. Reduced rates and aggressive sales of electrical appliances through SPUC attracted new customers (Durden 2001:110, 114; Maynor 1980:68–71).

The increased emphasis on selling residential power is reflected in *Duke Power Magazine* articles of the 1930s. More emphasis was placed on appealing to women, and the company hired home economists that offered classes for housewives on how to cook with electric ranges, use household appliances, and save time around the house with electricity. There were even classes offered to African-American women, with curricula aimed at teaching them to be efficient house maids.

As transmission lines were gradually extended into the countryside, company publications increasingly touted the benefits of electricity for farm work, including heat for brooding houses, refrigeration for dairies, and lighting for longer work hours. The company was quick to point out that farm production increased exponentially at farms supplied with electricity. Mechanical devices driven by electricity allowed one farmer to handle 40,000 broilers, without having to feed, water, or clean up by hand. Similar devices for the dairy farmer increased the number of cattle that one farmer could handle by a factor of five. As of 1937, about one-third of Duke Power's 150,000 residential customers lived in rural areas, which was of benefit to the company because farms drew power during off-peak hours. The marketing efforts to rural users were to some extent forced because of competition with the REA in the 1930s, during which time Duke Power fought in court to block government involvement in utilities (Durden 2001:111–113).

By 1938, the economic picture had improved enough for Duke Power to announce plans for a new steam station, although it was not known where the plant would be located. The Cliffside steam plant eventually began operations in Cleveland County, North Carolina, in 1940. With the United States' entry into World War II in late 1941, Duke Power's focus changed from commercial expansion to an all out effort to maintain operations during shortages of men and materials. The last additions to the system's generating capacity before 1946 were two new generating units at Buck Steam Station installed between 1940 and 1942. The Mill Power Supply Company would play an important role in procurement during the war, and that department would expand more than any other during the 1940s. Blackout drills were conducted throughout the system, and plans were put in place for emergency service and repairs. The company's efforts in support of the war were reflected in *Duke Power Magazine*, which featured stories and ads urging people to conserve valuable items, buy war bonds, and support the country. When the war ended in 1945, Duke Power went to work upgrading neglected power lines and equipment and planned for an expected boom in power demand (Durden 2001:115; Maynor 1980:73, 77–78, 91–92). The desire to enjoy leisure time in the postwar period contributed to increasing emphasis in company publications on recreational activities at Duke Power lakes and at corporate picnics. The company often touted its efforts at conservation and the creation of state parks.

The investment in military bases, factories, and chemical plants by the federal government during World War II was a major spark to the South's industrial potential. Technical and managerial experience was gained that helped the region explode in growth in the 1950s and 1960s. Demand for electric power grew at an even greater rate than before the war, due in part to a decline in its overall cost relative to other fuels. Larger and more sophisticated generating plants were able to realize economies of scale, thereby reducing costs. In less than 10 years after World War II, the capacity of a typical coal-burning plant rose from 100,000 kilowatts to over 500,000 kilowatts. As new facilities were installed, aging equipment neglected during the war was being repaired or replaced. Line crews often worked on Sunday mornings when demand was lowest in order to repair and upgrade the distribution system. Shortages of materials continued after the war, and creative reuse was necessary. Herbert Tibbs, who went to work in the hydro-mechanical department of Duke Power in the 1930s, became an expert at creating replacement parts and rebuilding worn-out equipment using discard junk from Duke Power sites and local junkyards (Durden 2001:117–118; Maynor 1980:90–91).

In 1956, Duke Power joined with three other utilities in North Carolina, South Carolina, and Virginia to form Carolinas-Virginia Nuclear Power Associates, Inc. This organization worked with the federal Atomic Energy Commission to develop an experimental nuclear power generator at Parr Nuclear Station on the Broad River north of Columbia, South Carolina. Commercial power generation from nuclear reactors was still a futuristic idea, however. In response to current power demands that continued to stretch the capabilities of the Duke system, the company began to add generating units to existing steam stations and also constructed a new steam plant on Lake Catawba (Lake Wylie) in 1957. Allen Steam Station, named for George G. Allen, who had taken over as president of the company after J. B. Duke's death in 1925, cost $41 million and was equipped with two 165,000-kilowatt generators. At the time, it was the largest investor-owned generating plant in the Southeast.

The Last Link in the Chain Begins an Era of Shifting Fortunes for Duke Power: 1958–Present

By 1958, Duke Power's grid reached nearly the entire Carolina Piedmont from the Appalachian Mountains to the coastal plain. It served about 80 percent of a 20,000-square-mile area, representing about one-third of the land area of the two states, but containing over half of the metropolitan population and 40 percent of the rural population. The expansion of old steam plants and the building of new ones over the past 30 years had brought fuel-burning plants to the forefront of Duke Power's generating capabilities. Over 85 percent of the 12.5 billion kilowatt hours produced system-wide was produced by steam plants, while only 13.2 percent was produced by the hydroelectric facilities. The remainder was purchased from other sources (Durden 2001:123–124).

Nevertheless, there was still a role for hydroelectric power in the Duke Power system. Because hydroelectric plants are easier to start and stop than coal-fired plants, they are critical for efficient operation of the system during peak loads. They can be called on for additional power when needed and then shut down afterward at minimal expense. In the late 1950s, Duke Power began to study the possibility of a dam that would harness the power of the last significant untapped section of the Catawba River. The Cowans Ford dam and powerhouse would take advantage of the 112-foot fall between the Mountain Island and Lookout Shoals developments northwest of Charlotte. Duke Power began construction of the massive project in 1959, creating Lake Norman and effectively capturing the remaining power of the Catawba River, often called "the most electrified river in the world," with 85 percent of its fall available for power generation. Duke Power acquired approximately 37,000 acres for Lake Norman, most of which had been acquired in the 1920s. It was also necessary to purchase two textile mills that were to be inundated by the lake (Duke Power Company 1963; Nabow 1956; Wray 1961).

This last piece of the Catawba system was designed on a much larger scale and with different technology than the other plants. Lake Norman, named for retired Duke Power President Norman A. Cocke, is the largest impoundment in the system; at 32,500 acres, it is almost as large as the combined area of the other ten lakes. The nearly 7,000-foot earthen dam has a 1,279-foot concrete center section that includes a gravity spillway with 11 gates. Its four vertical-shaft Kaplan turbines are capable of generating 87,500 kilowatts each, more than the combined output of any single station in the system and the fourth largest installed capacity in the U.S. as of the early 1960s. To reach maximum capacity, however, the amount of water that would have to flow through the development would overwhelm the downstream facilities, and thus it has never operated at full capacity. The first three generating units began operation in 1963; a fourth unit went on line in 1967 (Duke Power Company 1959, 1963; Gleasner and Gleasner 1986; Wray 1961).

During the 1960s, 1970s, and 1980s Duke Power continued to maintain the Catawba system to meet peak power needs. The system also provided a reliable source of cooling water for large base load steam plants. During this time period, Duke Power built two nuclear power plants, McGuire Nuclear Station on Lake Norman and Catawba Nuclear Station on Lake Wylie.

By the 1990s, Duke Power's hydroelectric plants were in need of technological updates to make them more efficient. Under the Hydrovision Program, generators were rebuilt (often simply rewound for greater generating capacity), turbines were overhauled, computerized controls were installed, and other supporting equipment was replaced. Nevertheless, the Catawba-Wateree developments remained relatively unchanged and continued to operate as they always had.

In 1997, Duke Power officially merged with PanEnergy of Houston, Texas, one of the nation's largest natural gas providers. Duke Power became a divison of the new company, called Duke Energy, which was also to be headquartered in Charlotte. The new company was the largest energy provider in the country, with approximately $23 billion in assets. It has forged ahead into the complex world of the deregulated power industry, diversifying its interests, selling its expertise, and minimizing those capital investments with uncertain returns, instead seeking cheaper alternatives through acquisition. This business model is a vast departure from the early-twentieth-century approach of Duke Power, which focused on plowing profits into capital expansion and performing as much work in-house as possible (Durden 2001:250, 254–260).

III. STUDY METHODOLOGY

The architectural survey and NRHP eligibility assessment of the six North Carolina hydroelectric developments were conducted in accordance with applicable federal laws and guidelines, including the National Historic Preservation Act of 1966 (as amended), the Section 106 implementation guidance in 36 CFR 800, the NRHP eligibility criteria in 36 CFR 60.4, and general survey and analysis guidelines issued by the National Park Service and the HPO.

BACKGROUND RESEARCH

TRC began its work with extensive background research of primary and secondary sources. The sources included letters, transcripts of interviews, magazine and journal articles, publications, press releases, legal documents, speeches of company officials, operations reports, and construction photographs. Secondary sources included books on Duke Power and the other power companies in the Carolinas, as well as general studies on electricity and the development of hydroelectric power. General histories of the local area and the region were also reviewed. Additional sources were accessed on-line at various Duke Power websites.

Most of the background materials reviewed by TRC were located in the Duke Power archives. Some historic photographs and drawings were available at individual developments, but usually these were pieces of larger collections housed at the archives. Previous survey information was gleaned from existing Duke Power GIS files, from the websites of the National Register and the Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER), and from the files of the HPO in Raleigh and Asheville.

FIELDWORK

The fieldwork phase of the survey and assessment involved taking detailed notes on the appearance of each dam, powerhouse, and associated office or warehouse building. Photographs of each element were taken using digital and 35 mm cameras, and sketch maps of the layout of each development were made. The operators at the developments were interviewed for information on alterations and changes. The field notes, photographs, and sketch maps were then used to prepare this document.

EVALUATION CRITERIA

According to 36 CFR 60.4, cultural resources eligible for the NRHP are defined as buildings, structures, objects, sites, and districts that have integrity of location, design, setting, materials, workmanship, feeling, and association, and that meet one or more of the criteria outlined below. Criterion D is most often (but not exclusively) associated with archaeological resources.

- Criterion A (Event). Association with one or more events that have made a significant contribution to the broad patterns of national, state, or local history.
- Criterion B (Person). Association with the lives of persons significant in the past.
- Criterion C (Design/Construction). Embodiment of distinctive characteristics of a type, period, or method of construction; or representation of the work of a master; or possession of high artistic values; or representation of a significant and distinguishable entity whose components may lack individual distinction.
- Criterion D (Information Potential). Properties that yield (or are likely to yield) information important in prehistory or history.

The seven aspects of integrity are defined as follows:

- Location: The place where the historic property (or properties) was/were constructed or where the historic event(s) occurred;
- Design: The combination of elements that create the form, plan, space, structure, and style of a property (or properties);
- Setting: The physical environment of the historic property (or properties);
- Materials: The physical elements that were combined to create the property (or properties) during the associated period of significance;
- Workmanship: The physical evidence of the crafts of a particular culture or people during any given period in history or prehistory;
- Feeling: The property's (or properties') expression of the aesthetic or historic sense of the period of significance; and
- Association: The direct link between the important historic event(s) or person(s) and the historic property (or properties).

IV. RESULTS

PREVIOUS SURVEYS

All of the North Carolina developments have been surveyed previously, except for Cowans Ford, which has not been surveyed to date due to its more recent age. The Bridgewater Development has been surveyed the most times, with eight or nine different studies conducted between 1974 and 2001 (Table 4-1). The remaining four developments were surveyed in the 1970s, except for Rhodhiss, which was also assessed in the 1980s. The previous survey work consisted of HAER inventories conducted in 1974–1975; HPO historic structure forms completed in the late 1970s and early 1980s; and placement of individual buildings and structures on the Study List in the 1970s and 1980s. HAER documentation, consisting of photographs and text, was prepared on two occasions (1984 and 2001) for the metal truss bridge that once sat atop the Catawba Dam spillway at the Bridgewater Development.

Beyond the survey and documentation work, only the Bridgewater and Lookout Shoals developments have had some or all of their components recommended significant and/or eligible for the NRHP. At Bridgewater, the Catawba River Dam and the metal truss bridge noted above were found eligible for the NRHP in 1979. At Lookout Shoals, the dam, powerhouse, substation, and bridge were said to have local significance in the area of industry in 1977 (the bridge has since been removed). TRC concurs with these recommendations, but also recommends all the Bridgewater dams, spillways, and the powerhouse and support structures eligible for the NRHP. In addition, TRC finds the Lookout Shoals development eligible for the NRHP and significant in more areas than just industry. It should also be considered significant—along with the Bridgewater, Rhodhiss, Oxford, and Mountain Island developments—in the areas of agriculture, architecture, commerce, conservation, engineering, and social history.

LISTING OF DAMS IN THE U.S.

Appendix 2 contains a detailed listing of 114 dams built in the U.S. between 1821 and 1964. The dams were constructed in 38 states in all regions of the country. The information is taken from Jackson's (1988) survey of notable bridges and dams in the United States. Although Jackson did not investigate every dam in the country, the 114 dams, taken from all sections of the nation and built over a 143-year period, represent the full spectrum of dam types and uses. The selection also allows for analysis of general trends in dam construction and hydroelectric development during the nineteenth and twentieth centuries. Of the 114 dams, 35 percent are located in the West, and 15 percent are in the Southwest. Another 15 percent are located in the South, and a third 15 percent are in the Midwest. Roughly 10 percent are located in the Mid-Atlantic, and another 10 percent are in New England.

Concrete gravity dams are the type most often identified in the survey, with 38 examples. Jackson defines a gravity dam as one that "resist[s] hydrostatic water pressure (the pressure exerted by a volume of water) by the sheer mass (bulk) of the materials. The underlying

Table 4-1. Previous Survey Information.

I. Bridgewater Development

Resource Name	Survey Date	Finding
1. Catawba Dam, Bridgewater Station	1974	HAER inventory (survey only)
2. Catawba River Dam and Bridge	1975	Placed on Study List
3. Paddy Creek Dam	1975	Placed on Study List
4. Lake James Dams and Spillways/ Bridgewater Dam, NC 126	1979	Recommended eligible for NRHP
5. Metal Truss Bridge (#126-87-10), NC 126 over Lake James Spillway, McDowell County, NC	1979	Determined eligible for NRHP
6. Bridgewater Power House	1983	Placed on Study List
7. Catawba River Dam and Bridge	1983	Historic Structures Short Data Sheet (survey only)
8. Lake James Spillway Bridge	1984	Recorded to HAER standards (photos only)
9. Bridge atop Catawba River Dam and Spillway	2001	Recorded to HAER standards (photos, text)

Notes:

A. Numbers 4 and 5 could refer to the same survey.
B. Number 4 references HAER documentation on the "Bridgewater dam and plant," but no other information is given.
C. Number 6 was surveyed in 1983 and placed on the Study List in 1984.
D. Number 8 was recorded as HAER NC-37.
E. After completion of number 9, the bridge was subsequently removed and donated to the City of Morganton, North Carolina, for use at a proposed greenway site.

II. Rhodhiss Development

Resource Name	Survey Date	Finding
1. Rhodhiss Dam and Power Plant	1975	HAER inventory (survey only)
2. Rhodhiss Dam	1984	Historic Structures Short Data Sheet (survey only)

III. Oxford Development

Resource Name	Survey Date	Finding
1. Oxford Dam and Power Plant	1975	HAER inventory (survey only)

IV. Lookout Shoals Development

Resource Name	Survey Date	Finding
1. Lookout Shoals Dam, Power Plant, Substation, and Bridge	1977	Said to have local significance in area of industry

V. Cowans Ford Development

No previous survey activity.

VI. Mountain Island Development

Resource Name	Survey Date	Finding
1. Mountain Island Dam and Power Plant	1975	HAER inventory (survey only)

principle…is to build up sufficient quantities of earth, rockfill, masonry or concrete so that the pressure of the stored water is insufficient to push the dam downstream. In essence, the force of gravity acting on the dam is what provides structural stability" (Jackson 1988:44). All of the North Carolina developments within the Catawba-Wateree system feature a concrete gravity dam and/or spillway, and several utilize earthen gravity dams or embankments; none, however, incorporate rockfill or masonry dams. By the time Lookout Shoals, the first Catawba-Wateree development in North Carolina, was completed in 1915, the technology of building concrete dams was nearly 30 years old, and concrete dams had been in use at hydroelectric developments for at least 15 years. The first concrete dam in the U.S., a gravity structure impounding a water supply reservoir for San Francisco, was built in San Mateo, California, in 1888. The dam was of poured concrete construction, reinforced with metal rods. Notably, it survived the great San Francisco earthquake of 1906 (Hay 1991:xix; Jackson 1988:280–281).

The Library of Congress's online HABS/HAER files indicate that a concrete gravity dam was built at the Trenton Falls hydroelectric development in Trenton Falls, New York, in 1900 or 1901 (Raber et al. 1993:3). In 1902, a concrete gravity dam was constructed at the North Highlands hydroelectric facility near Columbus, Georgia (Karfunkle et al. 1977:3). Between 1904 and 1909, the three earliest hydroelectric developments in the Catawba-Wateree system were completed, and each included a concrete gravity dam: Catawba (1904), near Fort Mill, South Carolina (replaced in 1925 by New Catawba and later renamed Wylie); Great Falls (1907), near Great Falls, South Carolina; and Rocky Creek (1909), south of Great Falls, South Carolina (Duke Energy Corporation 2003:3:50, 52, 59–60; Duke Power Archives 1924). In 1910, a concrete gravity dam was built for the Holtwood hydroelectric facility in Holtwood, Pennsylvania. The following year, concrete gravity dams were constructed at the Goat Rock hydroelectric development in Mulberry Grove, Georgia, and the Ocoee No. 1 hydroelectric development in Parksville, Tennessee. In 1912, a concrete gravity dam was built for the Hauser Lake hydroelectric facility in York, Montana. In 1913, concrete gravity dams were constructed at the Tallulah Falls hydroelectric development in Tallulah Falls, Georgia, and the Keokuk hydroelectric development in Keokuk, Iowa (Jackson 1988:144–145, 171–172, 189, 204, 295). Certainly, additional hydroelectric facilities with concrete gravity dams were built between 1900 and 1915. What the 11 developments noted here demonstrate, however, is that the use of concrete gravity dams at hydroelectric facilities was an established practice in different regions of the country by the time the Lookout Shoals development came on line.

Most scholars agree that the Romans were the first to employ concrete as a building material. The knowledge of its use disappeared after the Roman Empire fell, however, and it was not until the eighteenth century that scientists and inventors rediscovered "hydraulic cement." During the first few decades of the nineteenth century, inventors in a number of countries began to patent their own versions of cement. The first engineering uses of cement occurred at the Erie Canal in 1825 and the Thames Tunnel in 1828. In 1867, Joseph Monier patented the use of metal reinforcing in flowerpots and simple post and beam structures. Ernest L. Ransome in the United States patented a version of reinforced concrete in 1884 that called for embedding twisted metal rods in the concrete mixture. Ransome went on to design two reinforced concrete bridges in Golden Gate Park in San Francisco (1886–1887), as well as numerous reinforced concrete frame industrial buildings in California, New Jersey, and Massachusetts (1884–1906) (Auburn University 2004; Banham 1986:33–36, 70). Reyner Banham, in his study on the development and influence of concrete construction in the U.S. and Europe, refers to Ransome as "the great concrete 'pioneer'" (Banham 1986:11). Banham also notes that "[c]oncrete...was clearly the exciting new material at the turn of the [twentieth] century, and its use, as measured by the quantity of cement consumed, is reckoned to have increased some fifteen-hundred fold in the United States between 1880 and 1910" (Banham 1986:104–105). At roughly the same time that reinforced concrete was being used to build bridges and industrial buildings on the East and West coasts, Frank H. Peavey and Charles F. Haglin invented a reinforced concrete grain elevator in the Midwest in 1899, which went on to become "the 'industry standard' worldwide" (Banham 1986:133, 140).

Most of the Catawba-Wateree developments in North Carolina utilized cyclopean concrete construction with metal reinforcing (ribbed metal bars or rods, known as reinforcing bars, or "rebar" for short). Jackson defines cyclopean concrete as "a structural material consisting of concrete embedded with large stones" (1988:193). Historic construction photographs show cyclopean construction utilized at dams and spillways at Bridgewater, Lookout Shoals, and Mountain Island. No such photographs were found for Rhodhiss and Oxford, but it is assumed that the same cyclopean technology was employed there, as they were built only a few years after Mountain Island. Cowans Ford, built much later than the other developments, used more modern concrete construction techniques. Rebar is shown in the dams, spillways, intakes, and powerhouses at all of the North Carolina developments.

The second and third most noted types of dams in Jackson's survey are arch dams and earthen dams (23 and 21 examples, respectively). While none of the North Carolina developments utilize an arch dam, several utilize earthen dams or earthen embankments. The semi-hydraulic fill method of earthen construction was used at Bridgewater and Mountain Island.

Hydroelectricity is the number one use in Jackson's survey with 41 examples, while irrigation and water supply follow at 33 and 22 examples, respectively. Of the 41 hydroelectric facilities in the survey, private electric companies built 21, government agencies or entities constructed 17 (two municipal, one state, and 14 federal), and private mining companies built three.

Of the 17 dams in the survey located in the South, 10 are concrete gravity dams (the highest percentage dedicated to this type in any of the survey regions), three are arch dams, and two are earthen dams (there also is one masonry dam and one Ambursen dam). Sixteen of the 17 dams were constructed for hydroelectric use (the highest percentage dedicated to this use in any of the survey regions), and one was built for water supply. Of the 16 dams built for hydroelectric use, private electric companies constructed nine, the federal government built six, and a private corporation erected one. Jackson's data indicate that the use of concrete gravity dams at hydroelectric developments was more widespread throughout and more typical of the South than the other regions of the country.

What is learned from Jackson's data is that the pre-1930 Duke Catawba-Wateree developments in North Carolina were typical of the level of engineering and technology available in the 1910s and 1920s in the fields of dam construction and hydroelectric power generation. The developments were not the first of their kind, nor did they employ groundbreaking methods of construction or utilize unique types of equipment. Yet their significance lies in the fact that to this day they retain the distinctive characteristics of their types and uses, illustrating and representing their historic time period and cultural associations.

FIELDWORK AND ASSESSMENT FINDINGS

This section provides a physical description of each of the North Carolina developments, along with an assessment of each facility's NRHP eligibility. Map and photograph figures are located in Appendix 1.

Bridgewater Development

Description. Lake James features three dams, a spillway, and a powerhouse with associated buildings and structures (Figures 4.1–4.20). The reservoir was constructed between 1916 and 1923 and includes a central canal approximately 3,000 feet long linking the Catawba River (west) and Linville River (east) portions of the lake. The earthen Catawba Dam with its concrete spillway was completed in 1919 and straddles the McDowell County/Burke County line. The earthen Paddy Creek Dam and the earthen Linville Dam were completed in 1919. Work on the Paddy Creek concrete spillway was completed sometime after 1927, according to evidence supplied by historic photographs (Duke Energy Corporation 2003:3:1, 6; Duke Power Archives 1927a). Paddy Creek Dam, the Paddy Creek spillway, and Linville Dam are located in Burke County in the eastern portion of the lake. According to its date plaque, Linville Powerhouse, located at the foot of Linville Dam, was erected in 1919.

The interior of Linville Powerhouse features a tile floor, a concrete base, brick walls, and a concrete panel ceiling. The ceiling panels are reinforced with steel mesh and are held in place by steel beams running the length of the building. Seven steel trusses support the ceiling and the exterior built-up roof. Window openings contain large steel sash units, with six window bays at each side, one bay at the downstream (east) end, and three bays at the upstream (west) end. The building's clerestory level features a dozen 12-light windows at each side (a pair of sash at each bay). Each window unit at the sides and east end contains 150 lights, arranged in six groups of 25 lights each. All windows have concrete lintels and sills. Metal chains open and close the pivoting sections of the sash. Seven brick piers on each side (two in the corners and five between the bays) exhibit corbelled caps and support the steel rails of the 60-ton overhead gantry crane (manufacturer: Toledo Bridge & Crane Company of Toledo, Ohio). The operator's basket is suspended from the crane structure. The east and west ends each feature two brick piers with corbelled caps. The piers continue above the caps to support the end roof trusses. Paired vent fans are located at the clerestory level between the piers.

The powerhouse contains two alternating current (AC) generators, manufactured by the Allis-Chalmers Manufacturing Company of Milwaukee, Wisconsin. Unit No. 1 (Serial No. 108487) is located at the west end of the generator floor, and Unit No. 2 (Serial No. 108570) is situated at the east end of the floor. A generator is simply "a machine powered by a turbine that produces electric current" (Duke Energy Corporation 2003:1:13). Each generator was built to generate 6,600 volts of electricity at 171.5 revolutions per minute (rpm). Each generating unit features an adjacent governor that regulates the flow of water through the turbine (located below the basement level) to maintain uniform speed and keep the system operating in correct frequency. A turbine is "a machine that converts the energy of a stream of water into the mechanical energy of rotation. This energy is then used to turn an electrical generator or other device" (Duke Energy Corporation 2003:1:20). Units 1 and 2 each have a 13,200-horsepower (hp) turbine working under a rated gross head of 115 feet. The I. P. Morris Company of Philadelphia, Pennsylvania, built the turbines in 1917. "Head" is a term that denotes "the vertical distance between the water surface elevation of a reservoir and the water surface elevation at the tailrace" (i.e., the point where the water exits the powerhouse after having passed through the turbines) (Duke Energy Corporation 2003:1:13, 20). As noted in Chapter II, the higher the head, the greater the water pressure that is available to drive the turbine. The Bridgewater Development has the highest head of any of the Duke Power Company developments along the Catawba-Wateree system.

The powerhouse is over six stories high from the basement level to the roof and is roughly 40 feet wide. The control room is located at the west end of the building. It has been updated over time as the control equipment has been modernized. Within the room, there is a small kitchen area, a restroom, and desk space, in addition to the generator controls and relays. Two doors provide access to the generator floor. At one time, the control area was open to the generators. At an unknown date, frame partition walls and a ceiling were constructed, enclosing the controls in the current space. The freestanding control room sits beneath a reinforced concrete mezzanine.

The full-width mezzanine is supported by reinforced concrete piers. An exterior entry to the level in the west end wall provides access to the operator's basket of the gantry crane. A metal safety railing runs along the east edge of the mezzanine above the generator floor. A metal roll-down garage door is located near the west end of the powerhouse's south wall near the control room. A pair of railroad-type rails embedded in the floor leads into the powerhouse through the garage bay. Adjacent to the control room is an M-G (motor-generator) set for the gantry crane. The set consists of an AC motor attached to a direct current (DC) generator. The generator was manufactured by the General Electric Company of Schenectady, New York. A circuit breaker panel and the controls for the M-G set are directly adjacent.

A metal stair at the east end of the main generator floor (in the northeast corner) leads to the basement level. Five metal hatches or panels (two large and three small) in the floor—known as RFPs, or removable floor panels—are located on the main level. The basement level has a concrete floor and walls, and the ceiling structure (supporting the generator floor above) is constructed of reinforced concrete supported by concrete piers. The level features eight-light steel sash windows, with 12 units located along the north side (arranged in six pairs), two located at the east end, and one positioned at the west end (south side). Four of the windows contain sash; the rest are fitted with modern, vertical, metal louvers. At the west end of the level, there is a concrete block restroom/shower room with a three-panel wood door. In the nearby corner is the powerhouse battery room. A bank of freestanding metal lockers is located in the center of the space, and in the corner opposite the battery room is a concrete block room with a metal door, once used as a maintenance crew rest area but now utilized as an office. Below each generator is an eight-sided, approximately four-foot-thick, tapered, reinforced concrete base with curved interior walls housing the generator shaft and bearing and the wheel pit area associated with the turbine (positioned below the basement level). Each base has three arched entries and a circular metal catwalk at the bottom of the space. Each also has a set of metal rungs embedded in the inside wall that leads up into the generator. Outside each generator base are various concrete pits, motors, and oil tanks. Each base features an adjoining, large, steel pilot valve that controls flow between the penstock and the turbine. A sub-basement level is accessed by steel ladders located off concrete catwalks with metal railings adjacent to the pilot valves. Arched concrete tunnels lead to relief valves (one per unit) and may also access the turbines.

The exterior of Linville Powerhouse features a concrete base, Flemish bond brick walls (over a structural steel framework), and concrete sills and lintels at the openings. The flat lintels exhibit formed keystones. Brick pilasters divide the window bays, and a decorative metal cornice runs just below the parapet roof. The center bay of the west end of the building features two vent hoods at the clerestory level. Below are a narrow, horizontal 10-light window and two eight-light windows above a single-leaf metal door. The south bay contains a single eight-light window, while the north bay exhibits a modern single-pane window (installed in the control room for better visibility). A metal stair starts at the powerhouse's southwest corner and runs up the side of the building to a single-leaf metal door (this door leads to the interior mezzanine). A metal ladder accesses the roof from the top of the stair. The remaining sides of the building display the large 150-light steel sash windows, smaller 50-light windows, and the 12-light clerestory windows. A metal light standard with a historic lamp is located near the southeast corner of the building.

In addition to the powerhouse, the Bridgewater Development includes a one-story, brick warehouse building, built sometime after 1927. An aerial view of the powerhouse and its surroundings taken in 1927 shows two frame garages or warehouses where the brick warehouse currently sits (Duke Power Archives 1927a). It is not known when these two buildings were removed and the brick warehouse constructed. It is located along the entry drive at the main road. In the 1970s, the building was more than doubled in length with a brick extension off its north end. Two sets of double metal doors provide access to the warehouse, and steel industrial sash windows can be found at the south end and east side (the east side window was relocated from the north end of the original building). Three brick buttresses with concrete caps are located on the east and west sides of the original section. A modern garage door is located at the north end of the extension. The interior of the warehouse contains a finished office at the south end, a workroom in the remainder of the original building, and a storage room in the extension. The warehouse is located outside the FERC project boundary.

Between the warehouse and the powerhouse is a steel-framed substation with transformers and control boxes. A modern, one-story, side-gabled office building sits adjacent to the powerhouse's west end, and two non-historic, one-story maintenance sheds are located up the slope from the substation. Two flights of concrete steps lead up to and beyond the maintenance area; these steps used to access three dwellings utilized as operators' houses (Duke Power Archives 1927a). A metal water tank sits behind the sheds and is the only feature remaining from the workers' village built to support the construction of the Bridgewater Development between 1916 and 1919 (two small frame outbuildings and a concrete pad from the village are located across the road at the top of a hill but are outside the project area). The water tank is in poor structural condition and is considered a safety hazard; it is slated for removal in the near future.

The earthen Catawba Dam (semi-hydraulic fill) with its concrete gravity spillway is 3,155 feet long and 120 feet high. The spillway contains four sluice gates that are no longer operated. Until recently, a metal truss bridge sat atop the spillway, a holdover from the days when the dam and spillway carried NC 126 through the area (the road was relocated to the south sometime after

1960). The bridge was documented to HAER standards in 2001 and was subsequently removed and donated to the City of Morganton. The earthen Paddy Creek Dam (semi-hydraulic fill), the highest of the Bridgewater Development dams, measures 1,610 feet long and 165 feet high, and carries State Route 1233 along its crest. The Paddy Creek concrete spillway is roughly 464 feet long and approximately 430 feet wide at its widest point. The earthen Linville Dam (semi-hydraulic fill) is 160 feet high and 1,325 feet long. It carries State Route 1233 along its crest. The intake structure for the powerhouse is located in Lake James near the south end of Linville Dam. The structure consists of a concrete tower connected to land by a metal truss walkway. A 900-foot-long penstock, constructed of concrete and steel, runs underground from the intake to the two turbines in the powerhouse (Duke Energy Corporation 2003:3:1–5).

<u>NRHP Eligibility Assessment</u>. The Bridgewater Development, completed in 1919, illustrates the typical construction and engineering methods utilized at hydroelectric plants in the second and third decades of the twentieth century. The earthen or earthfill dam type had been in use since the mid- to late nineteenth century, and the concrete gravity dam type had been utilized since the late nineteenth century (Hay 1991:xix; Jackson 1988). The hydraulic fill dam type, a more specialized form of earthen dam, had been in use since the late nineteenth century (Jackson 1988:258–259). Turbines had been around since the 1850s, and water-powered generators had been in use since 1880. The vertical arrangement of turbine and generator had been utilized since ca. 1905. In ca. 1912, the Kingsbury thrust bearing was added to the vertical turbine-generator unit. Three years later, it was in widespread use, and by 1920, almost every hydroelectric facility in the U.S. had adopted it (Hay 1991:3, 13, 71–72, 74). The Bridgewater Development, then, is neither the first nor the oldest surviving example of its type, and it was not groundbreaking in its construction technique or use of equipment. However, it retains distinctive characteristics of its historic type and method of construction, serving to illustrate hydroelectric power generation in the 1910s and 1920s. Moreover, because of the Bridgewater Development's role in the electrification of the region, it has had a great impact on the area and the region in which it is located in the areas of agriculture, architecture, commerce, conservation, engineering, industry, and social history.

Based on TRC's research, field survey, and analysis, then, and in accordance with 36 CFR 60.4, the Bridgewater Development is recommended eligible for the NRHP under criteria A and C. The dams, powerhouse, and supporting elements have undergone minimal alteration and still appear—for the most part—as they did when they were first constructed. As an important part of the region's electrification process, they continue to illustrate the historical associations for which they are significant (both to the region and to the South as a whole): the growth of the electric power business; the growth of industry and commerce; changes in employment and improved working conditions; changes in the home and an improved quality of life; changes in rural areas, especially on the farm; and conservation of natural resources. Although the development has been altered, the alterations have been minor and have consisted of installation of modern, computerized control equipment; changes made for safety reasons; and normal upgrades of generating and transmission equipment. Because the development continues to be used for its original purpose, and because the operators have maintained the equipment and the structures as they have through the years, the development retains its integrity of location, setting, feeling, and association, and its historic design, workmanship, and use of materials and, thus, remains a good, representative example of its type.

Research undertaken for this survey has not shown the Bridgewater Development to be associated with the lives of persons significant in the past (Criterion B) or likely to yield information important in prehistory or history (Criterion D).

Contributing elements at the Bridgewater Development include the dams and spillways, the intake structure, the powerhouse, the warehouse, the substation, and the light standard. The warehouse, although altered, is in its historic location and setting and continues to display its historic materials, workmanship, and association. The warehouse is located outside the FERC project boundary. Non-contributing elements include the modern office building, the two non-historic maintenance sheds, and the water tank.

Rhodhiss Development

Description. Lake Rhodhiss features one dam, a powerhouse, and associated buildings and structures (Figures 4.21–4.33). The reservoir was constructed between 1924 and 1925. The concrete Rhodhiss Dam with its overflow spillway was completed in 1925 (Duke Energy Corporation 2003:3:8, 11). According to its date plaque, Rhodhiss Powerhouse, located at the north end of the dam, was erected in 1925. The development is located in Burke and Caldwell counties.

The interior of Rhodhiss Powerhouse features a tile floor, a tile base, plaster and exposed concrete walls, and a concrete panel ceiling. The ceiling panels are reinforced with steel mesh and are held in place by steel beams running the length of the building. Twelve steel trusses support the ceiling and the exterior built-up roof. Window openings contain large steel sash units, with 32 lights at the top (two sets of 16 lights), a transom panel in the middle, and 120 lights at the bottom (six sets of 20 lights). The building's clerestory level at the west side features 11 24-light windows (two sets of 12 lights). Twelve steel piers on each side support the steel rails of the 100-ton overhead gantry crane (manufacturer: Niles Crane). The operator's basket is suspended from the crane structure. The control room is located in an elevated extension off the rear mezzanine level. Adjoining offices also are located on the mezzanine, which runs the full length of the powerhouse. The control room has been updated over time as the control equipment has been modernized. Within the room, there is a small kitchen area, a restroom, and desk space, in addition to the generator controls and relays. Two doors provide access to the mezzanine.

The powerhouse contains three AC generators, manufactured by the Westinghouse Electric & Manufacturing Company of East Pittsburgh, Pennsylvania. Unit No. 1 is located at the north end of the generator floor, Unit No. 2 is situated in the center of the floor, and Unit 3 is located at the south end of the floor. Each generator was built to generate 6,600 volts of electricity at 100 rpm. Each generating unit features an adjacent governor that regulates the flow of water through the turbine (located below the basement level) to maintain uniform speed and keep the system operating in correct frequency. Unit 3 retains its historic governor, while Units 1 and 2 have been updated with modern governors. The generating units have 15,000-hp turbines working under a rated gross head of 57 feet. The turbines were manufactured by the S. Morgan Smith Company of York, Pennsylvania. In 2000, the Unit 2 turbine received a replacement runner rated at 16,600 hp. The new runner was installed by American Hydro Corporation of York, Pennsylvania.

The basement level has a concrete floor and walls, and the ceiling structure (supporting the generator floor above) is constructed of reinforced concrete supported by concrete piers. The level features 32-light steel sash windows fitted with modern, metal vents. At the north end of the level is the powerhouse battery room. Below each generator is a five-sided, approximately four-foot-thick, reinforced concrete base with curved interior walls housing the generator shaft and bearing and the wheel pit area associated with the turbine (positioned below the basement level). Each base has three arched entries.

The exterior of Rhodhiss Powerhouse features a concrete base, common bond brick walls (over a structural steel framework), and brick sills and concrete lintels at the openings. Brick pilasters divide the window bays, and a decorative brick cornice with a cornice band and panels runs just below the parapet roof. The east side of the building features ten full-height window bays and a garage bay at the north end. Below are ten basement level openings fitted with metal vent hoods. The north and south ends each contain three window bays, while the west side of the powerhouse features the clerestory level window openings (fitted with vent hoods) above the intake deck.

In addition to the powerhouse, the Rhodhiss Development includes a one-story, brick warehouse building, likely built in 1925. It is located along the entry drive leading to the powerhouse. Three sets of double metal doors provide access to the warehouse, and steel industrial sash windows can be found at the north, east, and west sides. The interior of the warehouse contains workrooms and storage spaces. [Note: the warehouse was demolished in 2004 for safety reasons.]

Between the warehouse and the powerhouse is a steel-framed substation with transformers and control boxes. A modern, one-story office trailer sits adjacent to the substation. Off the north side of the substation in the hill is an inset area with concrete walls. This space appears to have served as a holding area for supplies and/or equipment.

The concrete gravity Rhodhiss Dam with its overflow spillway is 1,517 feet long and 72 feet high. There is no separate intake structure for the powerhouse; the intake and powerhouse were built as a unit and serve as part of the dam impounding Lake Rhodhiss. In 2001, as part of the FERC-mandated modifications due to revised federal regulations, floodwalls were added atop the north and south abutments, a sheet pile wall was installed at the south earthen embankment, and anchors were drilled in the spillway and abutments (Duke Energy Corporation 2003:3:8–9).

<u>NRHP Eligibility Assessment</u>. The Rhodhiss Development, completed in 1925, illustrates the typical construction and engineering methods utilized at hydroelectric plants in the second and third decades of the twentieth century. The earthen or earthfill dam type had been in use since the mid- to late nineteenth century, and the concrete gravity dam type had been utilized since the late nineteenth century (Hay 1991:xix; Jackson 1988). The hydraulic fill dam type, a more specialized form of earthen dam, had been in use since the late nineteenth century (Jackson 1988:258–259). Turbines had been around since the 1850s, and water-powered generators had been in use since 1880. The vertical arrangement of turbine and generator had been utilized since ca. 1905. In ca. 1912, the Kingsbury thrust bearing was added to the vertical turbine-generator unit. Three years later, it was in widespread use, and by 1920, almost every hydroelectric facility in the U.S. had adopted it (Hay 1991:3, 13, 71–72, 74). The Rhodhiss Development, then, is not the first nor the oldest surviving example of its type, and it was not groundbreaking in its

construction technique or use of equipment. However, it retains distinctive characteristics of its historic type and method of construction, serving to illustrate hydroelectric power generation in the 1910s and 1920s. Moreover, because of the Rhodhiss Development's role in the electrification of the region, it has had a great impact on the area and the region in which it is located in the areas of agriculture, architecture, commerce, conservation, engineering, industry, and social history.

Based on TRC's research, field survey, and analysis, then, and in accordance with 36 CFR 60.4, the Rhodhiss Development is recommended eligible for the NRHP under criteria A and C. The dam, powerhouse, and supporting elements have undergone minimal alteration and still appear—for the most part—as they did when they were first constructed. As an important part of the region's electrification process, they continue to illustrate the historical associations for which they are significant (both to the region and to the South as a whole): the growth of the electric power business; the growth of industry and commerce; changes in employment and improved working conditions; changes in the home and an improved quality of life; changes in rural areas, especially on the farm; and conservation of natural resources. Although the development has been altered over time, the alterations have been minor and have consisted of installation of modern, computerized control equipment; FERC-mandated upgrades for flood control; and normal upgrades of generating and transmission equipment. Because the development continues to be used for its original purpose, and because the operators have maintained the equipment and the structures as they have through the years, the development retains its integrity of location, setting, feeling, and association, and its historic design, workmanship, and use of materials and, thus, remains a good, representative example of its type.

Research undertaken for this survey has not shown the Rhodhiss Development to be associated with the lives of persons significant in the past (Criterion B) or likely to yield information important in prehistory or history (Criterion D).

Contributing elements at the Rhodhiss Development include the dam, the powerhouse, the warehouse, and the substation. The dam—although altered with the FERC-mandated floodwalls, sheet pile wall, and anchors—is still considered contributing, as most of it remains intact. The floodwalls and sheet pile wall are of minimal height, and the anchors are not visible. There are no non-contributing elements.

Oxford Development

Description. Lake Hickory features one dam, a powerhouse, and associated buildings and structures (Figures 4.34–4.44). The reservoir was constructed in 1927. The concrete Oxford Dam with its gated spillway was completed in 1928 (Duke Energy Corporation 2003:3:14, 17). According to its date plaque, Oxford Powerhouse, located at the south end of the dam, was erected in 1928. The development is located in Alexander and Catawba counties.

The interior of Oxford Powerhouse features a tile floor, plaster and exposed concrete walls, and a concrete panel ceiling. The ceiling panels are reinforced with steel mesh and are held in place by steel beams running the length of the building. Eight steel trusses support the ceiling and the exterior built-up roof. Window openings on the east side contain large steel sash units, with 18-light sash units at the clerestory level and 90-light sash units below (the bottom 30 lights have been fitted with vents). The north and south ends of the building each feature 36-light sash units at the clerestory level and 90-light sash units below. Eight steel piers on each side support the steel rails of the modern 30- and 115-ton overhead gantry crane (manufacturer: Whiting). The operator's basket is suspended from the crane structure. The former control room is located in a freestanding room between the two generating units. The current control room is located in a brick office/warehouse building outside the powerhouse. The move was made following a fire inside the powerhouse in the 1980s. In front of the former control room and between the two generators is a large opening in the floor, with a staircase down to the basement level. A metal railing encircles the opening.

The powerhouse contains two AC generators, manufactured by the Westinghouse Electric & Manufacturing Company of East Pittsburgh, Pennsylvania. Unit No. 1 is located at the south end of the generator floor, and Unit 2 is located at the north end of the floor. Each generator was built to generate 6,600 volts of electricity at 120 rpm. Each generating unit features an adjacent modern governor that regulates the flow of water through the turbine (located below the basement level) to maintain uniform speed and keep the system operating in correct frequency. The units have 29,250-hp turbines working under a rated gross head of 87 feet. The current turbines feature replacement runners manufactured by GEC Alsthom Energies of Tracy (Quebec), Canada. The runners were installed in 1997 (Unit 1) and 1998 (Unit 2).

The basement level has a concrete floor and walls, and the ceiling structure (supporting the generator floor above) is constructed of reinforced concrete supported by concrete piers. The level features both 9- and 15-light steel sash windows. At the north end of the level is a locker and shower room; the powerhouse battery room is located at the south end of the level. Below each generator is a round, several-foot-thick, reinforced concrete base with curved interior walls housing the generator shaft and bearing and the wheel pit area associated with the turbine (positioned below the basement level). The interiors of the bases were not accessible at the time of the survey.

The exterior of Oxford Powerhouse features a concrete base, common bond brick walls (over a structural steel framework), and concrete sills and metal lintels at the openings. Brick pilasters divide the window bays, and a cast concrete cornice cap and a cast concrete band highlight the parapet roof. The east side of the building features seven full-height window bays with brick panels encircled by cast concrete trim forming the transom panels. The north and south ends each contain two window bays, while the west side of the powerhouse features the clerestory level window openings (fitted with vent hoods) above the intake deck. The main entrance is located in the east bay of the south end and features the word "Oxford" in the transom panel above.

In addition to the powerhouse, the Oxford Development includes a one-story, brick office/warehouse building, likely built in 1928. It is located along the entry drive leading to the powerhouse. Two sets of double metal doors and one set of modern aluminum doors provide access to the building, and steel industrial sash and modern aluminum sash windows can be found at all sides of the building. The interior contains offices, workrooms, and storage space.

Between the office/warehouse and the powerhouse is a steel-framed substation with transformers and control boxes. A large metal tank sits adjacent to the substation off the west end of the office/warehouse.

The concrete gravity Oxford Dam with its gated spillway is 1,336 feet long and 133 feet high (Duke Energy Corporation 2003:3:14). The spillway contains 10 gates that can be raised and lowered by a modern 68-ton-capacity Whiting gantry crane. There is no separate intake structure for the powerhouse; the intake and powerhouse were built as a unit and serve as part of the dam impounding Lake Hickory. In 2003–2004, as part of the FERC-mandated modifications due to revised federal regulations, a large concrete buttress was added to the front of the powerhouse, an overflow spillway was constructed at the north end of the dam, a floodwall was installed atop the south abutment, and anchors were drilled in the spillway and abutments. The buttress is anchored to bedrock and rises a few feet above the level of the tailrace. The spillway was constructed by lowering a portion of the abutment at the dam's north end and reconfiguring the riverbank. A new retaining wall near the top of the bank was built as part of the work. The floodwall work included the installation of a new concrete deck and handrails along the abutment and at the intake area.

NRHP Eligibility Assessment. The Oxford Development, completed in 1928, illustrates the typical construction and engineering methods utilized at hydroelectric plants in the second and third decades of the twentieth century. The earthen or earthfill dam type had been in use since the mid- to late nineteenth century, and the concrete gravity dam type had been utilized since the late nineteenth century (Hay 1991:xix; Jackson 1988). The hydraulic fill dam type, a more specialized form of earthen dam, had been in use since the late nineteenth century (Jackson 1988:258–259). Turbines had been around since the 1850s, and water-powered generators had been in use since 1880. The vertical arrangement of turbine and generator had been utilized since ca. 1905. In ca. 1912, the Kingsbury thrust bearing was added to the vertical turbine-generator unit. Three years later, it was in widespread use, and by 1920, almost every hydroelectric facility in the U.S. had adopted it (Hay 1991:3, 13, 71–72, 74). The Oxford Development, then, is not the first nor the oldest surviving example of its type, and it was not groundbreaking in its construction technique or use of equipment. However, it retains distinctive characteristics of its historic type and method of construction, serving to illustrate hydroelectric power generation in the 1910s and 1920s. Moreover, because of the Oxford Development's role in the electrification of the region, it has had a great impact on the area and the region in which it is located in the areas of agriculture, architecture, commerce, conservation, engineering, industry, and social history.

Based on TRC's research, field survey, and analysis, then, and in accordance with 36 CFR 60.4, the Oxford Development is recommended eligible for the NRHP under criteria A and C. The dam, powerhouse, and supporting elements have undergone minimal alteration and still appear—for the most part—as they did when they were first constructed. As an important part of the region's electrification process, they continue to illustrate the historical associations for which they are significant (both to the region and to the South as a whole): the growth of the electric power business; the growth of industry and commerce; changes in employment and improved working conditions; changes in the home and an improved quality of life; changes in rural areas, especially on the farm; and conservation of natural resources. Although the development has been altered, the alterations have been minor and have consisted of installation of modern, computerized control equipment; FERC-mandated upgrades for flood control; and normal upgrades of generating and transmission equipment. Because the development continues to be used for its original purpose, and because the operators have maintained the equipment and the structures as they have through the years, the development retains its integrity of location, setting, feeling, and association, and its historic design, workmanship, and use of materials and, thus, remains a good, representative example of its type.

Research undertaken for this survey has not shown the Oxford Development to be associated with the lives of persons significant in the past (Criterion B) or likely to yield information important in prehistory or history (Criterion D).

Contributing elements at the Oxford Development include the dam and spillway, the powerhouse, the office/warehouse, and the substation. The dam—although altered with the FERC-mandated spillway at its north end and floodwall at its south end—is still considered contributing, as most of it remains intact. The new spillway section is tucked into the bank, and the floodwall is of minimal height (the new decking and handrails are also minimally visible). The buttress in front of the powerhouse, although a modern addition, is mostly below water, and its concrete surface blends with the concrete base of the powerhouse. There are no non-contributing elements.

Lookout Shoals Development

Description. Lookout Shoals Lake features one dam, a powerhouse, and associated buildings and structures (Figures 4.45–4.58). The reservoir was constructed in 1915. The concrete gravity Lookout Shoals Dam with its ungated spillway was completed in 1915 (Duke Energy Corporation 2003:3:19, 23). According to its date plaque, Lookout Powerhouse, located at the east end of the dam, was erected in 1915. The Lookout Shoals Development was the first of Duke Power's Catawba-Wateree facilities to be constructed in North Carolina. It is located in Catawba and Iredell counties.

The interior of Lookout Powerhouse features a tile floor, a concrete base, brick walls, and a concrete panel ceiling. The ceiling panels are reinforced with steel mesh and are held in place by steel beams running the length of the building. Ten steel trusses support the ceiling and the exterior built-up roof. Window openings at the west end and south side contain large, 180-light steel sash units (six groups of 30 lights). Above a modern roll-down/pedestrian door near the east end of the south side is a 60-light steel sash window (two groups of 30 lights). The north side clerestory level contains eight 60-light steel sash windows (two groups of 30 lights each) with the 12-light pivoting section in each right-hand group of 30 lights fitted with a vent fan. The east end clerestory level features three 30-light steel sash windows. On each side of the generator floor, ten brick piers with molded concrete caps support the steel rails of the modern 60-ton overhead crane (manufacturer: Whiting). The operator's basket is suspended from the crane structure. Each pier also supports an angle bracket for the roof truss above it, helping to carry the load of the roof. The control room is located in the southeast corner of the powerhouse at a mezzanine level. It has been updated with later finishes and contains modern control equipment. To the north of the control room is a small kitchen area, a restroom, a closet, and an office. The space below the control room contains a laboratory and a locker room with showers. The space above the mezzanine level is open and is where the overhead crane is parked when not in use.

The powerhouse contains three AC generators, manufactured by the Allis-Chalmers Manufacturing Company of Milwaukee, Wisconsin. Unit No. 1 is located at the east end of the generator floor, Unit 2 is located in the center, and Unit 3 is located at the west end of the floor.

Each generator was built to generate 6,600 volts of electricity at 144 rpm. In 1993 and 1994, the stators of Units 2 and 3 were rewound by Magnetek National Electric Coil of Columbus, Ohio. Each generating unit features an adjacent modern governor that regulates the flow of water through the turbine (located below the basement level) to maintain uniform speed and keep the system operating in correct frequency. The units have 11,000-hp turbines working under a rated gross head of 76 feet. Like the generators, the turbines also were manufactured by the Allis-Chalmers Manufacturing Company.

East of Unit 1 and closest to the control room are two synchronous AC generators. The modern generators, manufactured by the Reliance Electric Company of Mankato, Minnesota, sit on older footings and include modern governors, also positioned atop older pedestals.

The basement level has a concrete floor and walls, and the ceiling structure (supporting the generator floor above) is constructed of reinforced concrete supported by concrete piers. The level features seven bays of louvered metal vents along the south side, with each bay containing a group of three vents. On the exterior, large steel shutters can be raised and lowered to cover the vents. At the east end of the level is the powerhouse battery room, along with pumping and control equipment. Three window openings fitted with paired six-light steel sash are located at the east end, two of which have been fitted with HVAC vents. Below each generator is a five-sided, several-foot-thick, reinforced concrete base with curved interior walls housing the generator shaft and bearing and the wheel pit area associated with the turbine (positioned below the basement level). The interiors of the bases feature three arched entries. At the east end of the basement, at a floor level lower than the entries to the generator bases, are two large steel penstocks with large steel valves. These are connected via open shafts to the synchronous generators above.

The exterior of Lookout Powerhouse features a concrete base, cream-colored, common bond brick walls (over a structural steel framework), and concrete sills and lintels at the openings. Each lintel features a molded concrete keystone at its center. Brick pilasters divide the window bays on the north and south sides, and on the south side they are supported by concrete pilasters starting below the basement vent openings. A molded copper cornice highlights the parapet roof. The south side of the building features seven full-height window bays and one garage bay, while the north side of the powerhouse features the clerestory level window openings (partially fitted with vent fans) above the intake deck. The west end contains one window bay, and the east end features three window bays, as well as the entrance to the control room.

In addition to the powerhouse, the Lookout Shoals Development includes a one-story, brick warehouse building, likely built in 1915. It is located southeast of the powerhouse on the main road, outside the fenced area. Two sets of double metal doors with 12 lights each provide access to the building, and steel industrial sash windows of 24 lights can be found on all sides of the building. All doors and windows have been covered with metal plates, except for one window at the rear. The interior contains two unfinished storage rooms. The warehouse is located outside the FERC project boundary.

East of the powerhouse is a steel-framed substation with transformers and control boxes. A prefabricated metal building constructed in the mid-1970s is located immediately south of the substation.

The concrete gravity Lookout Shoals Dam with its ungated spillway is 2,731 feet long and 78 feet high (Duke Energy Corporation 2003:3:20). The spillway evidences a slight curve near the powerhouse. There is no separate intake structure for the powerhouse; the intake and powerhouse were built as a unit and serve as part of the dam impounding Lookout Shoals Lake. The intake area and east abutment feature a series of buttresses supporting the deck above. Arched openings within each buttress once contained a walkway of wood slats atop metal rails; however, this walkway is no longer accessible. As part of the FERC-mandated modifications due to revised federal regulations, concrete floodwalls were added at the ends of the east and west abutments. In addition, anchors were installed for stability behind the powerhouse and in the east and west abutments.

NRHP Eligibility Assessment. The Lookout Shoals Development, completed in 1915, illustrates the typical construction and engineering methods utilized at hydroelectric plants in the second and third decades of the twentieth century. The earthen or earthfill dam type had been in use since the mid- to late nineteenth century, and the concrete gravity dam type had been utilized since the late nineteenth century (Hay 1991:xix; Jackson 1988). The hydraulic fill dam type, a more specialized form of earthen dam, had been in use since the late nineteenth century (Jackson 1988:258–259). Turbines had been around since the 1850s, and water-powered generators had been in use since 1880. The vertical arrangement of turbine and generator had been utilized since ca. 1905. In ca. 1912, the Kingsbury thrust bearing was added to the vertical turbine-generator unit. Three years later, it was in widespread use, and by 1920, almost every hydroelectric facility in the U.S. had adopted it (Hay 1991:3, 13, 71–72, 74). The Lookout Shoals Development, then, is not the first nor the oldest surviving example of its type, and it was not groundbreaking in its construction technique or use of equipment. However, it retains distinctive characteristics of its historic type and method of construction, serving to illustrate hydroelectric power generation in the 1910s and 1920s. Moreover, because of the Lookout Shoals Development's role in the electrification of the region, it impacted the area and the region in which it is located in the areas of agriculture, architecture, commerce, conservation, engineering, industry, and social history.

Based on TRC's research, field survey, and analysis, then, and in accordance with 36 CFR 60.4, the Lookout Shoals Development is recommended eligible for the NRHP under criteria A and C. The dam, powerhouse, and supporting elements have undergone minimal alteration and still appear—for the most part—as they did when they were first constructed. As an important part of the region's electrification process, they continue to illustrate the historical associations for which they are significant (both to the region and to the South as a whole): the growth of the electric power business; the growth of industry and commerce; changes in employment and improved working conditions; changes in the home and an improved quality of life; changes in rural areas, especially on the farm; and conservation of natural resources. Although the development has been altered, the alterations have been minor and have consisted of installation of modern, computerized control equipment; FERC-mandated upgrades for flood control; and normal upgrades of generating and transmission equipment. Because the development continues to be used for its original purpose, and because the operators have maintained the equipment and the structures as they have through the years, the development retains its integrity of location, setting, feeling, and association, and its historic design, workmanship, and use of materials and, thus, remains a good, representative example of its type.

Research undertaken for this survey has not shown the Lookout Shoals Development to be associated with the lives of persons significant in the past (Criterion B) or likely to yield information important in prehistory or history (Criterion D).

Contributing elements at the Lookout Shoals Development include the dam and spillway, the powerhouse, the warehouse, and the substation. The dam, although altered with the FERC-mandated floodwalls at its ends, is still considered contributing, as most of it remains intact, and the new walls are of minimal height. The warehouse is located outside the FERC project boundary. The mid-1970s prefabricated metal building is the only non-contributing element.

Cowans Ford Development

Description. Lake Norman features one dam, a dike, a powerhouse, and associated buildings and structures (Figures 4.59–4.79). The reservoir was constructed between 1959 and 1963. The concrete gravity Cowans Ford Dam with its gated spillway was completed in 1963 (Duke Energy Corporation 2003:3:26). According to its date stone, Cowans Ford Powerhouse, located at the west end of the dam, was officially dedicated in September 1964. The development is located in Lincoln and Mecklenburg counties.

The Cowans Ford Development differs from the other five Catawba-Wateree system developments in North Carolina in several ways. First, it was built in the 1960s, 35 years after the fifth North Carolina development, Oxford, was completed. Second, it utilizes Kaplan-type turbines, not Francis-type units like the other developments, and has a generating capacity some six to 18 times the capacity at any of the other developments. Finally, its semi-outdoor powerhouse design stands in contrast to the traditional powerhouse designs employed at the other developments. At Cowans Ford, the generators are protected from the elements by metal covers and are serviced by an exterior rolling gantry crane on rails (Hay 1991:93–94).

The Cowans Ford Development is similar to all but the Bridgewater Development in that the powerhouse and intake are essentially one structure tied directly to the dam. The Cowans Ford Powerhouse features an aboveground visitor center/entry point that leads to the generator floor and inspection tunnels belowground. The interior of the visitor center/entry point features a tile floor, polished granite walls, and a suspended ceiling with large, flush-mounted, circular lights. Floor-to-ceiling plate glass windows in aluminum frames mark the north, east, and south sides of the building. Double glass doors in aluminum frames are located at the west side entry and the northeast corner. The building features several displays, a corner television cabinet, leather benches, and an aluminum clock set in the granite panel over the entryway. The southeast corner contains an open steel and concrete staircase with aluminum railings that travels three flights down to the generator floor. The south wall of the stair hall is covered with blue tiles and features a large map of the Duke Power hydroelectric system. Down two flights of steps is an HVAC area, and at the bottom of the staircase is an open room with displays and construction photographs on two walls. The room features a tile floor and three walls covered with drywall (the blue tiles cover the south wall). An adjacent hallway with beige tile walls leads to restrooms and a janitor's closet.

Below the staircase in the display and photograph room is a smaller metal stair that leads down to a maintenance and equipment bay. This concrete-framed space contains removable metal ceiling panels so that machinery can be lowered down for repair and/or storage. The space features two large air compressors, several boiler tanks, and numerous valves and controls. A metal stair in the center of the room leads up to the generator floor, which is also accessible via double metal doors from the display and photograph room.

The west end of the generator floor consists of an open, concrete-framed workroom with an adjacent locker and shower room and break room. To the rear (facing north) is a hallway leading to the elevator within the dam. A thick metal door separates the hallway from the workroom and can be closed to seal off the generator area in the event of water infiltration. The elevator accesses three levels: the top of the dam/spillway, the generator floor, and an inspection tunnel near the base of the dam. The concrete inspection tunnel runs nearly the full length of the concrete portion of the dam and contains headgate bypass valves at each generator and two pumps. Metal ladders at each end of the tunnel lead to exterior exit hatches.

The generator floor east of the workroom consists of four large concrete cells containing the generators and turbines. The governors and associated machinery are located adjacent to each cell. The controls are located in rooms on the south side of the wide corridor running the length of the floor. The construction throughout is concrete, although interior partition walls and stairwell walls are of concrete block. Midway down the floor on the south side is the main powerhouse control room, which is one level up from the generator floor and can be reached via two staircases. Besides the modern control equipment, the room features tile walls, a suspended ceiling, and vinyl tile flooring. The east end of the generator floor contains a staircase leading up to a breaker and control level and then on to an exterior exit at the east end of the powerhouse "roof" (where the generator covers and gantry crane are located). Along the rear of the generator-turbine cells is a full-length concrete inspection hallway that provides access to the generators and contains a number of valves. The tunnel entry is located off the workroom adjacent to the metal door leading to the rear elevator hallway.

The Cowans Ford Powerhouse contains four AC generators, manufactured by the Westinghouse Electric Corporation of Monroeville, Pennsylvania. Unit 1 is located at the west end of the generator floor, and Unit 4 is located at the east end, with Units 2 and 3 between. Units 1–3 were installed in 1963; Unit 4 was installed four years later. Each generator was built to generate 13,800 volts of electricity at 105.9 rpm. As noted above, each generating unit features an adjacent governor, manufactured by the Woodward Governor Company of Rockford, Illinois, that regulates the flow of water through the turbine to maintain uniform speed and keep the system operating in correct frequency. The generating units also feature Westinghouse DC generators that generate 375 volts of electricity at 105.9 rpm. The units are connected to 121,000-hp turbines working under a rated gross head of 92 feet. The turbines were manufactured by Allis-Chalmers of York, Pennsylvania.

As noted above, the Cowans Ford Powerhouse is mostly a below ground building, with only the "roof" visible above ground. This flat concrete area includes the four metal generator covers and the large gantry crane. The crane features two 150-ton hoists and one 25-ton hoist. The powerhouse roof also includes three concrete enclosures containing transformers, the visitor center/entry point, the east end exit penthouse that ties into the generator floor staircase, and three removable reinforced concrete pads that allow equipment to be lowered into the workroom. The visitor center/entry point features a slate base, a pebbledash panel exterior, and a metal cornice cap. Low pebbledash walls, a pebbledash deck, metal steps, and two lampposts mark the entry. The exit penthouse also has pebbledash panel walls and an aluminum-framed door and windows. The final element of the powerhouse is the full-width tailrace deck with its 30-ton gantry crane.

Near the west end of the powerhouse roof, the concrete elevator enclosure extends above the crest of the dam, allowing access to the top of the dam and spillway. The elevator enclosure is capped with a tall steel tower. A 30-ton gantry crane services the headgates from the top of the dam. The 11 spillway gates are raised and lowered by two traveling hoists, each with a 55-ton capacity.

In addition to the powerhouse, the Cowans Ford Development includes a one-story, metal office building constructed in the early 1990s. It is located southwest of the powerhouse on a side road off the main entry drive. To the rear of the office building are two maintenance buildings. The first is a one-story, brick warehouse that appears to be original to the development. The flat-roofed building has two garage bays on its east side, and pedestrian doors and aluminum-framed windows on its east, south, and west sides. The interior features one large storage space and one smaller equipment room. Immediately east of the warehouse is a corrugated metal tractor shed of unknown age. The building contains a number of open bays facing west, with an enclosed room near the north end of the structure.

Additional buildings on the property include a boat storage building to the west of the powerhouse, and three additional buildings to the west-northwest. The boat storage building is comprised of a brick section and two attached frame sections, all with open front bays. The age of the building is unknown. The three other buildings on the property are located in a wooded area near a storage yard. The first building is a small frame and metal shed with an open north end. The second is a small clapboard shed that may have been moved to the site from another location. The third structure is a metal trailer. The age of these three buildings is unknown.

The office building, maintenance buildings, boat storage building, two sheds, and metal trailer are located outside the FERC project boundary.

The concrete gravity Cowans Ford Dam with its gated spillway is approximately 130 feet high. In 2000, as part of the FERC-mandated modifications due to revised federal regulations, floodwalls were installed atop the east and west abutments, and anchors were drilled in the spillway and west abutment. There is no separate intake structure for the Cowans Ford Powerhouse; the intake, powerhouse, and dam were built as a unit and serve to impound Lake Norman along with two earthen embankments. These embankments extend from either side of the dam, giving it a total length of 8,738 feet. Approximately three miles to the east, an earthen dike, known as the Hicks Cross Roads Dike, serves to impound Lake Norman in that area and was a component of the original construction program. The dike is some 3,134 feet long and parallels NC Highway 73 (Duke Energy Corporation 2003:3:26–27).

NRHP Eligibility Assessment. Based on TRC's research, field survey, and analysis, and in accordance with 36 CFR 60.4, the Cowans Ford Development is not currently eligible for the NRHP due to its more recent age. The NRHP eligibility criteria allow for resources less than 50 years old to be determined eligible, but such resources must demonstrate "exceptional importance." Although Cowans Ford was the largest of the Catawba-Wateree developments and was the last hydroelectric development constructed on the river, thereby completing the build-out of the river system begun in the historic period, it does not meet NRHP Criteria Consideration G as an exceptionally significant resource. Cowans Ford followed a different design, had a much larger capacity than any of the other developments on the Catawba-Wateree system, and was built during a different period—the post-World War II, modern era—which places it in a different context. At that point in time, Duke Power was looking to fossil fuel-powered steam plants, pumped-storage facilities, and nuclear power to meet the electricity needs of the Carolina Piedmont; hydroelectric power generation accounted for only a small percentage of the company's total output.

Mountain Island Development

Description. Mountain Island Lake features one dam, a powerhouse, and associated buildings and structures (Figures 4.80–4.94). The reservoir was constructed between 1922 and 1924. The concrete gravity Mountain Island Dam with its ungated spillway was completed in 1923 (Duke Energy Corporation 2003:3:32, 35). According to its date plaque, Mountain Island Powerhouse, located at the west end of the dam, was erected in 1923. The development is located in Gaston and Mecklenburg counties.

The interior of Mountain Island Powerhouse features a tile floor, a tile base, plastered brick walls (over a steel structure), exposed steel framing, exposed concrete framing, and a concrete panel ceiling. The ceiling panels are reinforced with steel mesh and are held in place by steel beams running the length of the building. Seventeen steel trusses support the ceiling and the exterior built-up roof and span the generator floor as well as the full-width mezzanine along the north side. Window openings at the east, south, and west sides contain large, 128-light steel sash units at the main level (in four groups of 32 lights) and smaller, 24-light steel sash units at the clerestory level (in two groups of 12 lights). Above the garage bays, the large sash units are eliminated; above the pedestrian doors, the large units are halved (64 lights). Each end of the building contains a garage bay, and the south side features five garage bays and two pedestrian doors that lead to the exterior concrete balcony holding the transformers. Each garage bay, except for the one at the east end, displays a pair of railroad-type tracks embedded in the powerhouse floor, used to move heavy equipment into and out of the building. No window openings are located in the north side of the powerhouse, due to the fact that the intake/dam structure directly abuts the building on that side. On each side of the generator floor, 17 piers support the steel rails of the 100-ton overhead crane (manufacturer: Niles Crane). The operator's basket is suspended from the crane structure. On the south side, the piers are plastered and display molded caps. Each end of the building features a center pier of the same design. On the north side, exposed steel girders rise from concrete piers to support the crane rail, and then smaller girders rise to support the roof trusses.

The powerhouse control room is located in the center of the building at the mezzanine level. It extends out from the mezzanine on a concrete-framed base. The room has been updated with later finishes and contains modern control equipment and desk space. To the west of the control room, also on the mezzanine, are an office and restroom. A kitchen and break room lie at the far west end of the mezzanine. The north side of the mezzanine is characterized by a high concrete wall with regularly spaced buttresses. The wall serves as the inner face of the intake/dam structure, and the buttresses provide stability as well as support the powerhouse roof trusses.

The powerhouse contains four alternating current (AC) generators, manufactured by the Allis-Chalmers Manufacturing Company of Milwaukee, Wisconsin. Unit No. 1 is located at the west end of the generator floor, and Unit 4 is located at the east end, with Units 2 and 3 between. Each generator was built to generate 6,600 volts of electricity at 112.5 rpm. Units 1, 3, and 4 contain original equipment, although Unit 3 was in the process of being disassembled for rewinding and refurbishment at the time the present survey was conducted. [Note: Work on Unit 3 was completed in 2004.] In 2003, stator coils manufactured by Voith Siemens of Toronto, Canada, were installed in Unit 2. Each generating unit features an adjacent governor that regulates the flow of water through the turbine (located below the basement level) to maintain uniform speed and keep the system operating in correct frequency. Units 1 and 4 have original governors manufactured by the Woodward Governor Company of Rockford, Illinois; Units 2 and 3 have modern replacement governors. The four generating units are connected to 22,700-hp turbines working under a rated gross head of 83 feet. The turbines were manufactured by the S. Morgan Smith Company of York, Pennsylvania.

The basement level has a concrete floor and walls, and the ceiling structure (supporting the generator floor above) is constructed of reinforced concrete supported by concrete piers. Twenty-five 9-light steel awning sash windows are located along the south side of the level. A frame storage and locker room with an adjacent steel oil tank that is no longer in use are located in the southwest corner. Below each generator is a five-sided, tapered, several-foot-thick, reinforced concrete base with curved interior walls housing the generator shaft and bearing and the wheel pit area associated with the turbine (positioned below the basement level). The interiors of the bases feature several arched entries or openings. The powerhouse battery room, typically found in the basement, is located in the northeast corner of the main generator floor.

The exterior of Mountain Island Powerhouse features a concrete base, common bond brick walls (over a structural steel framework), and concrete sills and lintels at the openings. Each lintel features a molded concrete keystone at its center. Brick pilasters divide the window bays, and raised brick panels with concrete inserts separate the lower windows from the clerestory windows. A molded concrete cornice highlights the parapet roof. The south side of the building features a cantilevered concrete ledge holding four large transformers. The transformer for Unit 1 is a replacement unit, while those for Units 2–4 are the original General Electric Company units. The rooftop of the powerhouse contains a small brick penthouse, which serves as the access point to the roof, intake area, abutments, and spillway. A metal stair begins near the control room on the mezzanine level and continues up several flights to the penthouse. Historically, the rooftop featured a large substation, but it was removed sometime in the 1980s. The penthouse features brick pilasters and concrete lintels and sills at the steel sash windows.

In addition to the powerhouse, the Mountain Island Development includes a one-story, brick warehouse building, likely built in 1923. It is located southwest of the powerhouse on the north side of the entry drive. Three sets of double metal doors with 12 lights each and one single metal door with four lights provide access to the building, and steel industrial sash windows of 36 lights are located on all sides of the building. The building features brick pilasters, a corbelled brick cornice, and concrete lintels and sills. The interior contains three unfinished storage rooms.

Off the west end of the warehouse is a one-story, open shed with steel supports and a metal roof. Its date of construction is unknown. To the east of the warehouse is a historic metal transmission tower, once connected to the powerhouse's rooftop substation. At present it carries no transmission wires.

Northeast of the powerhouse is a steel-framed substation with transformers and control boxes. Three metal light standards with modern lamps are situated in a row along the substation's south side. North of the substation on the east abutment is a large, open, concrete base that once held a steel transmission tower. The substation and lights are outside the FERC project boundary.

The concrete gravity Mountain Island Dam with its ungated spillway is 2,375 feet long and 140 feet high. There is no separate intake structure for the powerhouse; the intake and powerhouse were built as a unit and serve as part of the dam impounding Mountain Island Lake. The west embankment was built according to the semi-hydraulic fill method (Duke Energy Corporation 2003:3:32). As part of the FERC-mandated modifications due to revised federal regulations, a concrete floodwall was added on top of the east abutment, and concrete matting was installed at the base of the east abutment north of the substation. In addition, the intake platforms and the tops of the east and west abutments were resurfaced with new concrete. In recent years, Duke Power constructed two concrete fishing piers along the west side of the tailrace.

NRHP Eligibility Assessment. The Mountain Island Development, completed in 1923, illustrates the typical construction and engineering methods utilized at hydroelectric plants in the second and third decades of the twentieth century. The earthen or earthfill dam type had been in use since the mid- to late nineteenth century, and the concrete gravity dam type had been utilized since the late nineteenth century (Hay 1991:xix; Jackson 1988). The hydraulic fill dam type, a more specialized form of earthen dam, had been in use since the late nineteenth century (Jackson 1988:258–259). Turbines had been around since the 1850s, and water-powered generators had been in use since 1880. The vertical arrangement of turbine and generator had been utilized since ca. 1905. In ca. 1912, the Kingsbury thrust bearing was added to the vertical turbine-generator unit. Three years later, it was in widespread use, and by 1920, almost every hydroelectric facility in the U.S. had adopted it (Hay 1991:3, 13, 71–72, 74). The Mountain Island Development, then, is neither the first nor the oldest surviving example of its type, and it was not groundbreaking in its construction technique or use of equipment. However, it retains distinctive characteristics of its historic type and method of construction, serving to illustrate hydroelectric power generation in the 1910s and 1920s. Moreover, because of the Mountain Island Development's role in the electrification of the region, it has had a great impact on the area and the region in which it is located in the areas of agriculture, architecture, commerce, conservation, engineering, industry, and social history.

Based on TRC's research, field survey, and analysis, then, and in accordance with 36 CFR 60.4, the Mountain Island Development is recommended eligible for the NRHP under criteria A and C. The dam, powerhouse, and supporting elements have undergone minimal alteration and still appear—for the most part—as they did when they were first constructed. As an important part of the region's electrification process, they continue to illustrate the historical associations for which they are significant (both to the region and to the South as a whole): the growth of the electric power business; the growth of industry and commerce; changes in employment and improved working conditions; changes in the home and an improved quality of life; changes in rural areas, especially on the farm; and conservation of natural resources. Although the development has been altered, the alterations have been minor and have consisted of installation of modern, computerized control equipment; FERC-mandated upgrades for flood control; and normal upgrades of generating and transmission equipment. Because the development continues to be used for its original purpose, and because the operators have maintained the equipment and the structures as they have through the years, the development retains its integrity of location, setting, feeling, and association, and its historic design, workmanship, and use of materials and, thus, remains a good, representative example of its type.

Research undertaken for this survey has not shown the Mountain Island Development to be associated with the lives of persons significant in the past (Criterion B) or likely to yield information important in prehistory or history (Criterion D).

Contributing elements at the Mountain Island Development include the dam and spillway, the powerhouse, the warehouse, the historic transmission tower, the substation, and the three light standards. The dam, although altered with the FERC-mandated floodwall and matting at the east abutment, is still considered contributing, as most of it remains intact. The new wall is of minimal height, and the matting is flush with the ground. The resurfacing of the intake platforms and the tops of the abutments is also a minimal visual change. The steel-framed open shed and the two modern fishing piers are the only non-contributing elements. The substation and light standards are located outside the FERC project boundary.

V. CONCLUSIONS AND RECOMMENDATIONS

During April and May of 2004, TRC, under contract to DTA, conducted an architectural survey and NRHP eligibility assessment of 11 hydroelectric developments on the Catawba and Wateree rivers in North and South Carolina. The work was undertaken for Duke Power as part of the relicensing effort for the Catawba-Wateree Hydroelectric Project (FERC No. 2232). This document has addressed the six developments in North Carolina: Bridgewater, Rhodhiss, Oxford, Lookout Shoals, Cowans Ford, and Mountain Island. The seven developments in South Carolina are addressed in a separate document.

The North Carolina developments have been surveyed previously (with the exception of Cowans Ford), but only Bridgewater and Lookout Shoals have had some or all of their components recommended significant and/or eligible for the NRHP. It is TRC's opinion that the Bridgewater, Rhodhiss, Oxford, Lookout Shoals, and Mountain Island developments are eligible for the NRHP under criteria A and C. The developments have been minimally altered and appear, for the most part, as they did when first built. Alterations have included installation of modern controls, changes made for safety reasons, FERC-mandated upgrades for flood control, and generating and transmission equipment upgrades. The developments also continue to illustrate the historical associations for which they are significant: the growth of the electric power business; the growth of industry and commerce; changes in employment and improved working conditions; changes in the home and an improved quality of life; changes in rural areas, especially on the farm; and conservation of natural resources. Because they are still used for their original purpose and have been well maintained over the years, the developments retain their integrity and remain good examples of their types.

It is TRC's opinion that the Cowans Ford development is ineligible for the NRHP due to its more recent age. Although it was the largest of the developments and the last to be constructed, thereby completing the build-out of the river begun in 1900, it does not meet NRHP Criteria Consideration G as an exceptionally significant resource. It followed a different design, had a much larger capacity than the other developments, and was built in the post-World War II, modern era—which places it in a different context.

Because most of the changes to the developments have been mandated by FERC for safety reasons or are day-to-day operational upgrades required for the efficient and profitable functioning of the facilities, it is suggested that Duke Power develop a Programmatic Agreement (PA) in consultation with the appropriate regulatory agencies to address these ongoing changes. As noted in 36 CFR 800.14(b)(1)(i), a PA is appropriate when the anticipated effects from an action or actions on historic resources "are similar and repetitive or are multi-State or regional in scope." This would certainly apply to the Catawba-Wateree developments, as the ongoing changes noted above are "similar and repetitive" and are implemented at all 11 of the developments in the two-state area. Having such a PA in place would greatly streamline the review process for most of the changes that occur on a regular basis, requiring only the most major of changes, such as partial or complete removal of buildings or structures, to undergo standard review under the Section 106 consultation process. It is also suggested that Duke Power reassess the eligibility of the Cowans Ford development after it becomes 50 years old.

REFERENCES CITED

Auburn University

2004 *Historical Timeline of Concrete.* Auburn University, College of Architecture, Design and Construction. Available online, http://www.auburn.edu/academic/architecture/bsc/classes/bsc314/timeline/timeline.htm. Accessed 13 September 2004.

Banham, Reyner

1986 *A Concrete Atlantis: U.S. Industrial Building and European Modern Architecture, 1900–1925.* The MIT Press, Cambridge, Massachusetts.

Brooks, R. P.

1929 The Industrialization of the South. *Bureau of Business Research, Study No. 1.* School of Commerce, University of Georgia, Athens.

Bureau of Reclamation

2003 *The History of Hydroelectric Development in the United States.* Bureau of Reclamation Hydropower Program. Available online, http://www.usbr.gov/power/edu/history.htm. Accessed 6 April 2004.

Carr, Charles C.

1952 *Alcoa: An American Enterprise.* Rinehart & Company, Inc., New York.

Cobb, James C.

1993 The Sunbelt South: Industrialization in Regional, National, and International Perspective. In *Searching for the Sunbelt: Historical Perspectives on a Region,* edited by Raymond A. Mohl, pp. 25–46. University of Georgia Press, Athens.

Cocke, Norman A.

1963 Oral History Interview, April 15. On file, Duke Power Archives, Charlotte, North Carolina.

Devine, Warren D., Jr.

1983 From Shafts to Wires: Historical Perspectives on Electrification. *Journal of Economic History.* 43(2):347–372.

DuBoff, Richard B.

1967 The Introduction of Electric Power in American Manufacturing. *Economic History Review, New Series.* 20(3):509–518.

Duke Energy Corporation

2003 *Catawba Wateree Project (FERC # 2232) First Stage Consultation Document.* Available online, http://www.catawbahydrolicensing.com/documents/fscd.html. Accessed 30 March 2004.

Duke Power Archives
1924 "Catawba R. D. 9-3-24." View of Dam and Powerhouse at Old Catawba Station. Photograph #P8x10.3442. On file, Duke Power Archives, Charlotte, North Carolina.

1927a Aerial View of Bridgewater Station. Photograph #38-1-1.3569, Box #64. On file, Duke Power Archives, Charlotte, North Carolina.

1927b Letter to the Commissioner of Internal Revenue, Washington, D.C. 17 February. On file, Duke Power Archives, Charlotte, North Carolina.

Duke Power Company
n.d. Utility Corporations, No. 76. On file, Duke Power Company Archives, Franklin, North Carolina.

1927 *Piedmont Carolinas: Where Wealth Awaits You.* Duke Power Company, Charlotte, North Carolina.

1935 Utility Corporations, No. 78: Commonwealth & Southern Corporation and Southern Public Utilities Company. On file, Duke Power Archives, Charlotte, North Carolina.

1959 Report & Recommendations Relative to the Cowans Ford Project. On file, Duke Power Archives, Charlotte, North Carolina.

1963 Cowans Ford-Lake Norman Fact Sheet. On file, Duke Power Archives, Charlotte, North Carolina.

1971 *Data Manual: A Compilation of Recorded Data Relating to the Utility System and Its Operation.* On file, Duke Power Archives, Charlotte, North Carolina.

1975 *Data Manual: A Compilation of Recorded Data Relating to the Utility System and Its Operation.* On file, Duke Power Archives, Charlotte, North Carolina.

2004 Duke Power History Timeline. Available online, http://www.dukepower.com/aboutus/company/history/timeline/. Accessed 13 April 2004.

Durden, Robert F.
2001 *Electrifying the Piedmont Carolinas: The Duke Power Company, 1904–1997.* Carolina Academic Press, Durham, North Carolina.

Federal Power Commission
1958 Order Issuing License (Major). On file, Key #111722, Duke Power Archives, Charlotte, North Carolina.

Gleasner, Bill, and Diana Gleasner
ca. 1986 *Lake Norman: Our Inland Sea.* Peninsula Press, n.p.

Hay, Duncan

1991 *Hydroelectric Development in the United States, 1880–1940*. 2 vols. Edison Electric Institute, Washington, D.C.

Jackson, Donald C.

1988 *Great American Bridges and Dams*. The Preservation Press, Washington, D.C.

Karfunkle, J. B., John S. Lupold, and Barbara A. Kimmelman

1977 North Highlands Hydroelectric Power Development, Bibb City, Georgia. Historic American Engineering Record (HAER) Written Historical and Descriptive Data. HAER No. GA-26. Available online, http://memory.loc.gov/ammem/hhquery.html (type "North Highlands Hydroelectric" in Search bar, click "Match all of these words," and hit Search button). Accessed 8 October 2004.

Lee, Arthur Carl

1934 State of South Carolina, County of Richland: Before the Railroad Commission: In Re: Rates for Electric Light and Power Consumers Served in South Carolina by Duke Power Company and Southern Utilities Company, Charlotte, N.C.: Order No. E-24: Affidavits on Behalf of Respondents, Duke Power Company and Southern Public Utilities Company, Filed January 15, 1934. Affidavit of A. C. Lee, Vol. II. On file, Duke Power Archives, Charlotte, North Carolina.

Lee, William S.

1987 *Duke Power Company, The Roots that Nourish the Future*. Publication No. 1279. Newcomen Society of the United States/Princeton University Press, Princeton, New Jersey.

Lee, W. S., and Richard Pfaehler

1920 The Southern Company's Largest Station. *Electrical World* 8 May:1072–1075. On file, Duke Power Archives, Charlotte, North Carolina.

Lynch, Larry, and John Russell (editors)

1996 *Where the Wild Rice Grows: A Sesquicentennial Portrait of Menomonie, 1846–1996*. Menomonie Sesquicentennial Committee, Menomonie, Wisconsin.

Maynor, Joe

1980 *Duke Power: The First Seventy-Five Years*. Delmar, Albany, New York.

McRae, Barbara

1992 The Development of the Thorpe Project. Remarks for Sylva Speech Group, November 23.

Nabow, David

1934 State of South Carolina, County of Richland: Before the Railroad Commission: In Re: Rates for Electric Light and Power Consumers Served in South Carolina by Duke Power Company and Southern Utilities Company, Charlotte, N.C.: Order No. E-24: Affidavits on Behalf of Respondents, Duke Power Company and Southern Public Utilities

Company, Filed January 15, 1934. Affidavit of David Nabow, pp. 1–3, Vol. II. On file, Duke Power Archives, Charlotte, North Carolina.

1956 *Duke Power Company: Preliminary Report on Cowan's Ford Project*. On file, Duke Power Archives, Charlotte, North Carolina.

Nantahala Power & Light Company (NP&L)

1999 NP&L History. Published online, http://www.natahalapower.com/history.html. (Note: This link no longer accesses the NP&L History. An operable replacement link has not yet been posted.)

National Planning Association

1949 *New Industry Comes to the South: A Summary of the Report of the NPA Committee of the South*. National Planning Association, n.p.

North Carolina Department of Cultural Resources (NCDCR)

1974 Badin Multiple Resource Nomination, Statement of Significance. *National Register of Historic Places Inventory-Nomination Form*. North Carolina Department of Cultural Resources, Division of Archives and History, Raleigh, North Carolina.

Nye, David E.

1990 *Electrifying America: Social Meanings of a New Technology, 1880–1940*. The MIT Press, Cambridge, Massachusetts.

Raber, Michael S., Gerald Weinstein, and William F. Johnson

1993 Trenton Falls Hydroelectric Station, Dam and Headworks, Trenton Falls, New York. Historic American Engineering Record (HAER) Written Historical and Descriptive Data. HAER No. NY-155-B. Available online, http://memory.loc.gov/ammem/hhquery.html (type "Trenton Falls Hydroelectric Station, Dam" in Search bar, click "Match all of these words," and hit Search button). Accessed 8 October 2004.

Riley, Jack

1958 *Carolina Power & Light Company*. Jack Riley, Raleigh, North Carolina.

Sampson, F. D.

1936 Development at Charlotte. In *Fifty Years of Electrical Progress*. Ms. on file, Key #111930, Duke Power Archives, Charlotte, North Carolina.

Saville, Thorndike

1922 *The Power Situation in North Carolina*. Circular No. 2, North Carolina Geological and Economic Survey, Water Resources Division, 32nd Report. North Carolina Department of Labor and Printing. [UNC Wilson Cp387 S26w1]

1924 *The Power Situation in North Carolina*. Circular No. 10, North Carolina Geological and Economic Survey, Water Resources Division, 32nd Report. North Carolina Department of Labor and Printing.

SCANA Corporation
2004 Company History. Available online, http://www.scana.com/SCANA/Investor+Relations/Company+Profile/Company+History.htm. Accessed 28 May 2004.

Smith, George David
1986 *From Monopoly to Competition: The Transformation of Alcoa, 1888–1986.* Cambridge University Press, New York.

Thomason, Philip
2003 *National Register of Historic Places Eligibility Study of Seven Hydroelectric Projects in the Nantahala Area, North Carolina.* Submitted to Duke Power, Charlotte, North Carolina, by Thomason and Associates, Nashville, Tennessee.

Thorpe, J. E. S.
1939 *History of Nantahala Power & Light.* N.p., n.p.

Tullos, Allen
1989 *Habits of Industry: White Culture and the Transformation of the Carolina Piedmont.* University of North Carolina Press, Chapel Hill.

Waddell, Charles
1932 *Report No. 158: Public Utility Rate Studies for North Carolina Corporation Commission.* Duke Power Archives Publications, Charlotte, North Carolina.

Wanzer, Charles T.
1934 State of South Carolina, County of Richland: Before the Railroad Commission: In Re: Rates for Electric Light and Power Consumers Served in South Carolina by Duke Power Company and Southern Utilities Company, Charlotte, N.C.: Order No. E-24: Affidavits on Behalf of Respondents, Duke Power Company and Southern Public Utilities Company, Filed January 15, 1934. Affidavit of C. T. Wanzer, pp. 1–3, Vol. I. On file, Duke Power Archives, Charlotte, North Carolina.

1956 Construction Periods of Company-Built Steam & Hydro Plants in Chronological Order as to Dates of Initial Construction. Ms. on file, Duke Power Archives, Charlotte, North Carolina.

Woolfe, Arthur G.
1982 Energy and Technology in American Manufacturing: 1900–1929. *Journal of Economic History* 42(1).

Wray, J. Q., Jr.
1961 The Cowan's Ford Project. A Paper Recommended by the AIEE Power Generation Committee and Approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Ithaca, New York, June 18–23, 1961.

APPENDIX 1: FIGURES

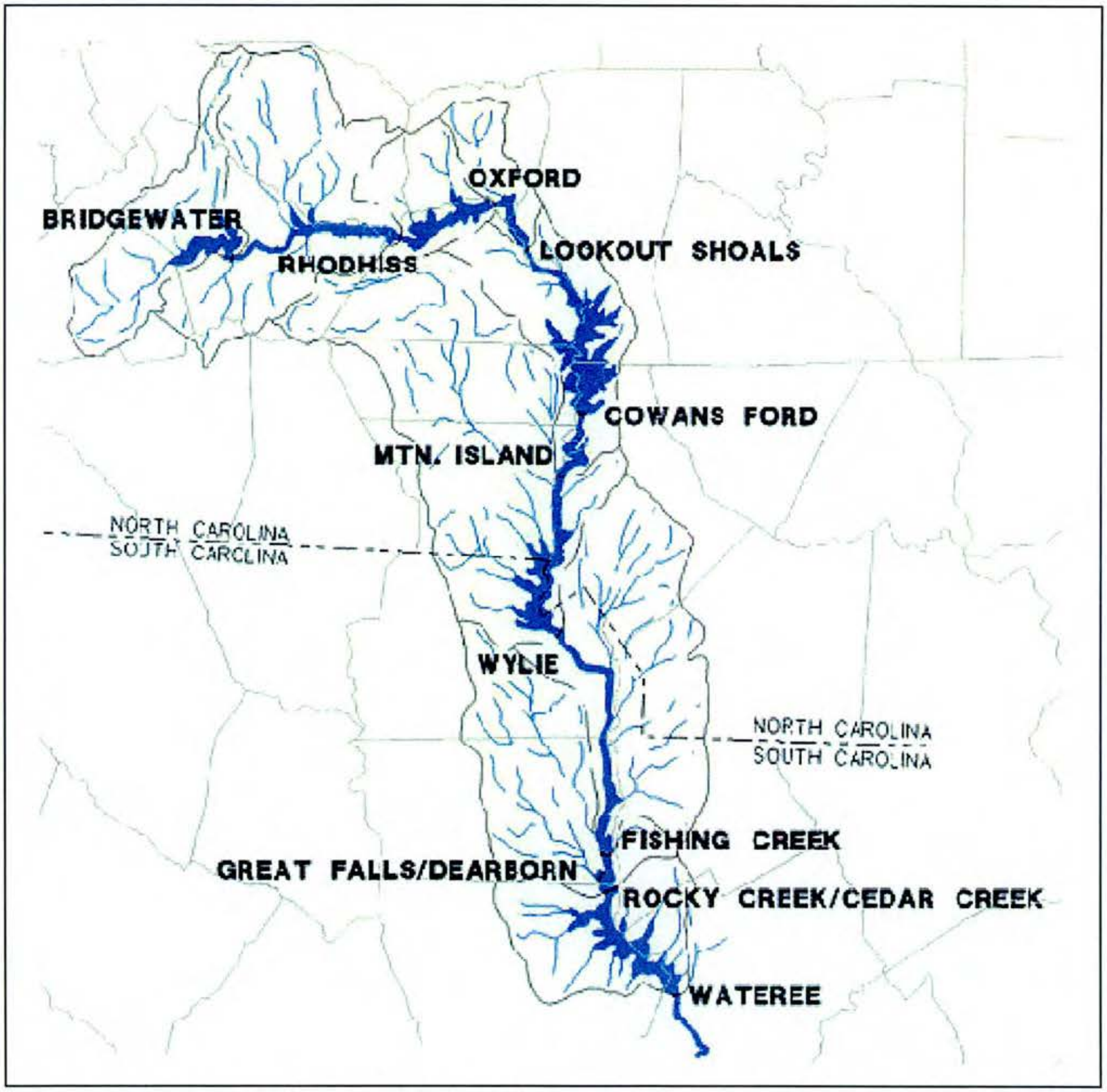

Figure 1.1. Map showing location of 11 hydroelectric developments along the Catawba River in North and South Carolina (Duke Power 2004).

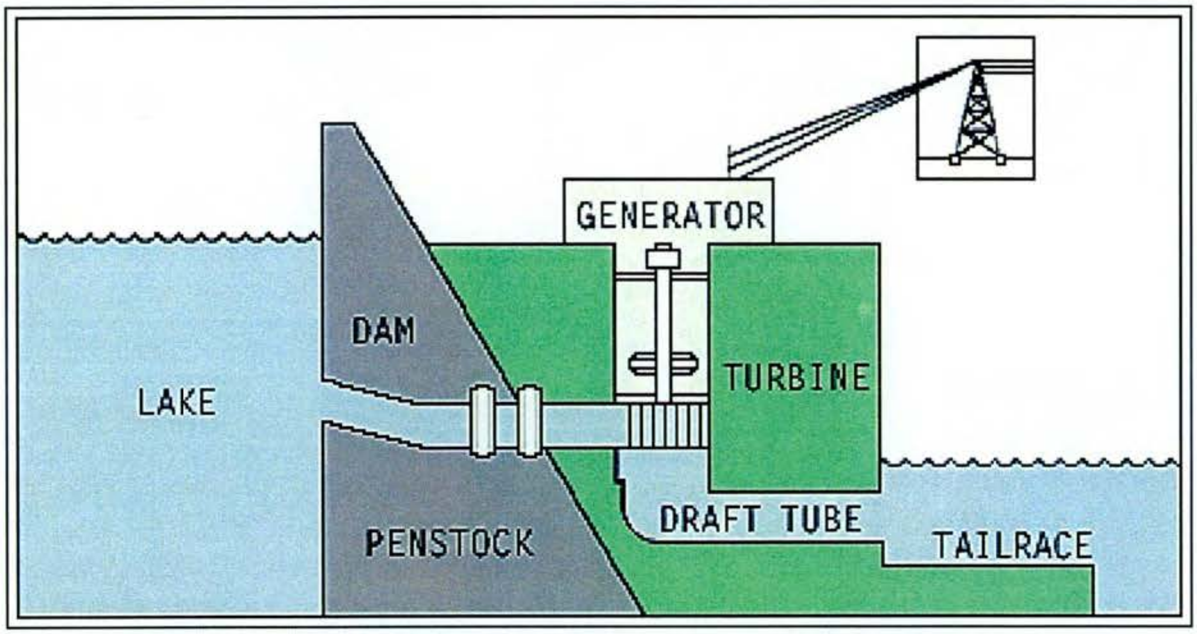

Figure 2.1. Diagram of a typical hydroelectric system (Duke Power 2004).

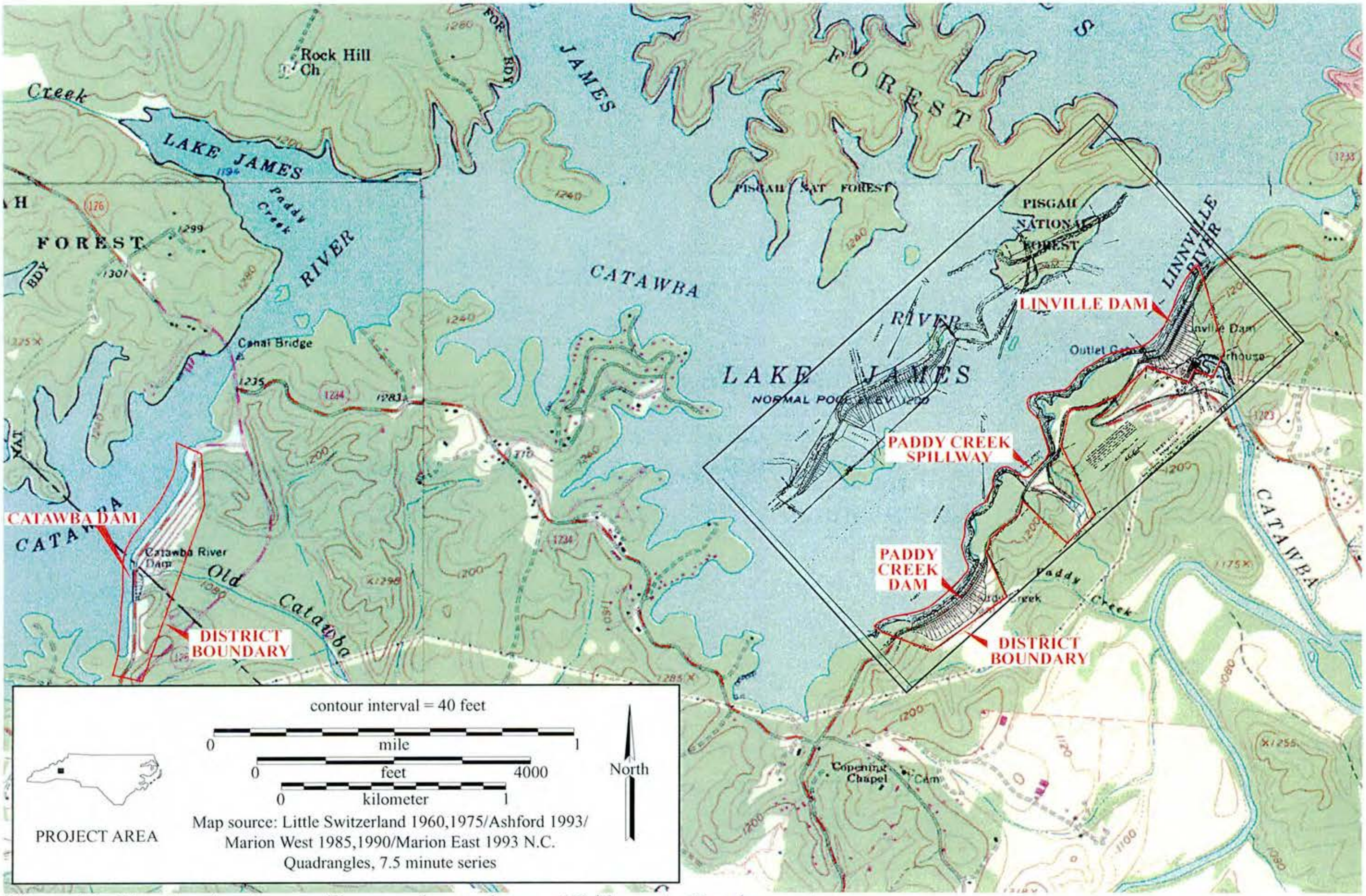

Figure 4.1. Map showing dams, spillway, and powerhouse at Bridgewater Development.

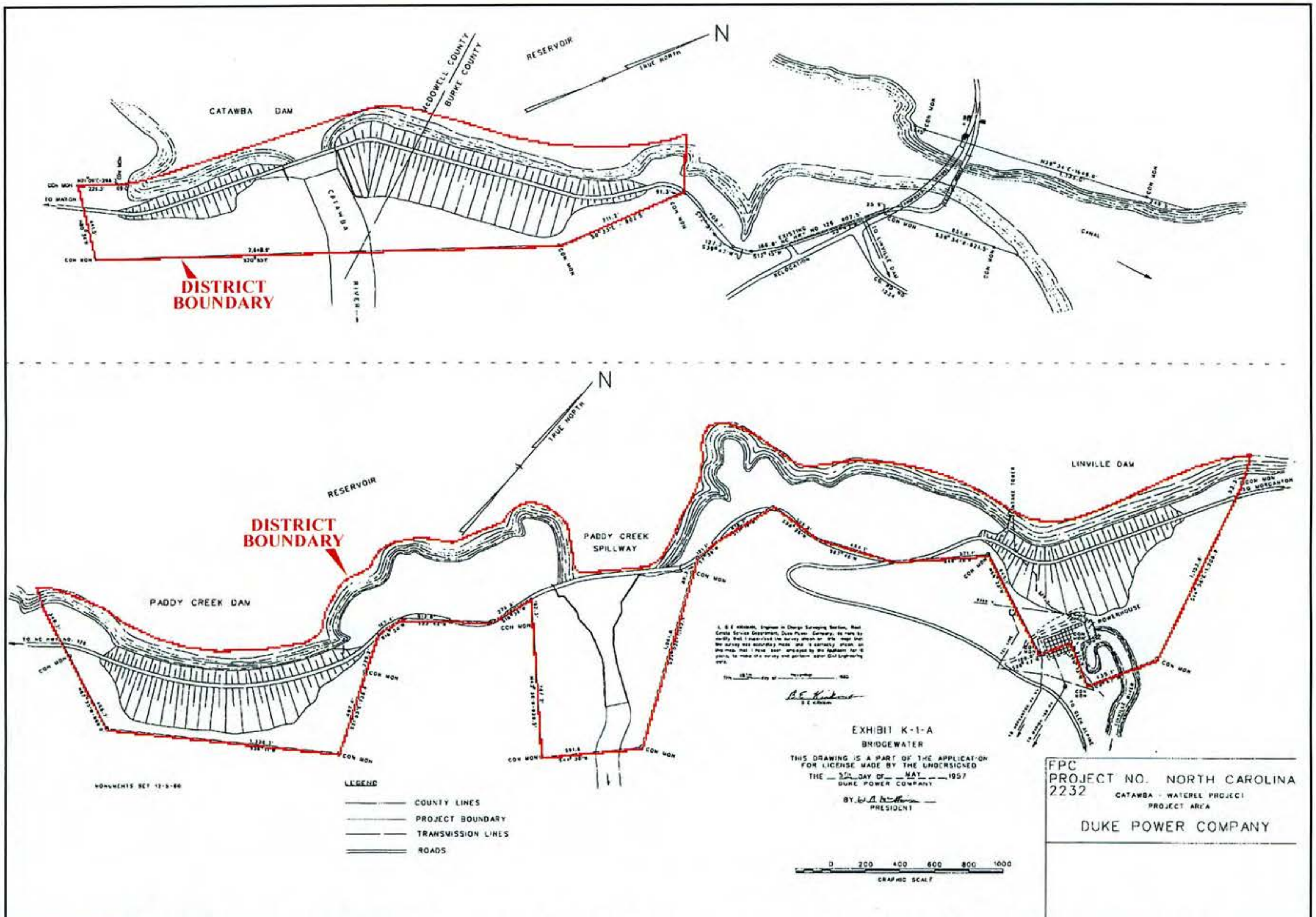

Figure 4.2. Site plan showing dams, spillway, and powerhouse at Bridgewater Development (Duke Energy Corporation 2003).

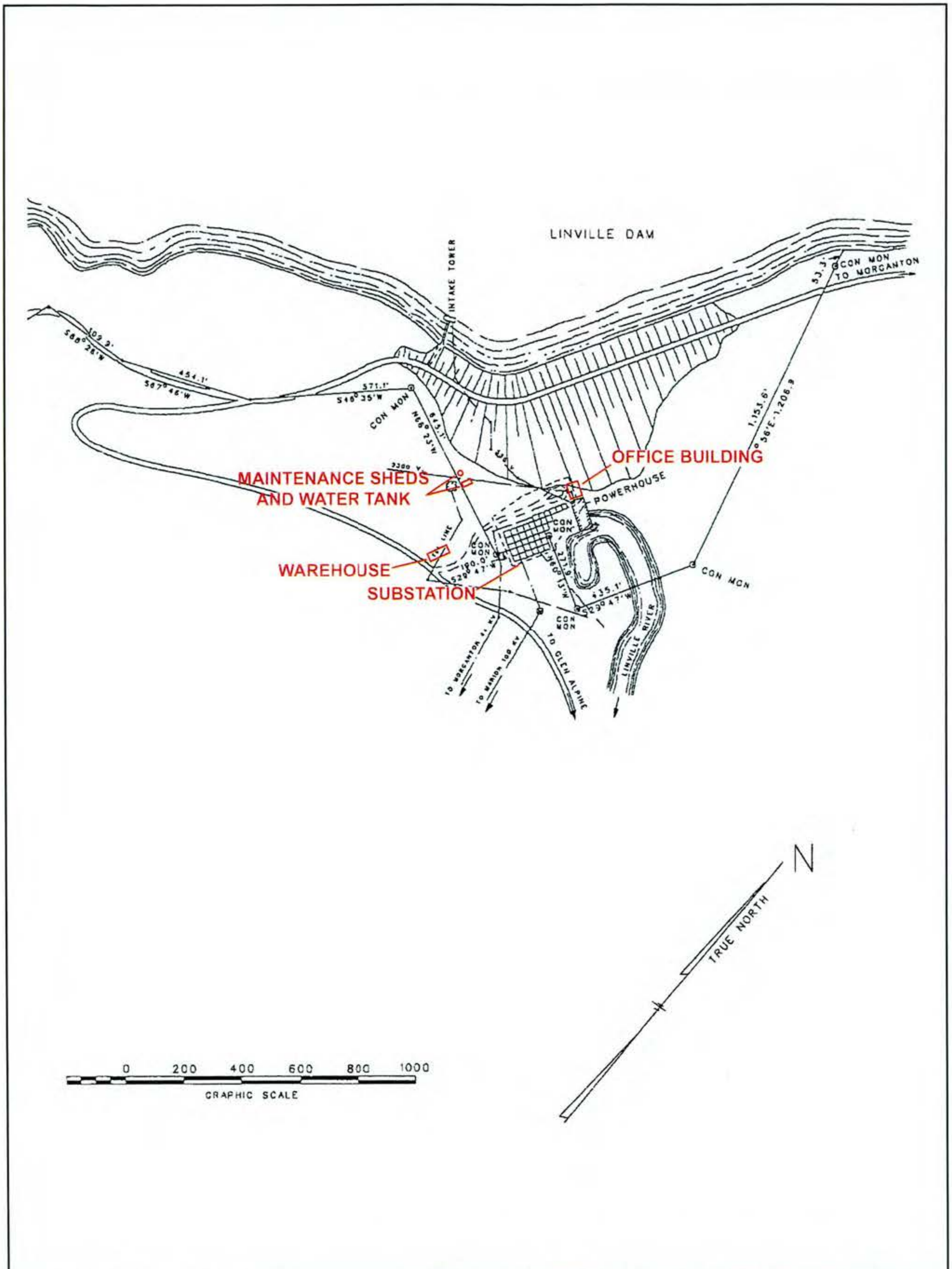

Figure 4.3. Site plan showing Linville Dam and Powerhouse at Bridgewater Development (Duke Energy Corporation 2003).

Figure 4.4. Bridgewater Development, Catawba Dam, east side; looking southwest.

Figure 4.5. Bridgewater Development, Catawba Dam, spillway; looking west-southwest.

Figure 4.6. Bridgewater Development, Paddy Creek Dam, west side; looking southwest.

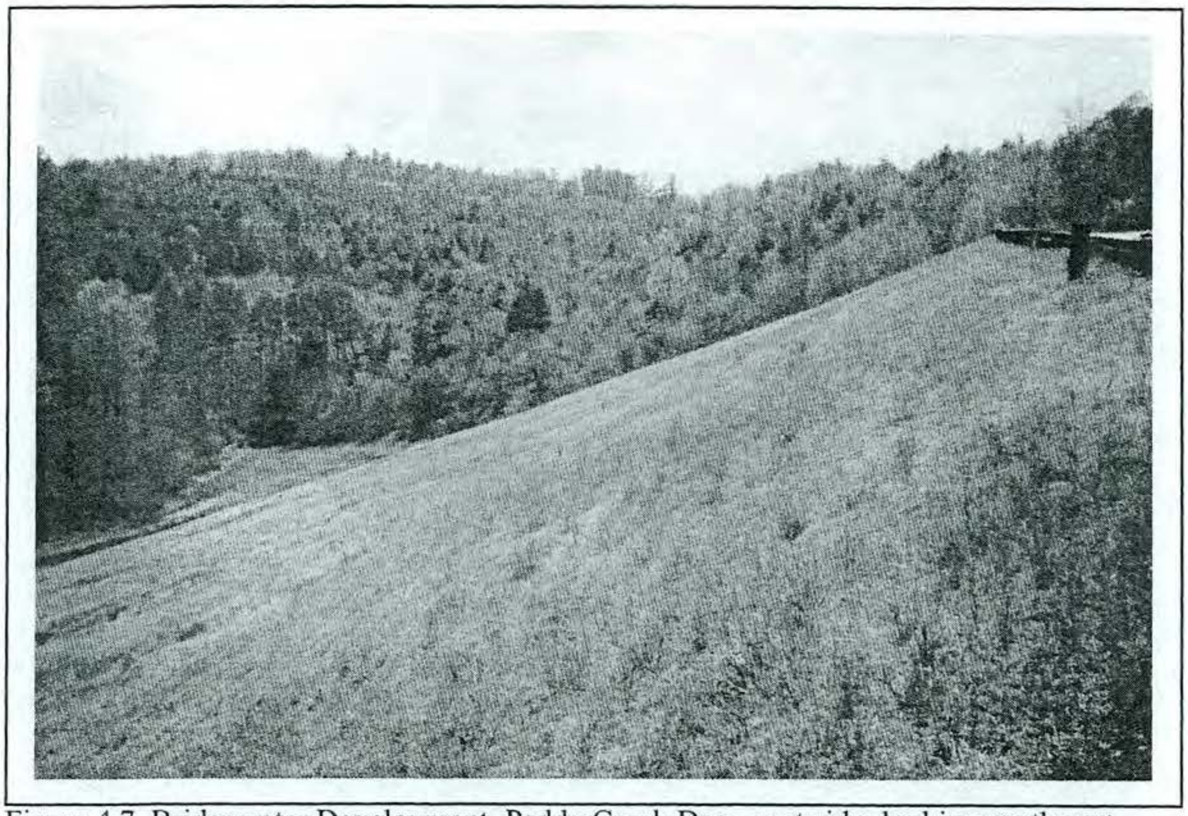

Figure 4.7. Bridgewater Development, Paddy Creek Dam, east side; looking southwest.

Figure 4.8. Bridgewater Development, Paddy Creek spillway; looking southeast.

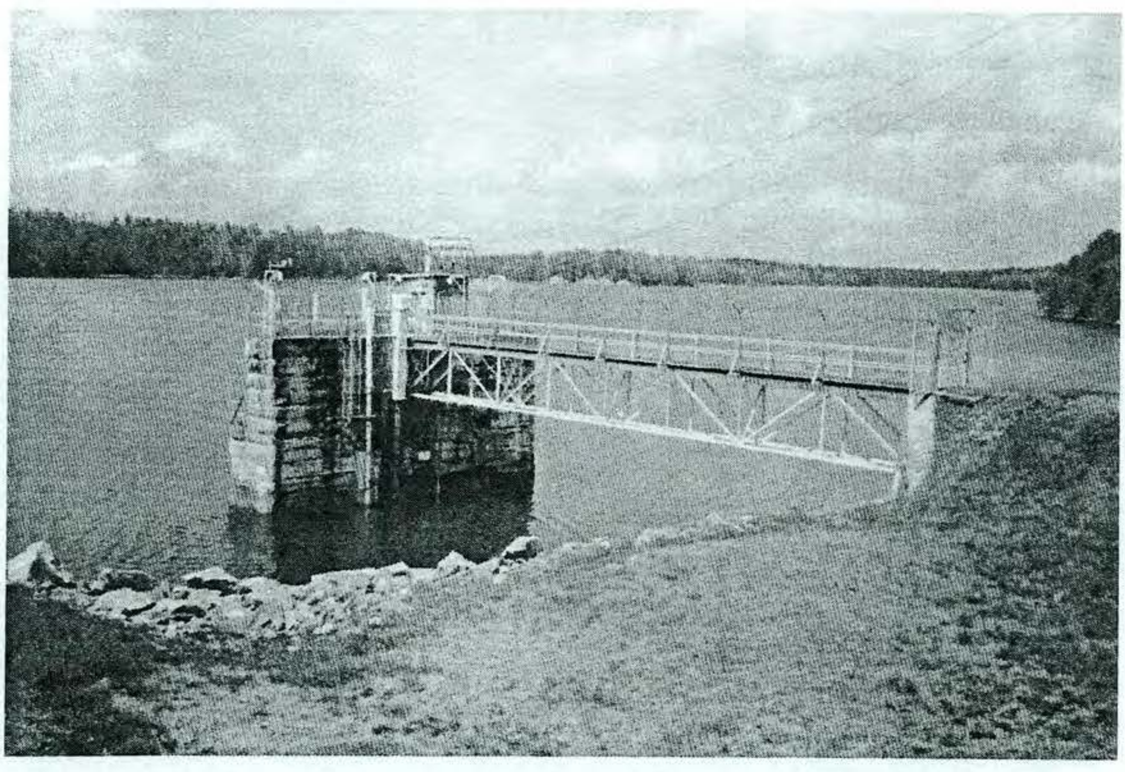

Figure 4.9. Bridgewater Development, intake at Linville Dam; looking north.

Figure 4.10. Bridgewater Development, Linville Dam, east side; looking northeast.

Figure 4.11. Bridgewater Development, Linville Powerhouse; view of office building, powerhouse (behind substation), and substation; looking northeast.

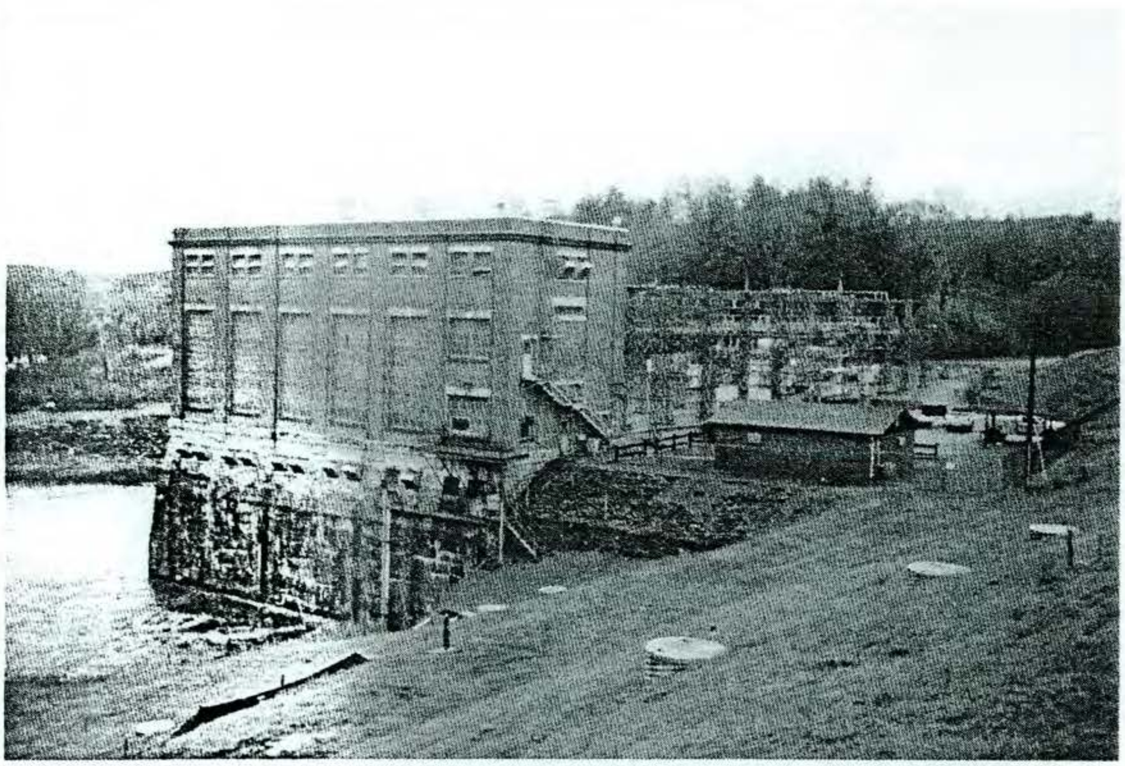

Figure 4.12. Bridgewater Development, Linville Powerhouse; view of powerhouse, substation, and office building; looking southwest.

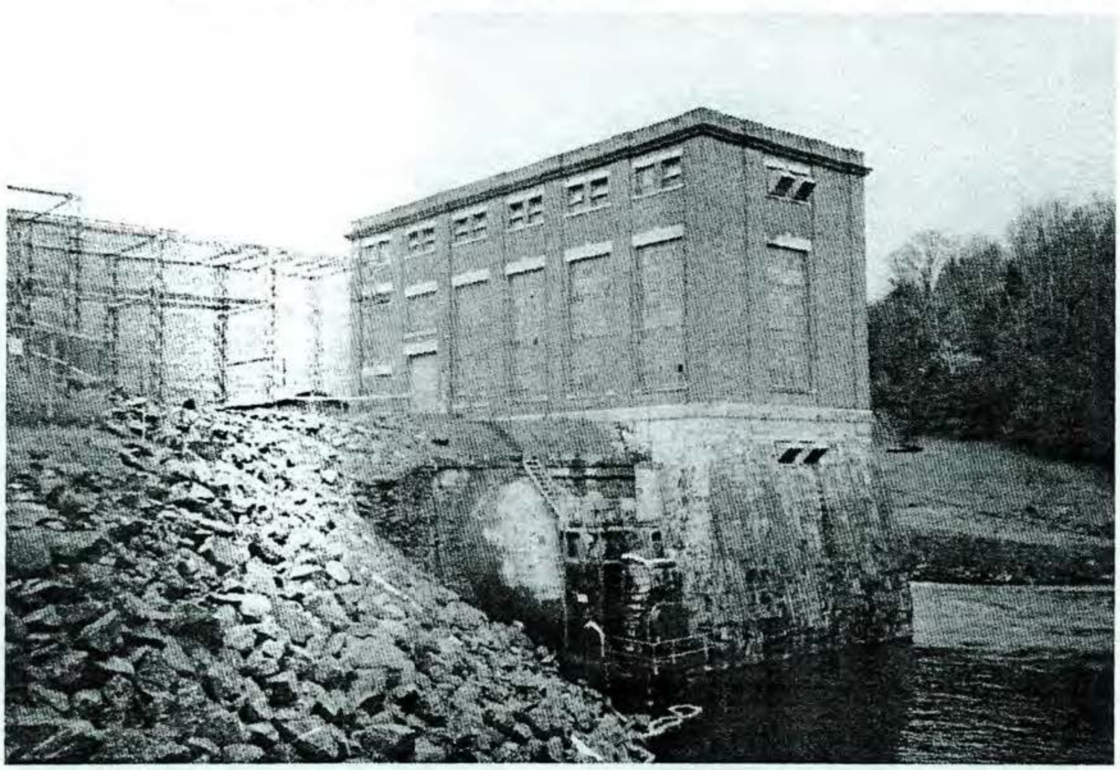

Figure 4.13. Bridgewater Development, Linville Powerhouse; view of substation and powerhouse; looking north.

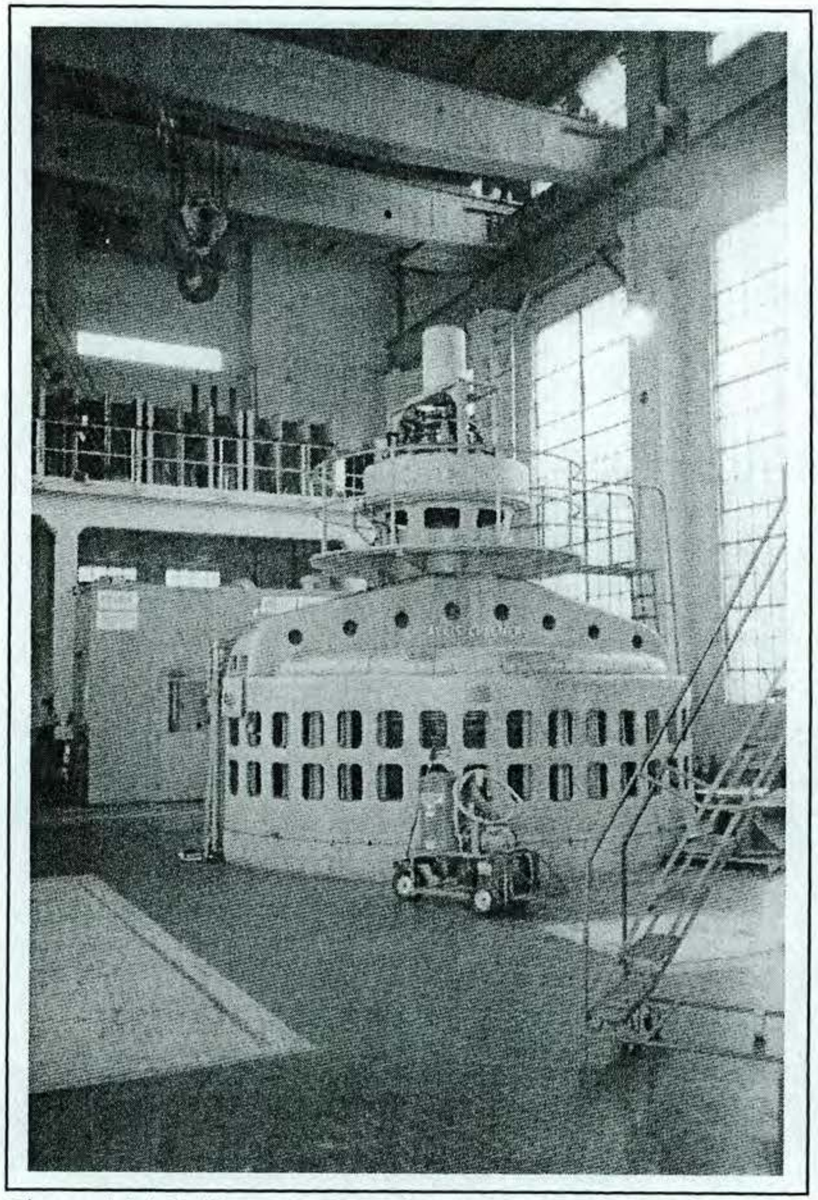

Figure 4.14. Bridgewater Development, Linville Powerhouse; view of generator floor, west end; looking northwest.

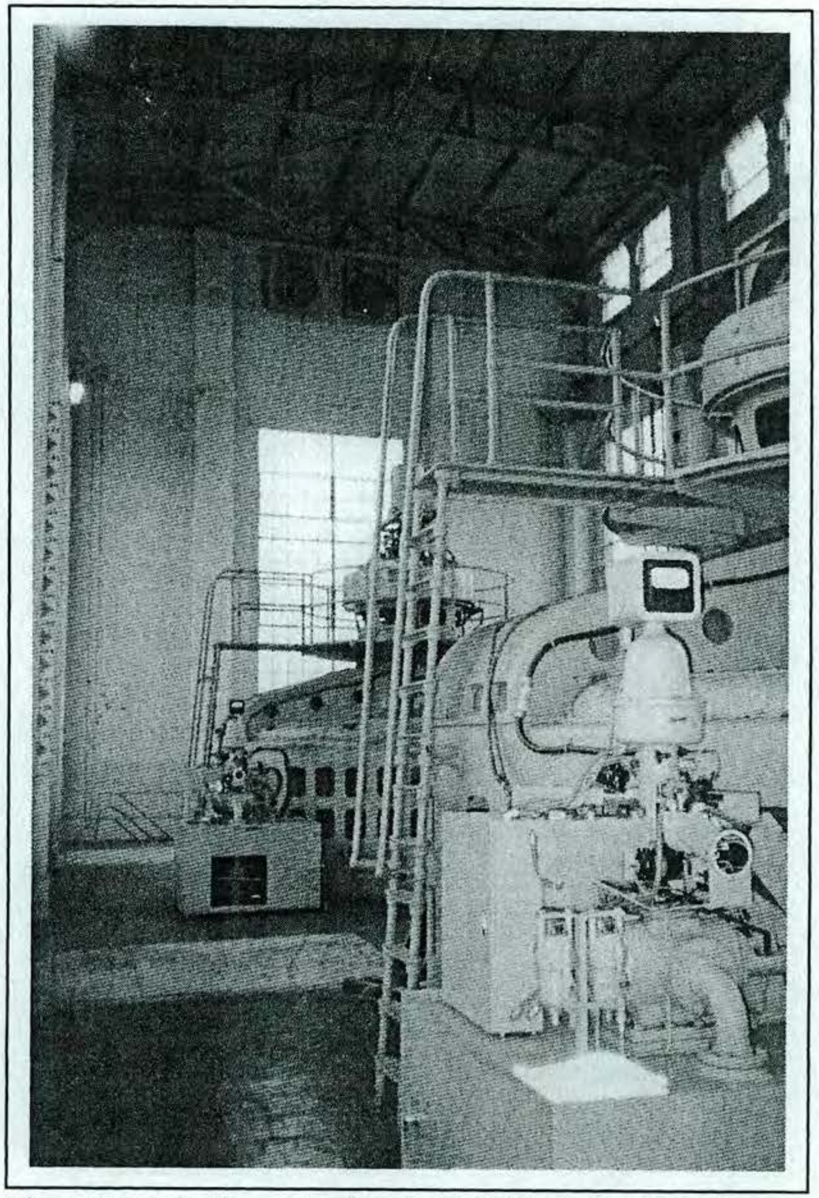

Figure 4.15. Bridgewater Development, Linville Powerhouse; view of generator floor; looking east-southeast.

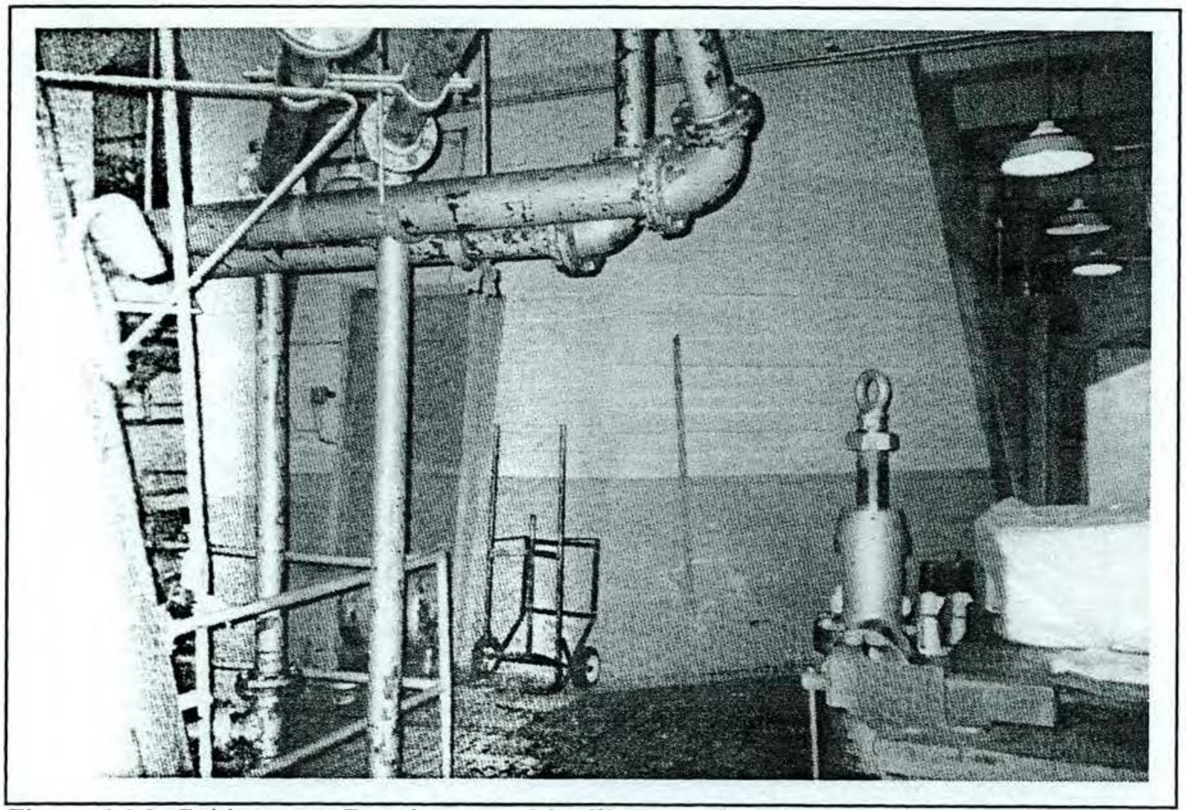

Figure 4.16. Bridgewater Development, Linville Powerhouse; view of basement; looking southwest at exterior of generator base.

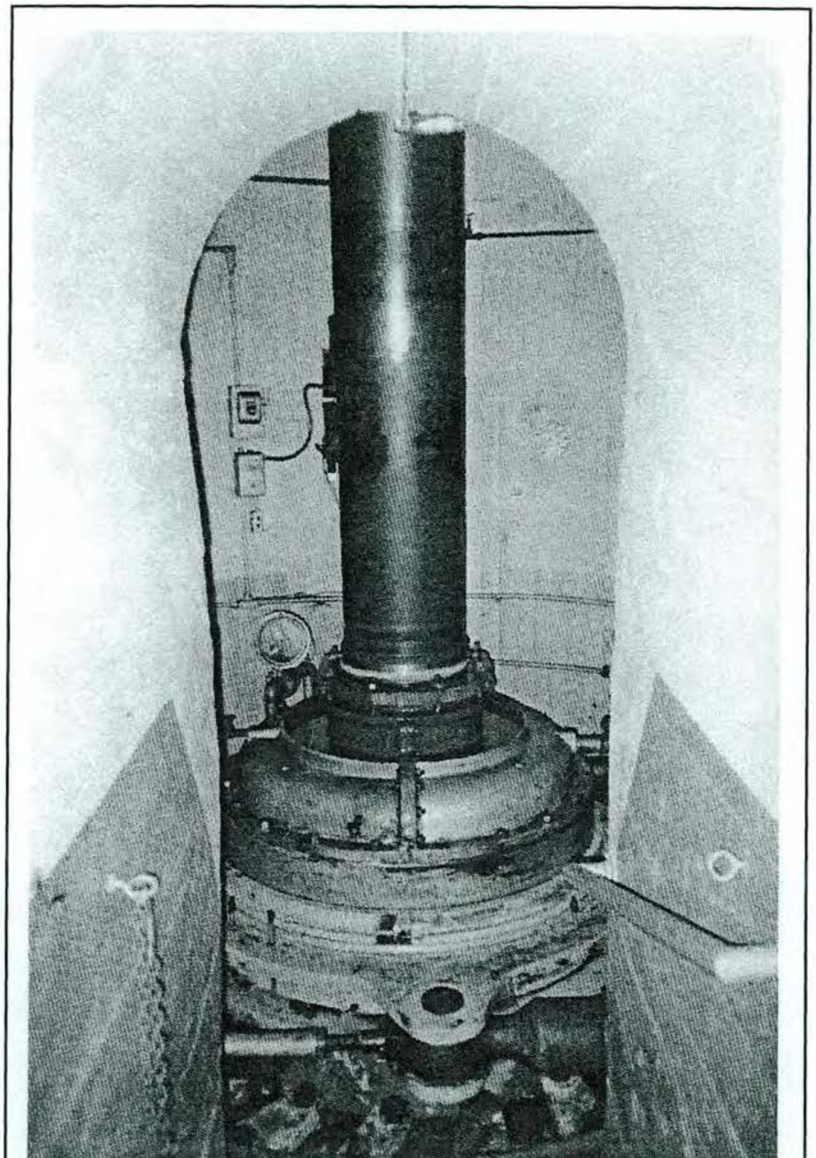

Figure 4.17. Bridgewater Development, Linville Powerhouse; view of interior of generator base; looking south at generator-turbine shaft and wheel pit area.

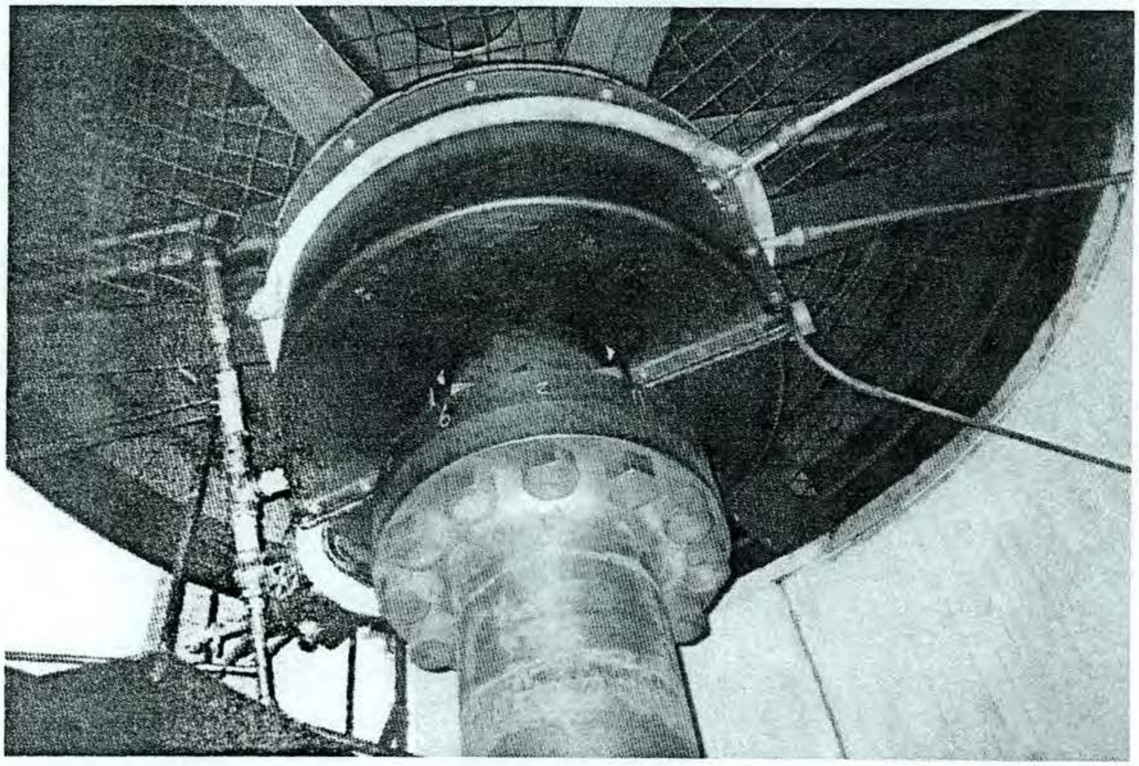

Figure 4.18. Bridgewater Development, Linville Powerhouse; view of interior of generator base; looking south at bottom of generator and rotor spider.

Figure 4.19. Bridgewater Development, Linville Powerhouse; view of warehouse; looking west.

Figure 4.20. Bridgewater Development, Linville Powerhouse; view of maintenance sheds and water tank; looking south.

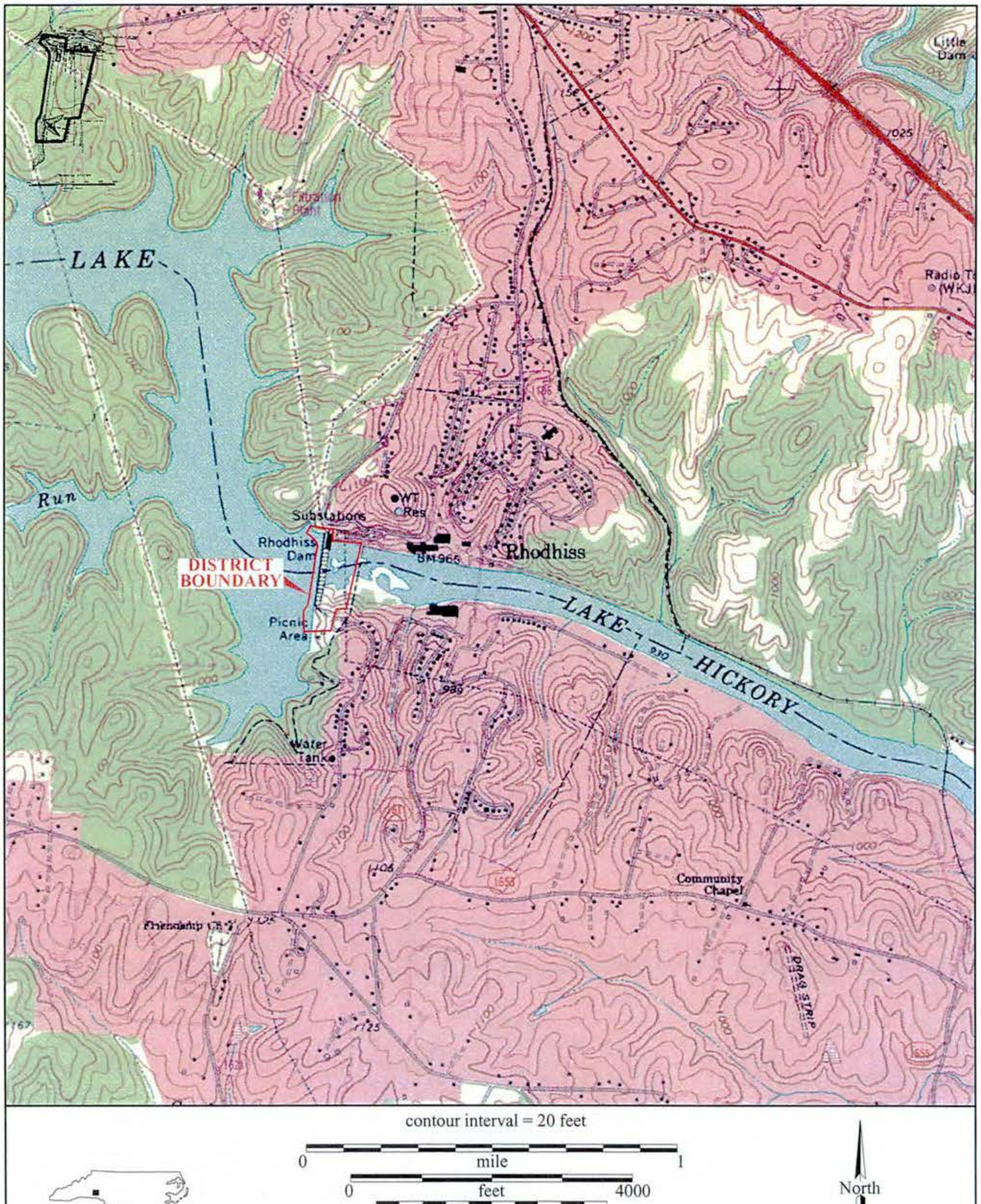

Figure 4.21. Map showing dam and powerhouse at Rhodhiss Development.

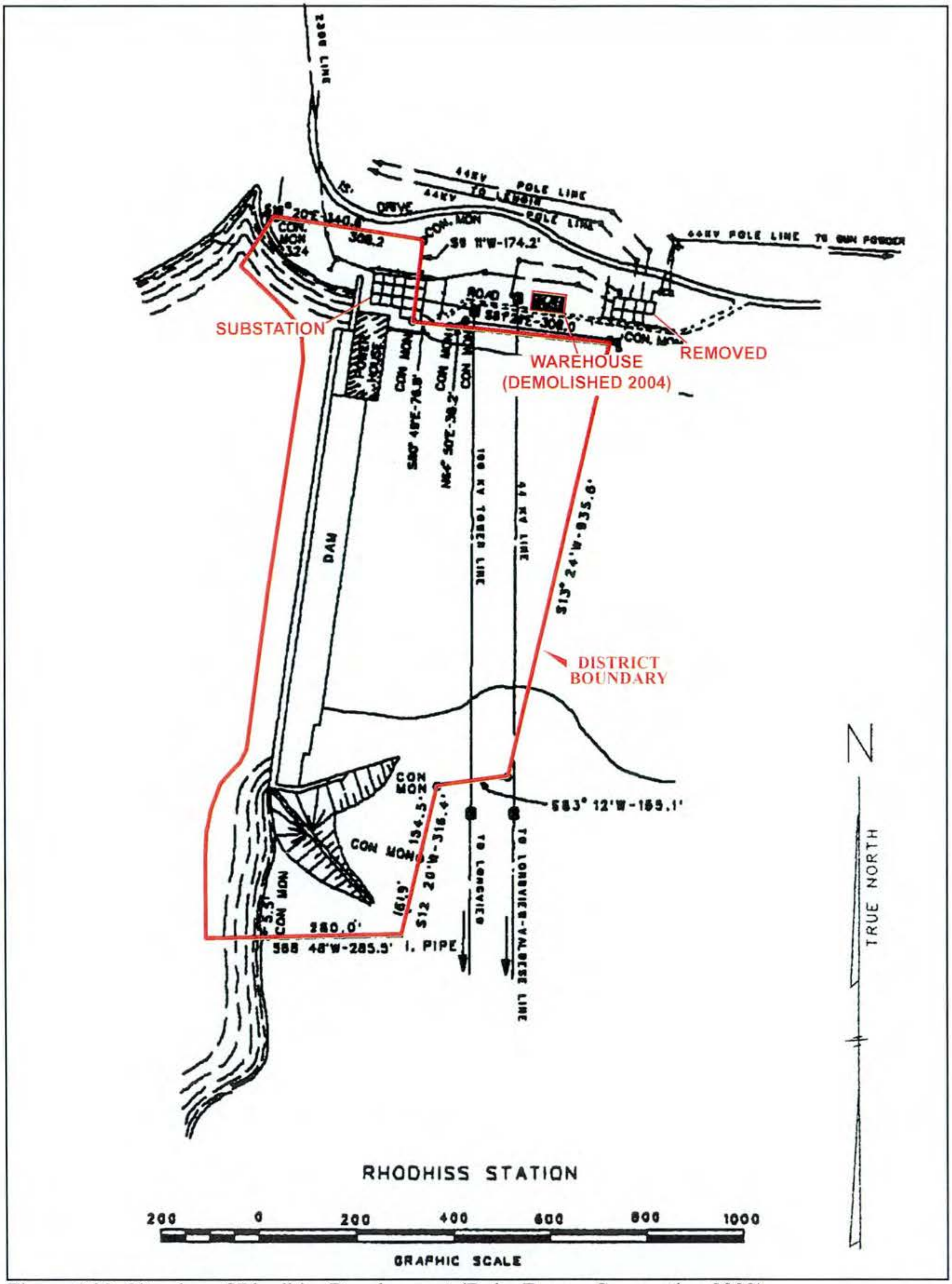

Figure 4.22. Site plan of Rhodhiss Development (Duke Energy Corporation 2003).

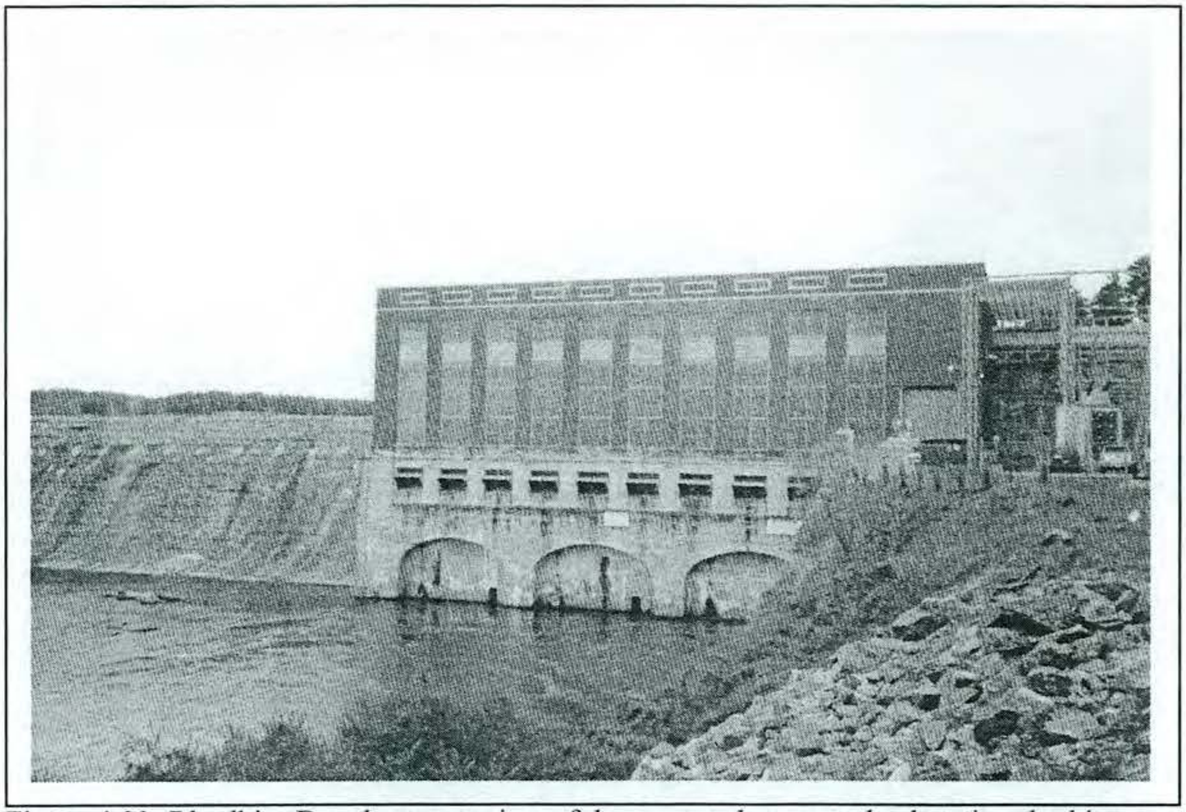

Figure 4.23. Rhodhiss Development; view of dam, powerhouse, and substation; looking west.

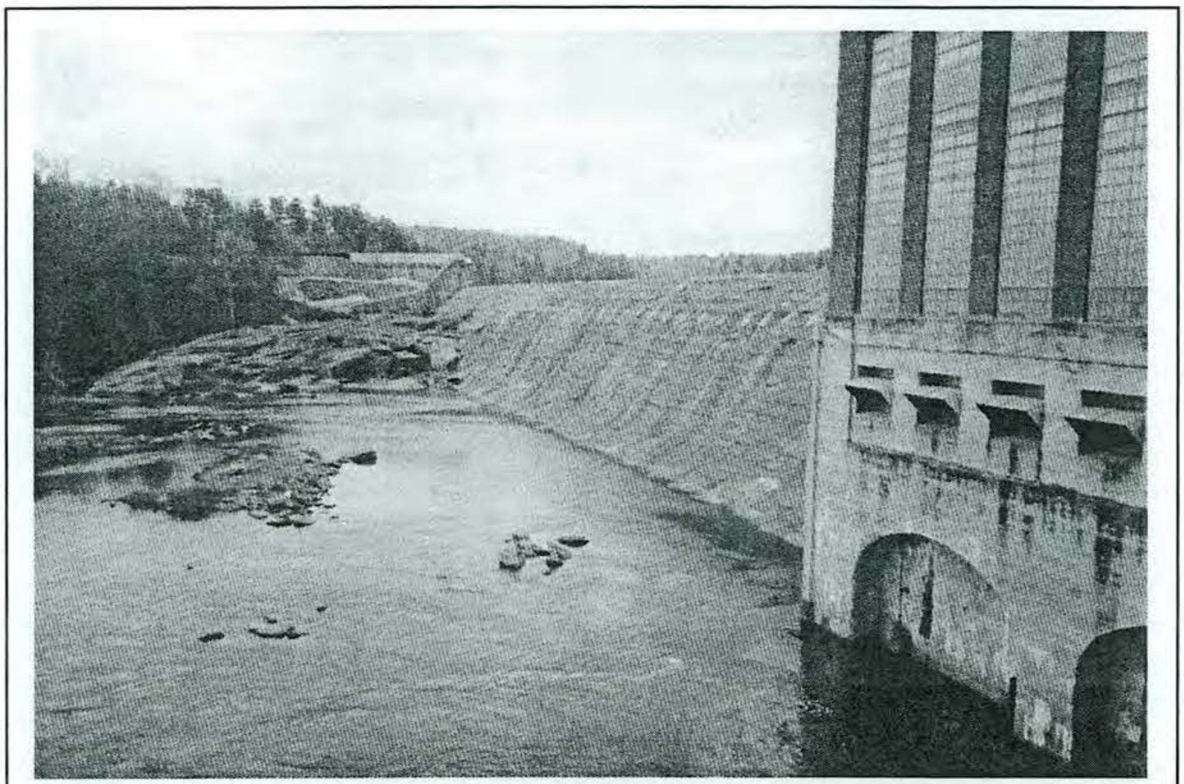

Figure 4.24. Rhodhiss Development; view of dam and powerhouse (floodwall improvements visible at south end of dam); looking southwest.

Figure 4.25. Rhodhiss Development; view of dam, powerhouse, substation, and warehouse; looking north.

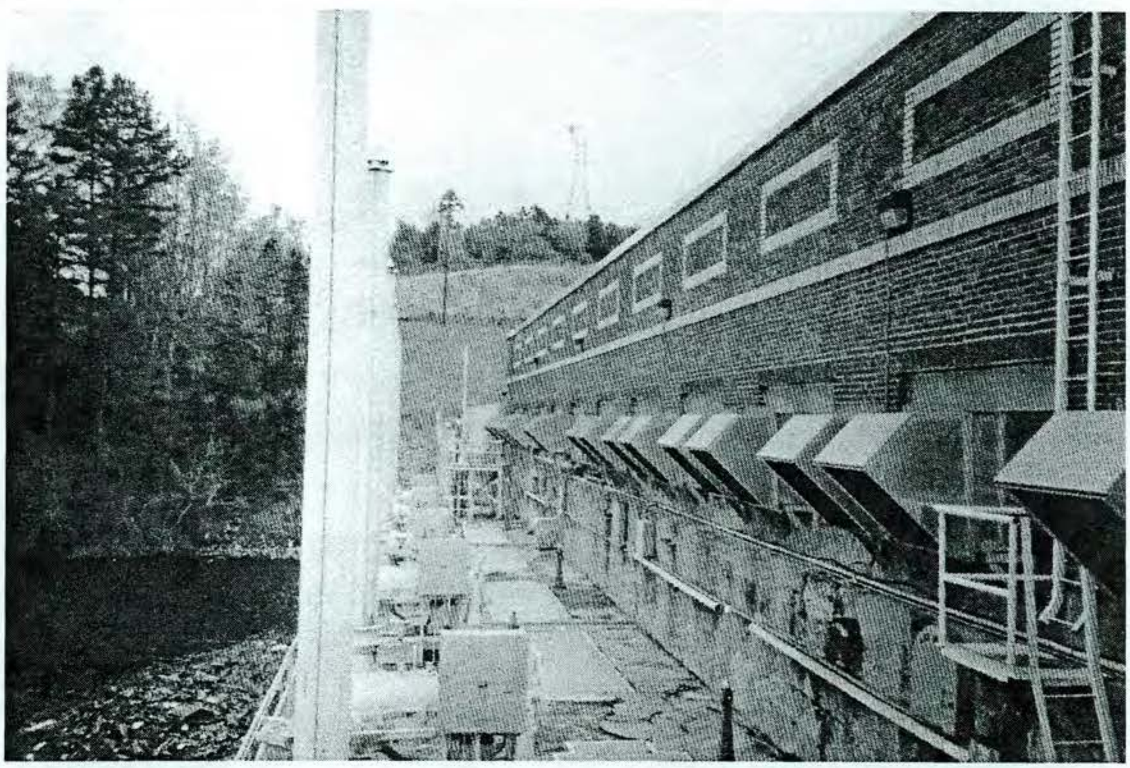

Figure 4.26. Rhodhiss Development, Rhodhiss Powerhouse; view of rear intake deck; looking north.

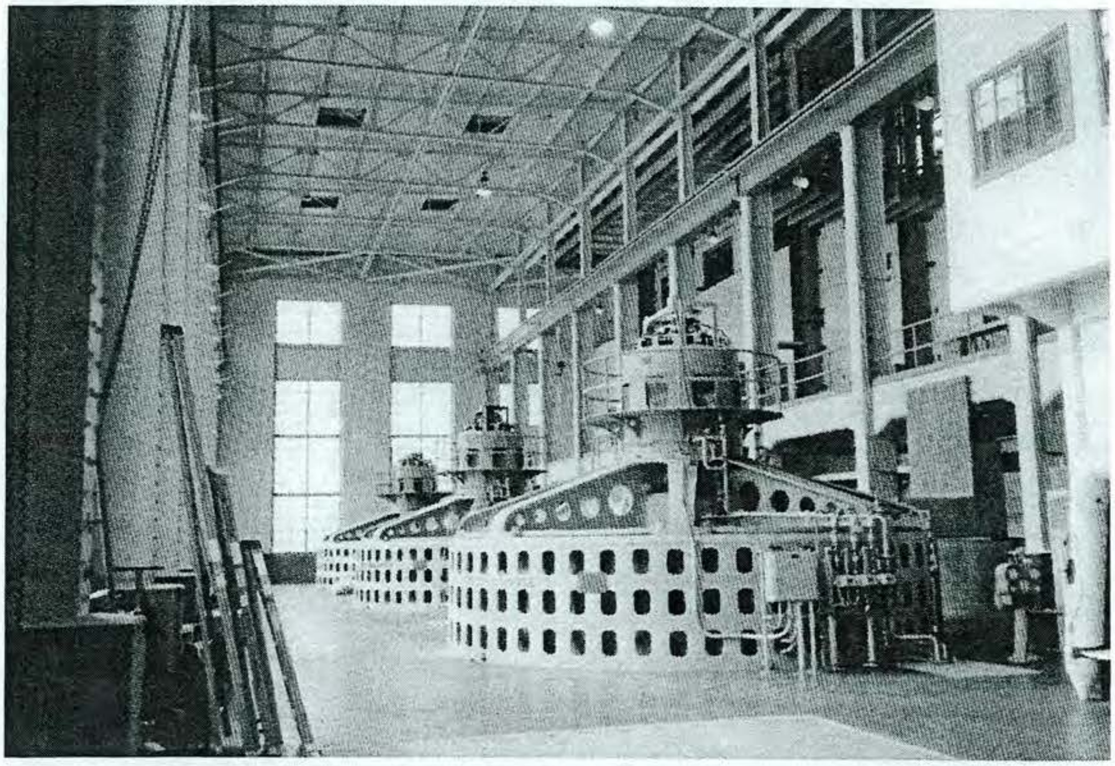

Figure 4.27. Rhodhiss Development; Rhodhiss Powerhouse; view of generator floor; looking south-southwest.

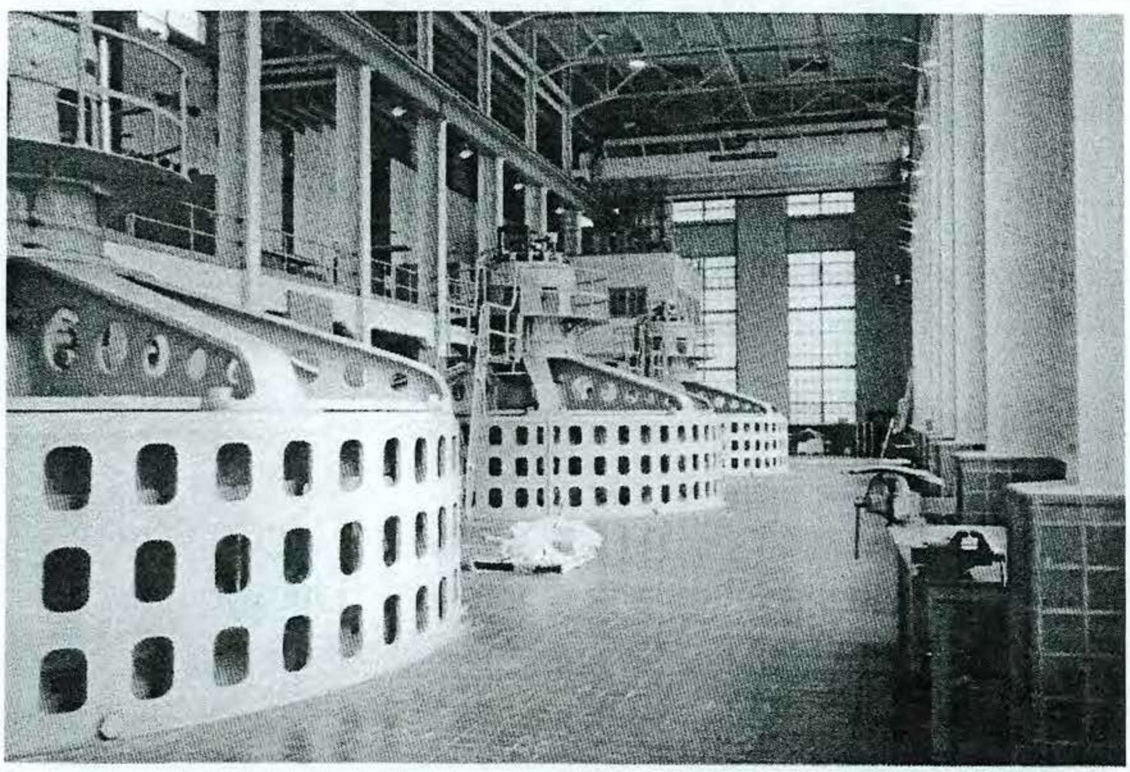

Figure 4.28. Rhodhiss Development, Rhodhiss Powerhouse; view of generator floor; looking north-northwest.

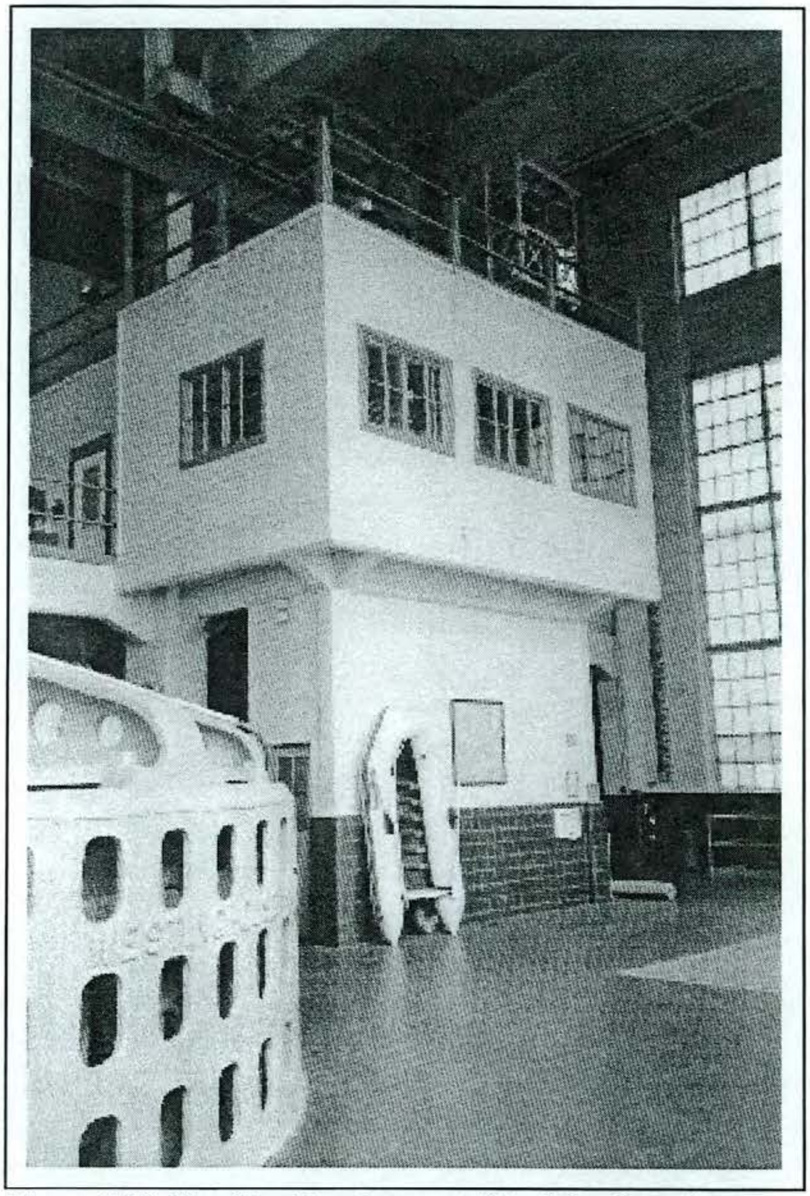

Figure 4.29. Rhodhiss Development, Rhodhiss Powerhouse;
view of mezzanine-level control room;
looking northwest.

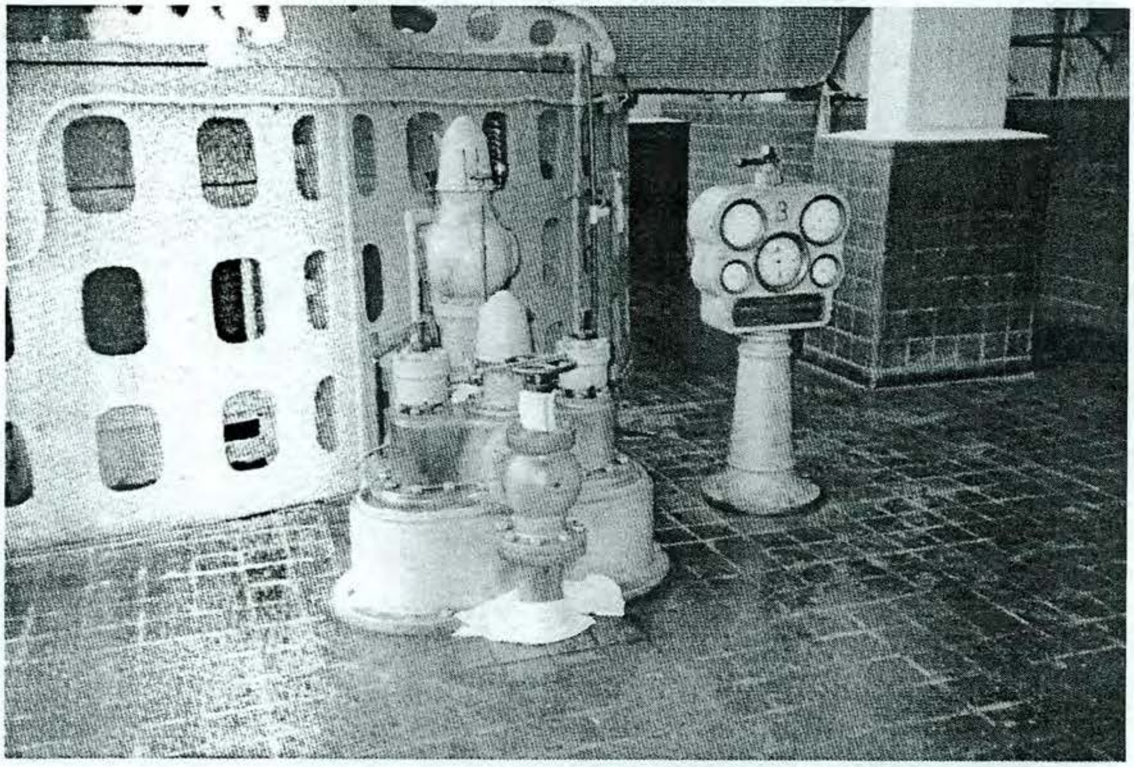

Figure 4.30. Rhodhiss Development, Rhodhiss Powerhouse; view of historic governor at generating unit #3; looking south-southwest.

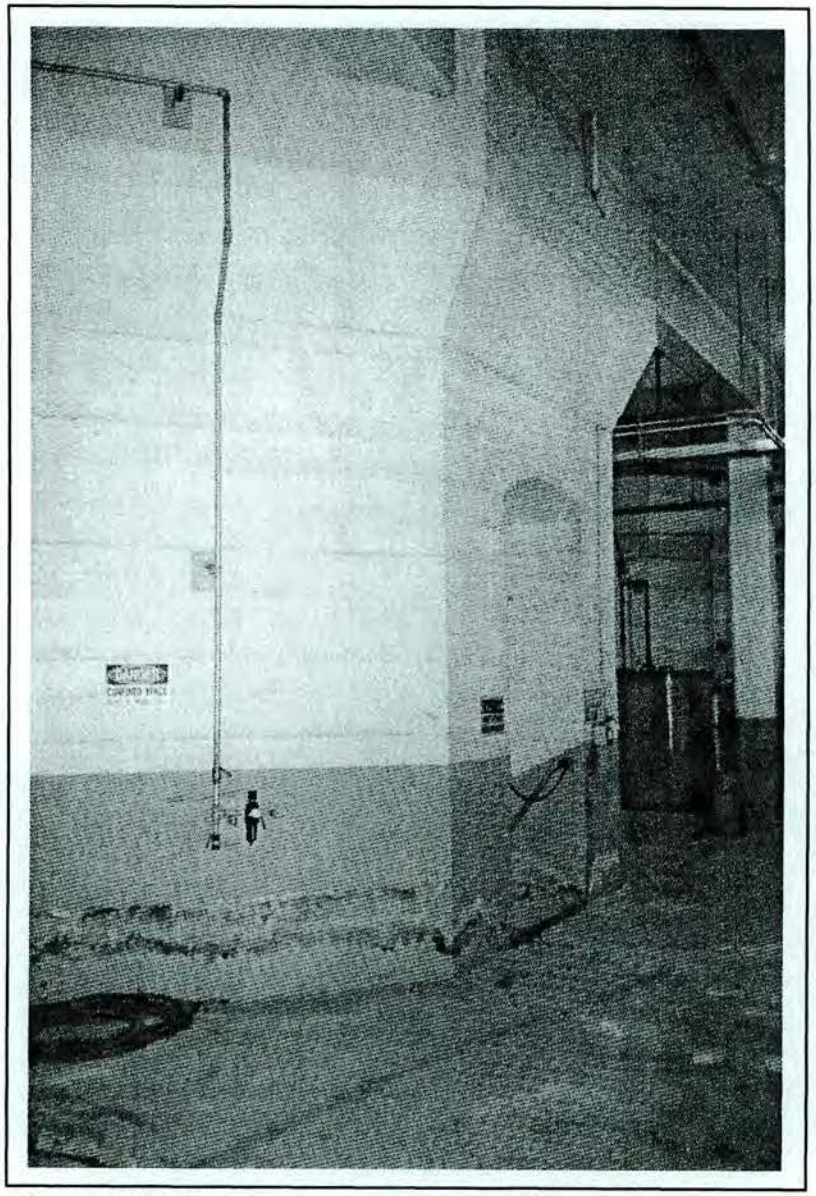

Figure 4.31. Rhodhiss Development, Rhodhiss Powerhouse; view of basement; looking northwest at exterior of generator base.

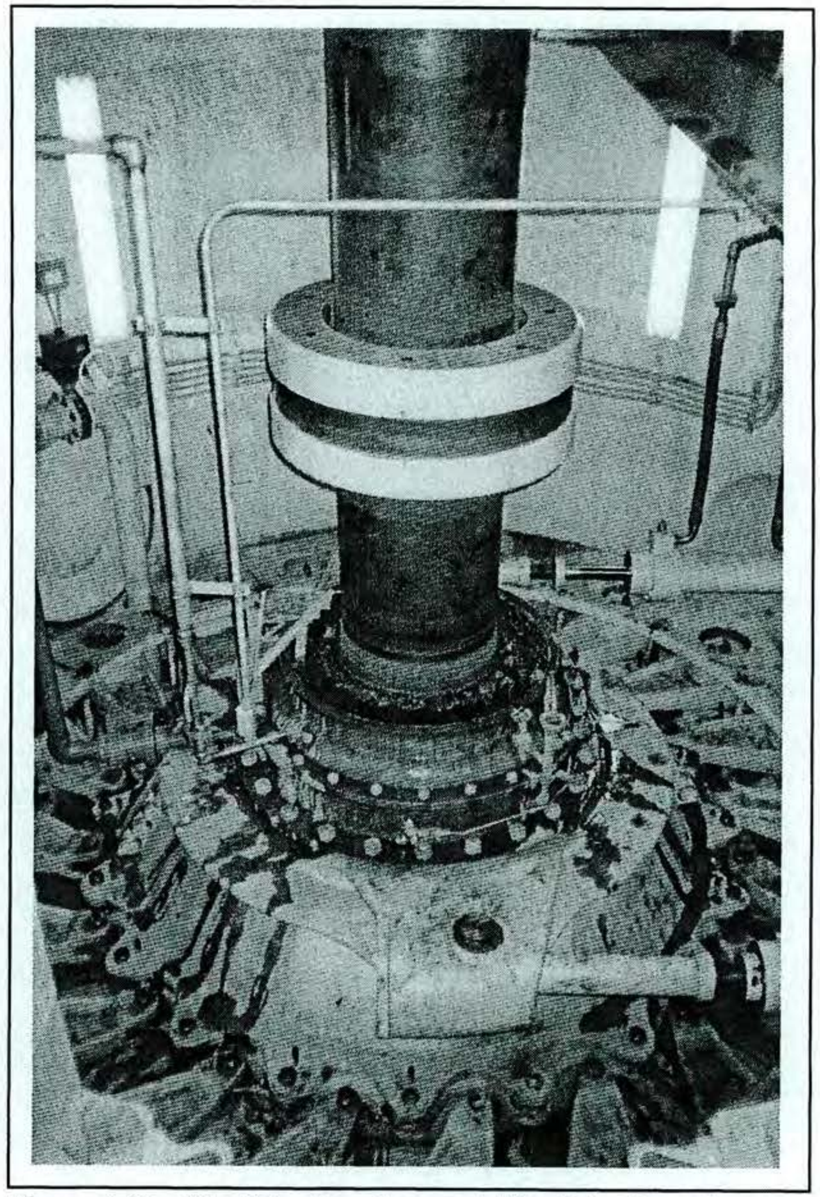

Figure 4.32. Rhodhiss Development, Rhodhiss Powerhouse; view of interior of generator base; looking west at generator-turbine shaft and wheel pit area.

Figure 4.33. Rhodhiss Development; view of warehouse; looking northwest. The warehouse was demolished in 2004.

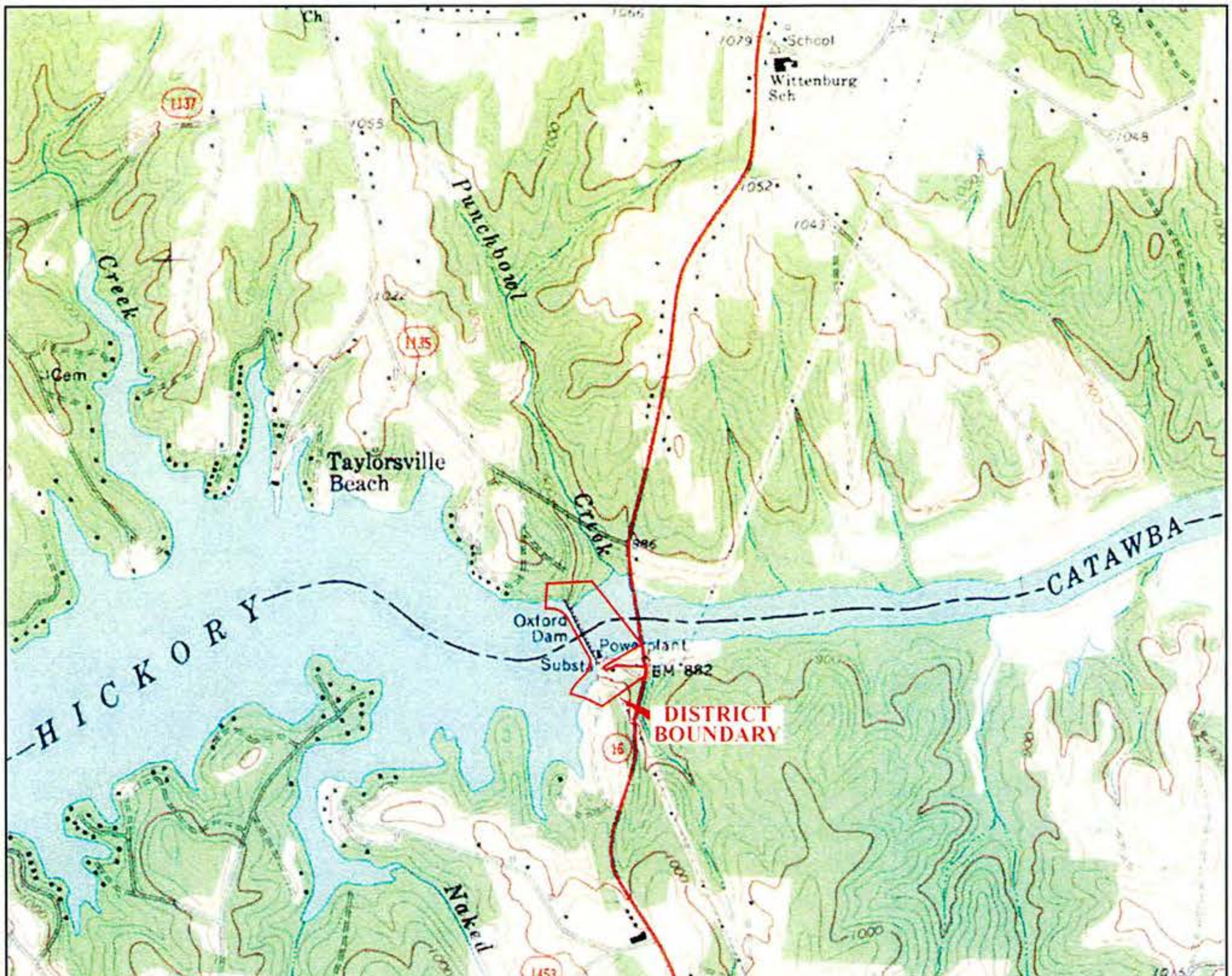

Figure 4.34. Map showing dam and powerhouse at Oxford Development.

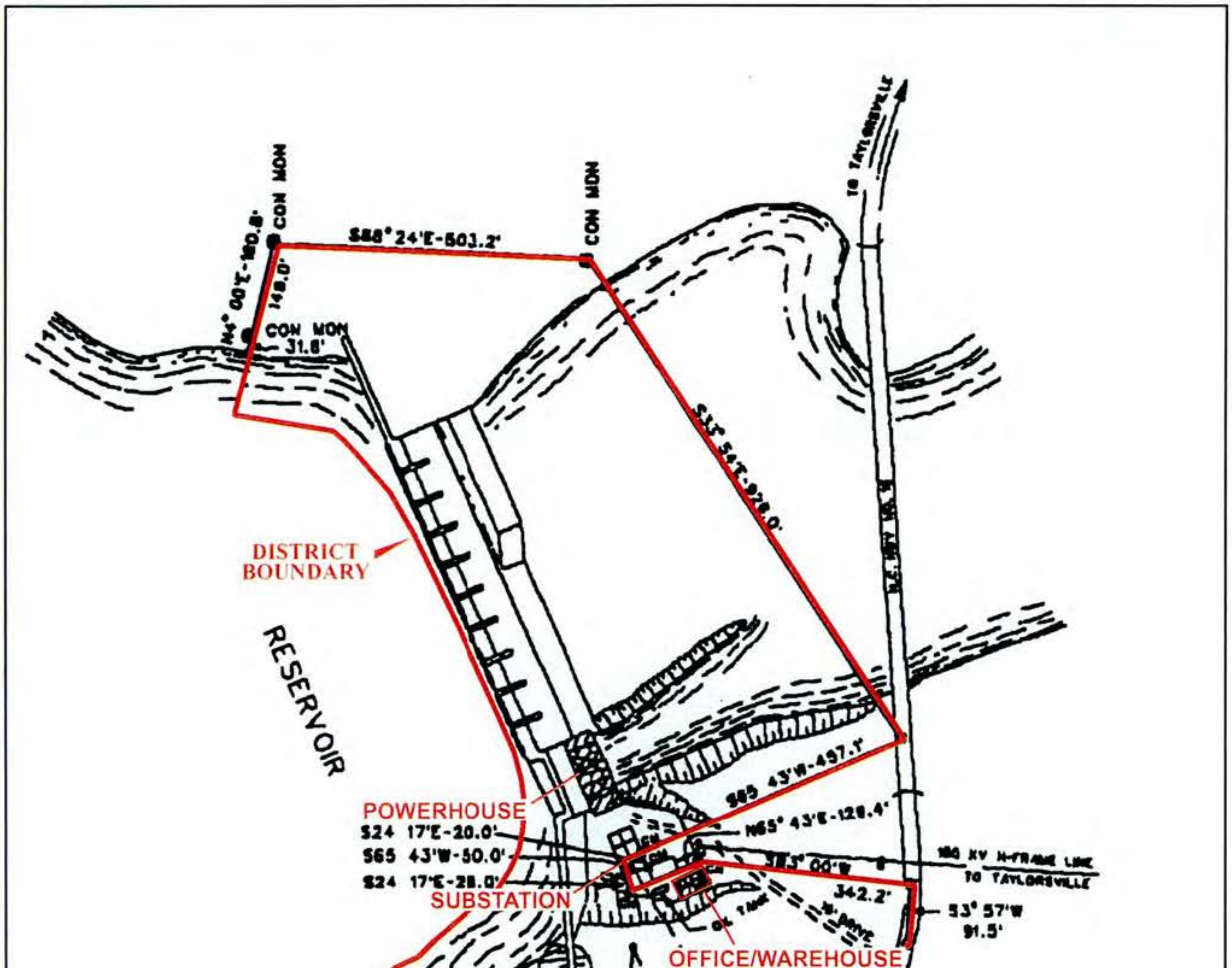

Figure 4.35. Site plan of Oxford Development (Duke Energy Corporation 2003).

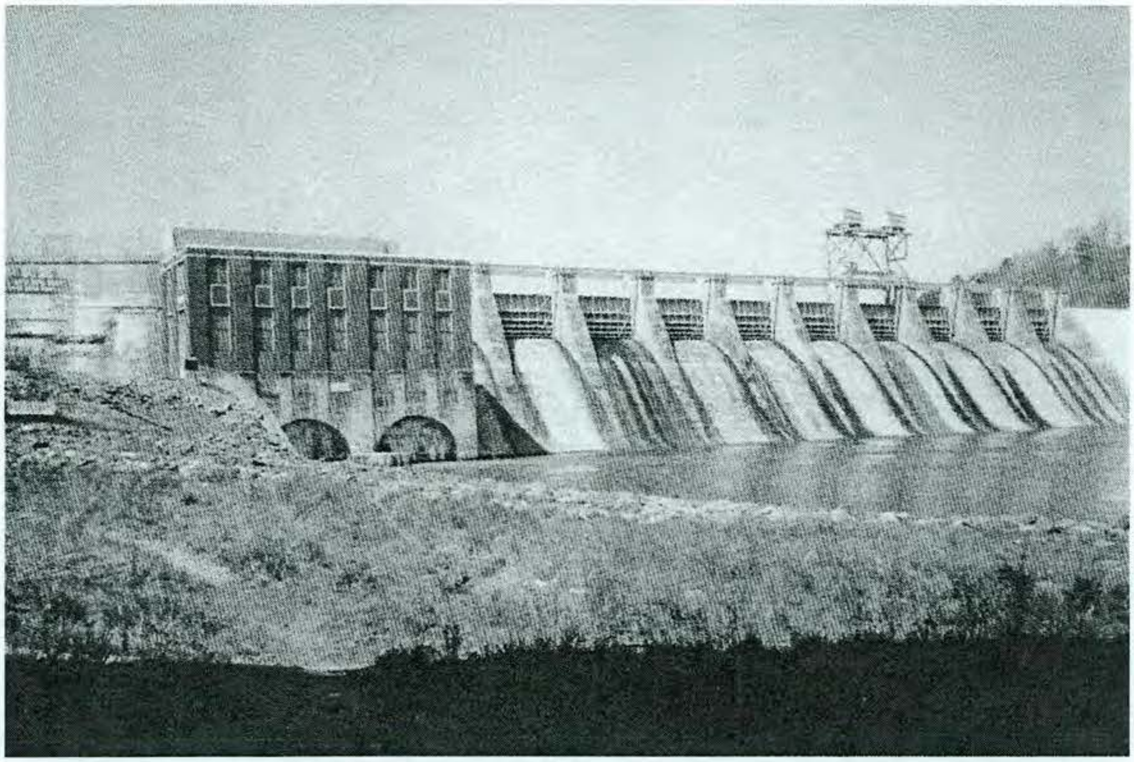

Figure 4.36. Oxford Development; view of substation, powerhouse, and dam with spillway; looking west.

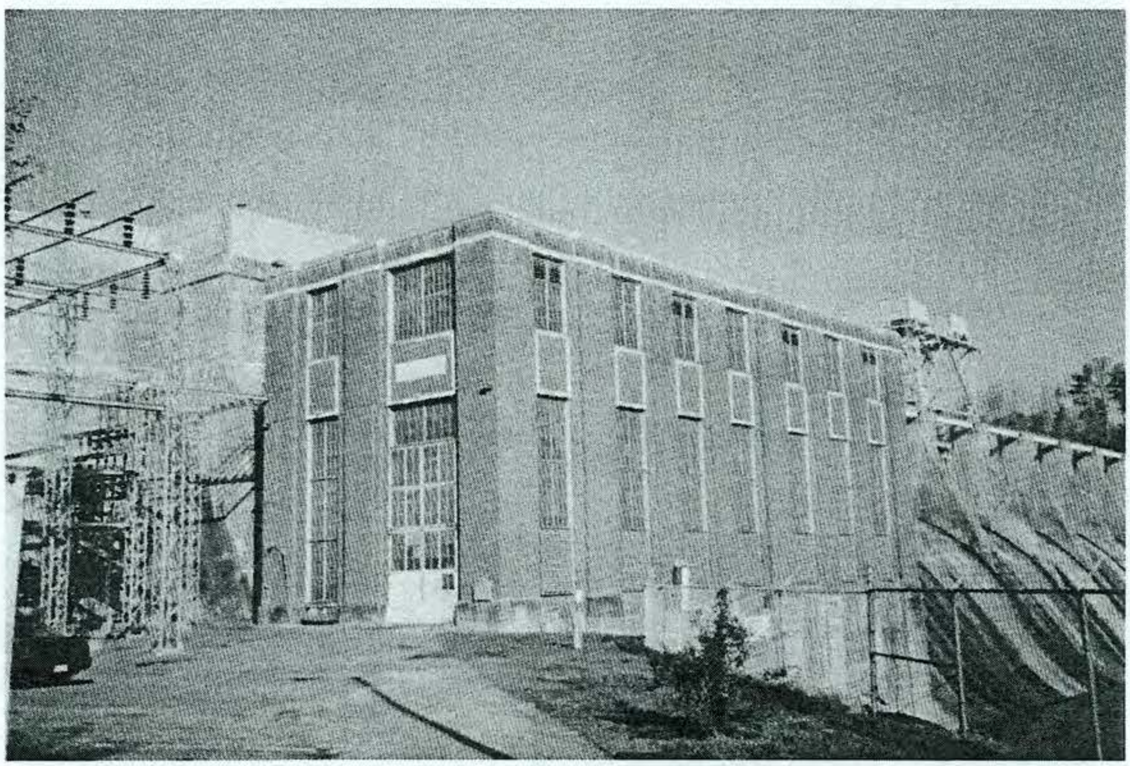

Figure 4.37. Oxford Development, Oxford Powerhouse (floodwall improvements visible atop south abutment); looking west-northwest.

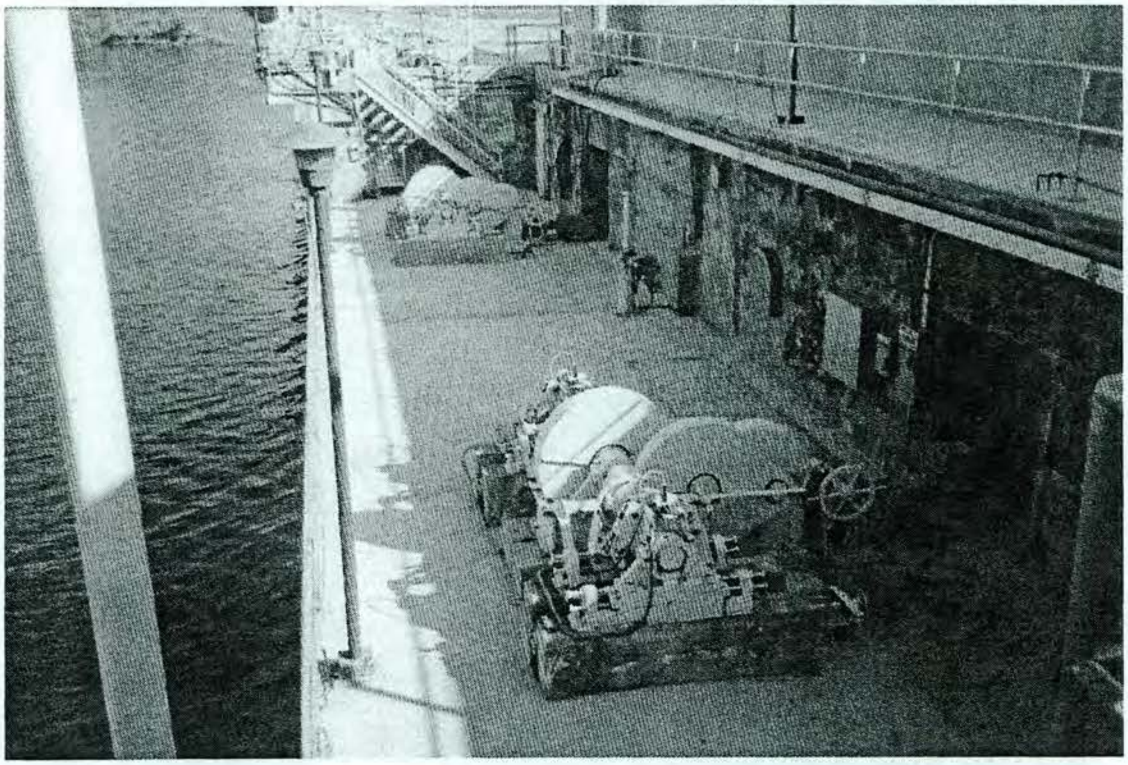

Figure 4.38. Oxford Development, Oxford Powerhouse; view of rear intake deck (with new decking, railings, and lampposts); looking north.

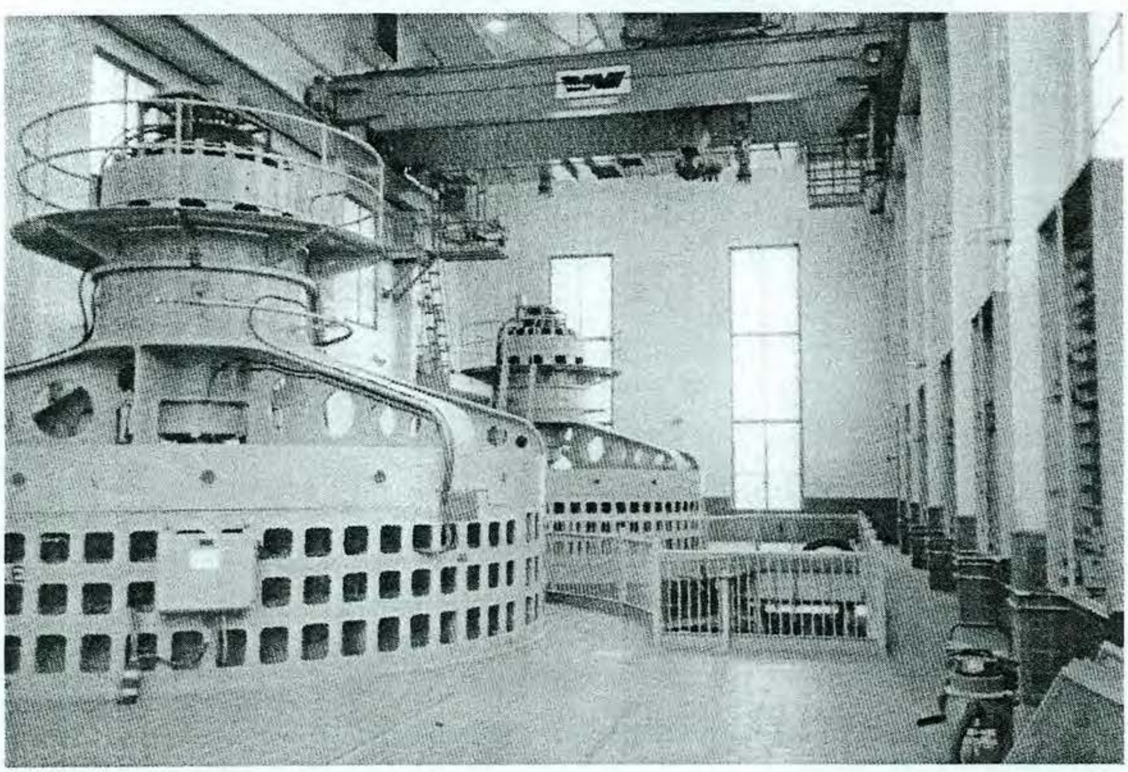

Figure 4.39. Oxford Development, Oxford Powerhouse; view of generator floor; looking north.

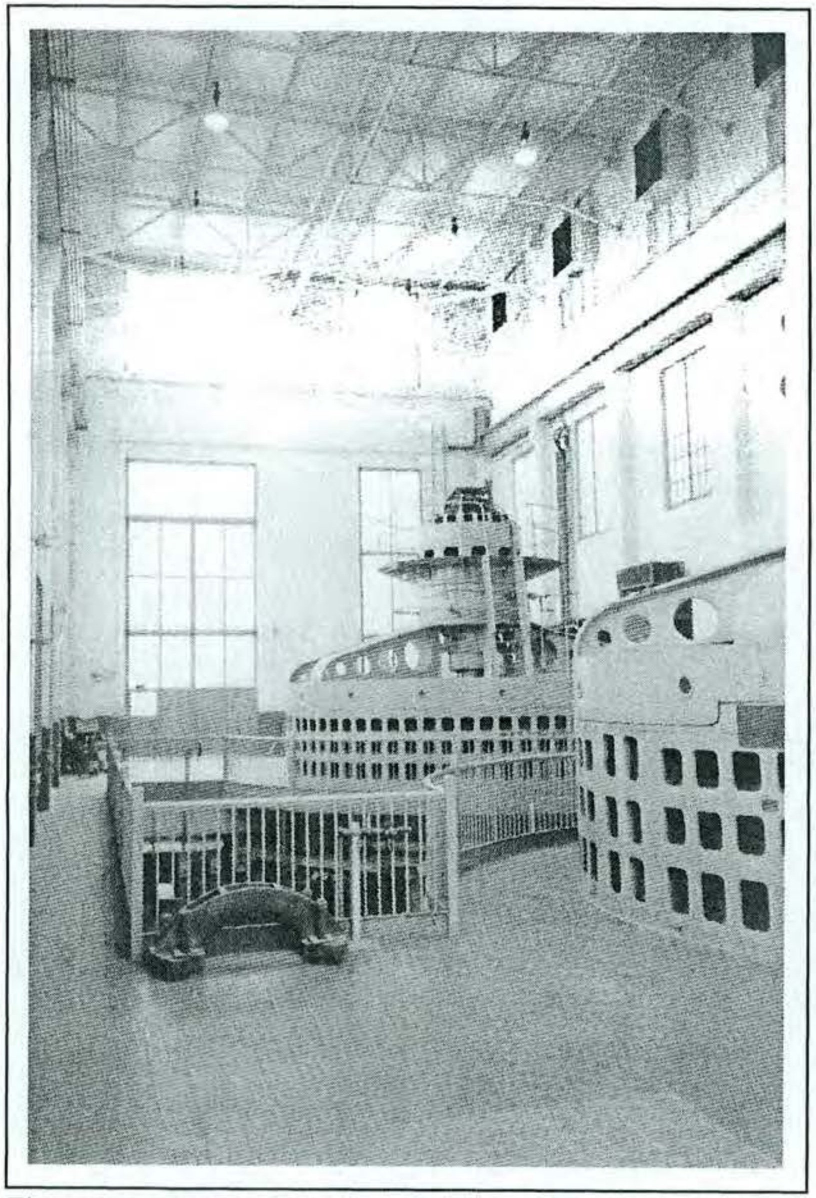

Figure 4.40. Oxford Development, Oxford Powerhouse; view of generator floor; looking south.

Figure 4.41. Oxford Development, Oxford Powerhouse; view of generating unit #2 from basement level; looking northwest.

Figure 4.42. Oxford Development; view of warehouse; looking west-southwest.

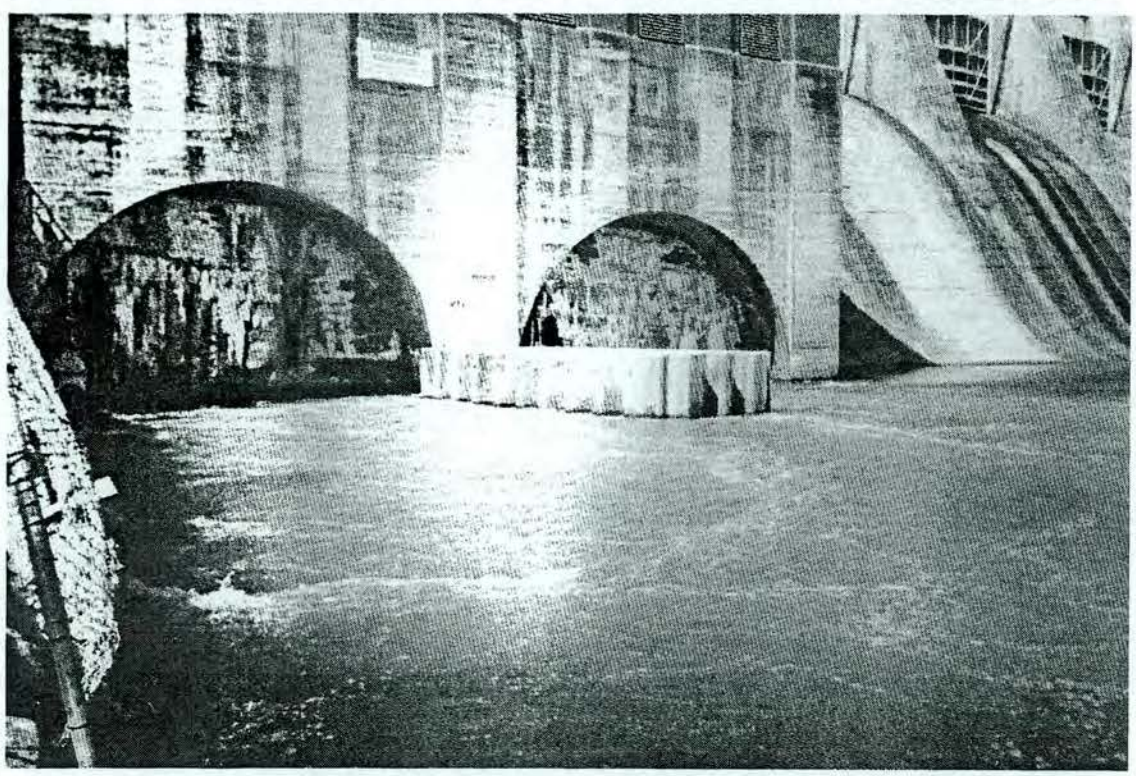

Figure 4.43. Oxford Development; view of new buttress in front of Oxford Powerhouse; looking west.

Figure 4.44. Oxford Development; view of new spillway at north end of dam; looking southwest.

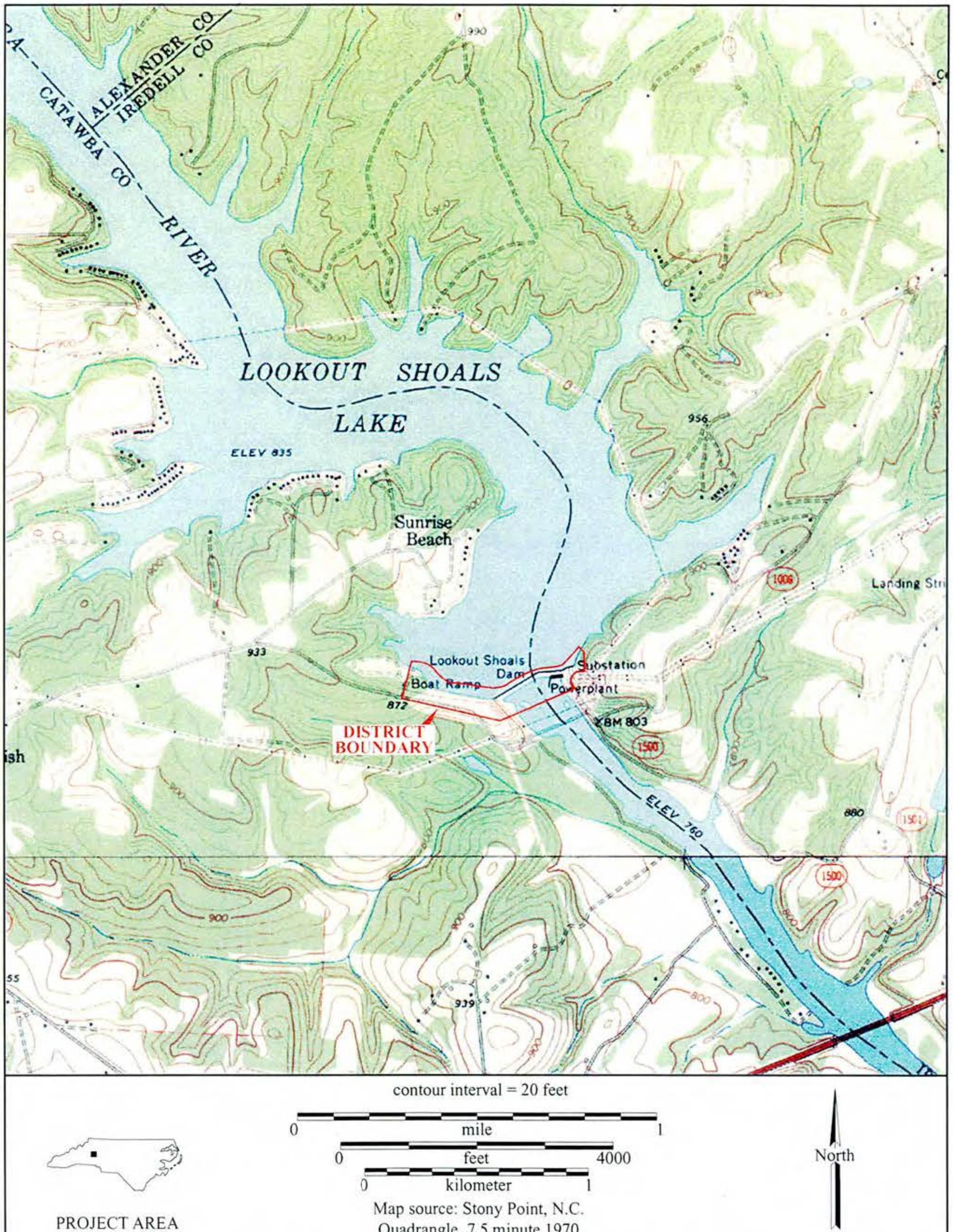

Figure 4.45. Map showing dam and powerhouse at Lookout Shoals Development.

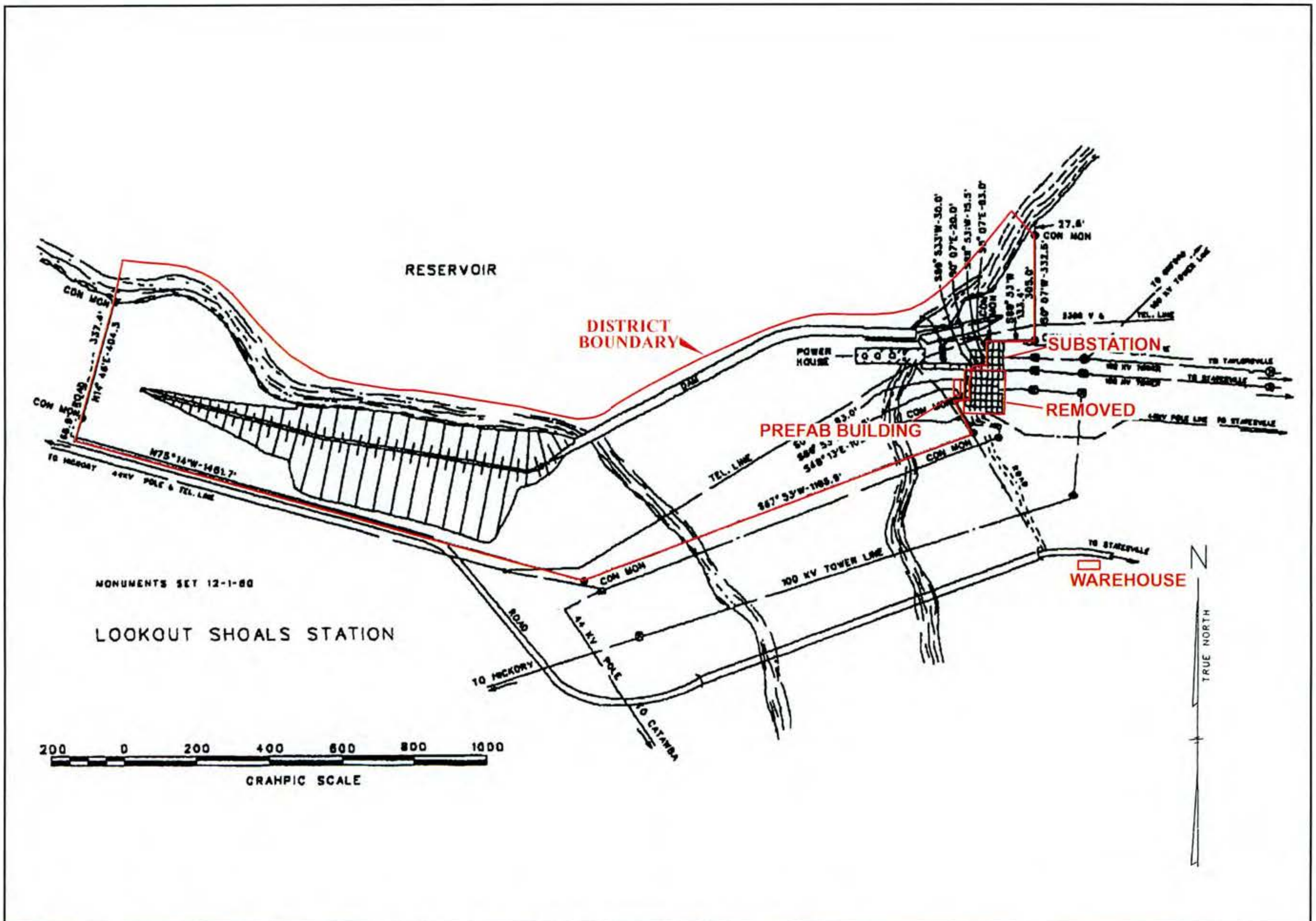

Figure 4.46.Site plan of Lookout Shoals Development (Duke Energy Corporation 2003).

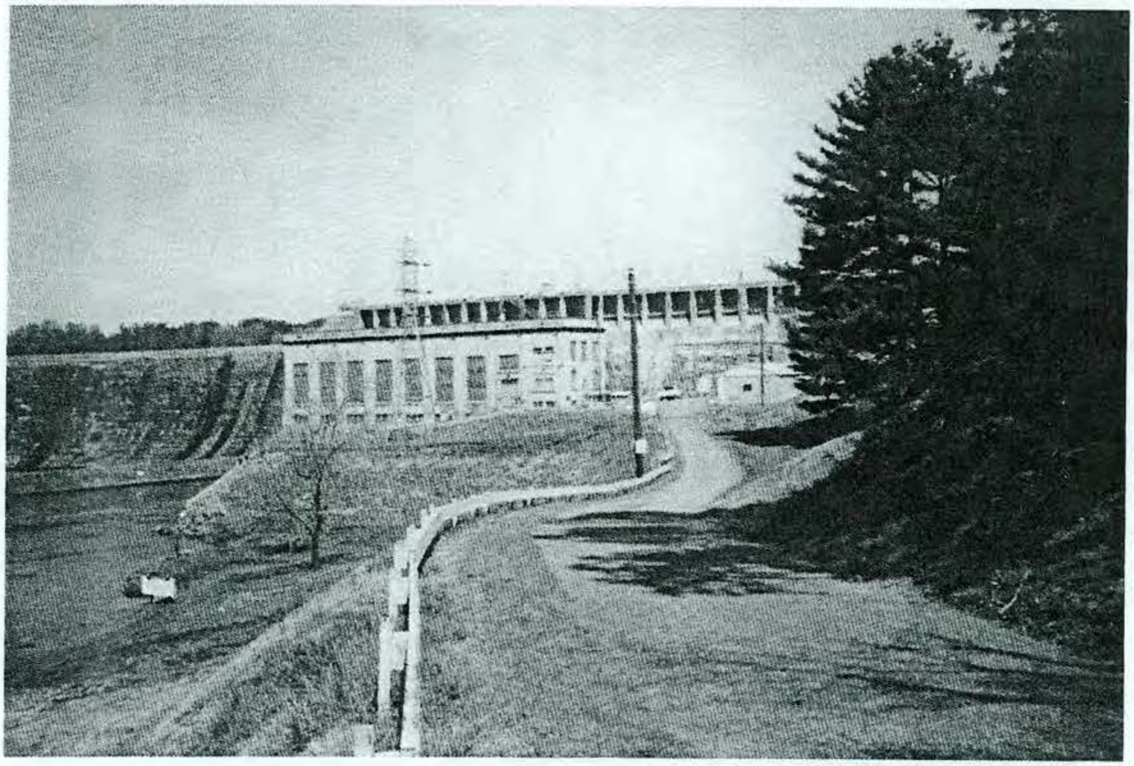

Figure 4.47. Lookout Shoals Development; view of dam, powerhouse, substation, and prefabricated building; looking northwest.

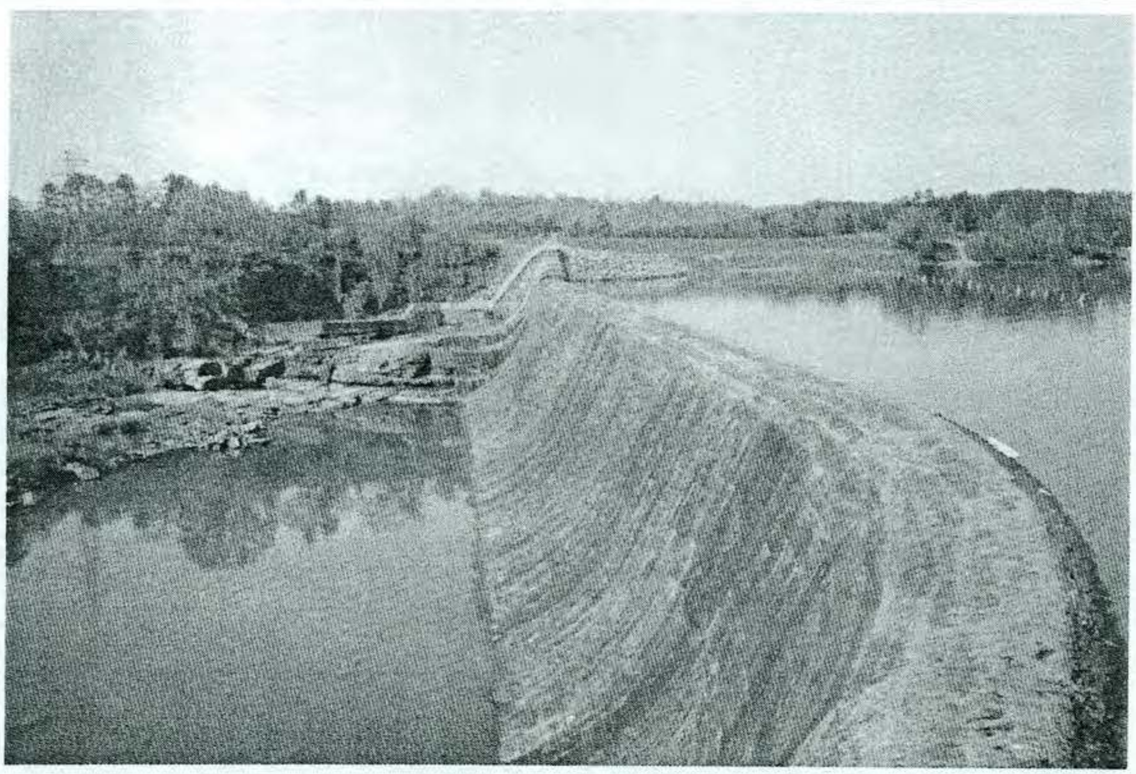

Figure 4.48. Lookout Shoals Development; view of dam (floodwall improvements visible at west end of dam); looking southwest.

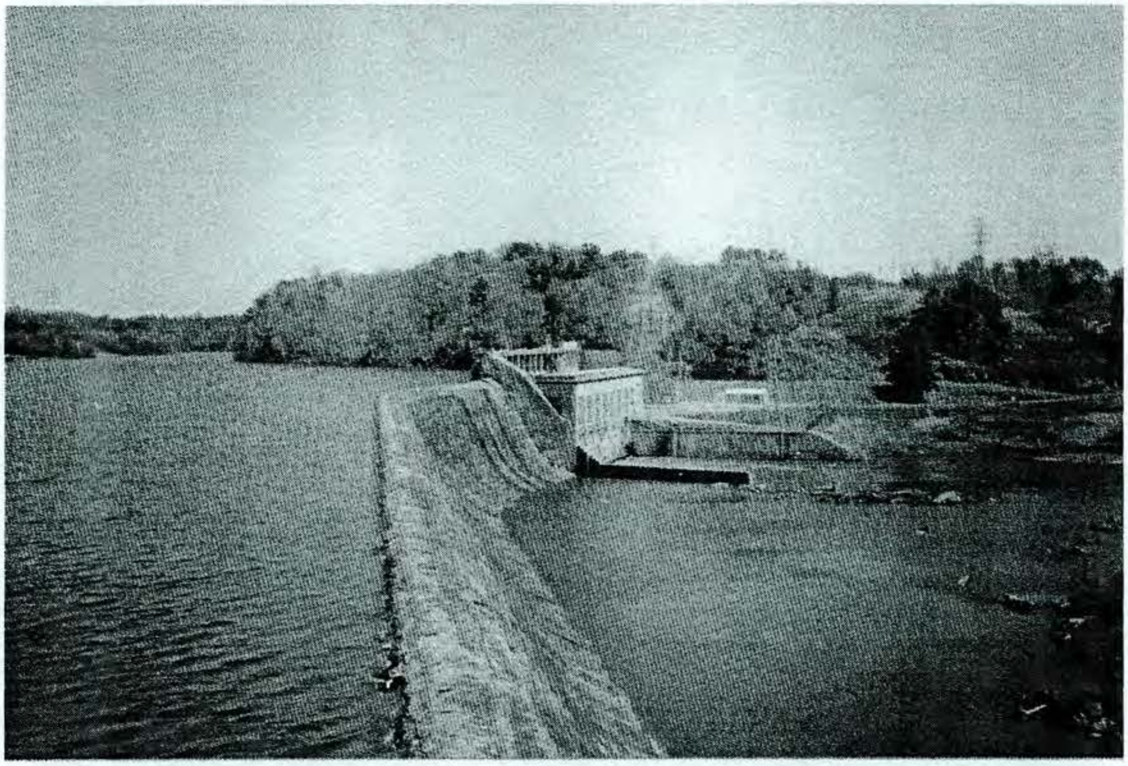

Figure 4.49. Lookout Shoals Development; view of dam, powerhouse, substation, and prefabricated building; looking northeast.

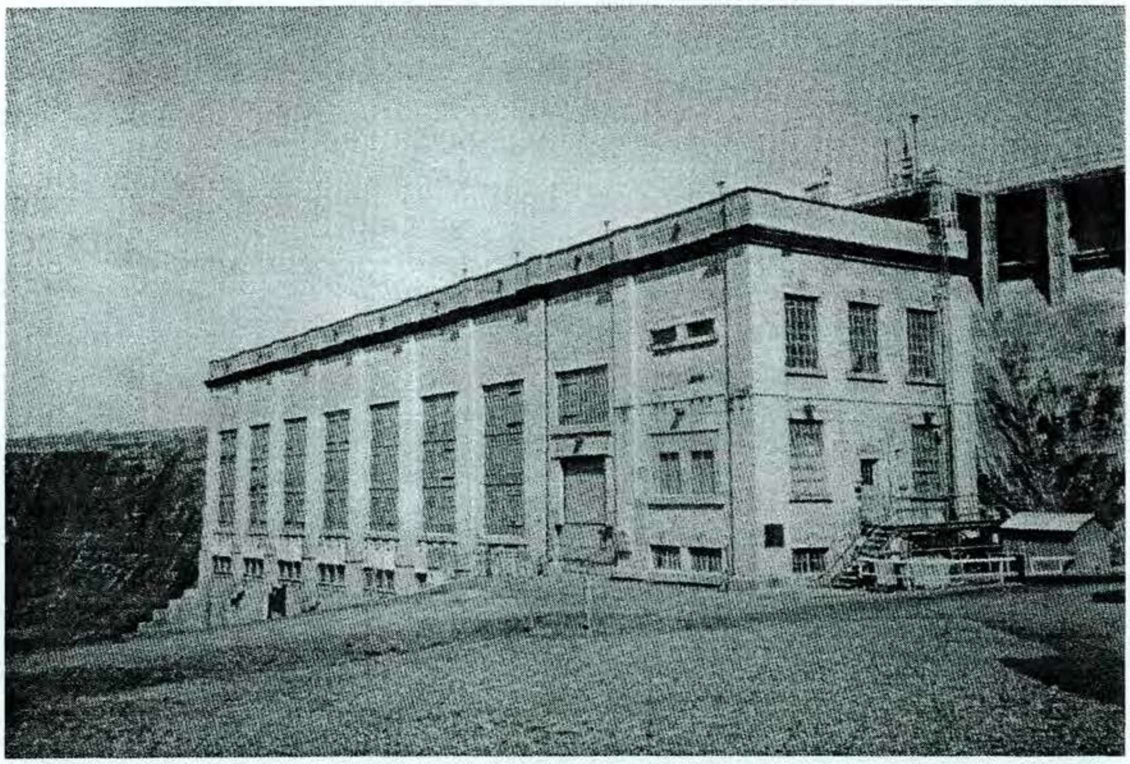

Figure 4.50. Lookout Shoals Development, Lookout Powerhouse; looking northwest.

Figure 4.51. Lookout Shoals Development; view of dam/intake area to rear of powerhouse; looking west-northwest.

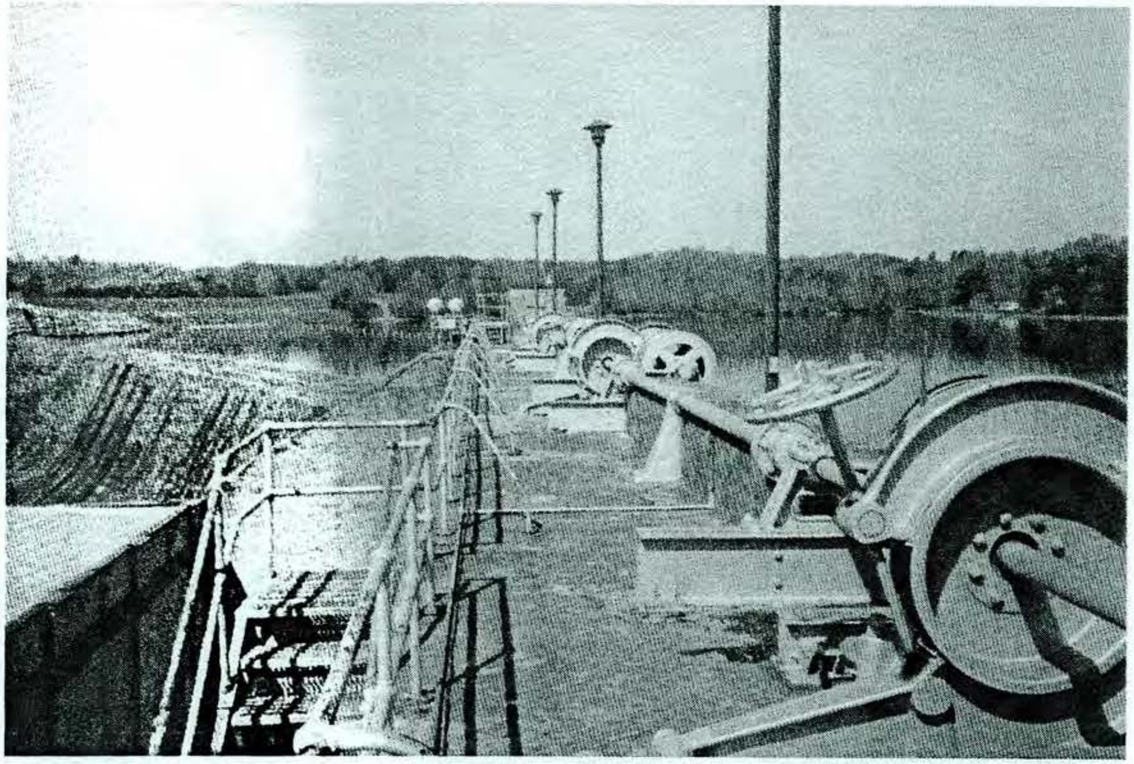

Figure 4.52. Lookout Shoals Development; view of crest of dam/intake area; looking west.

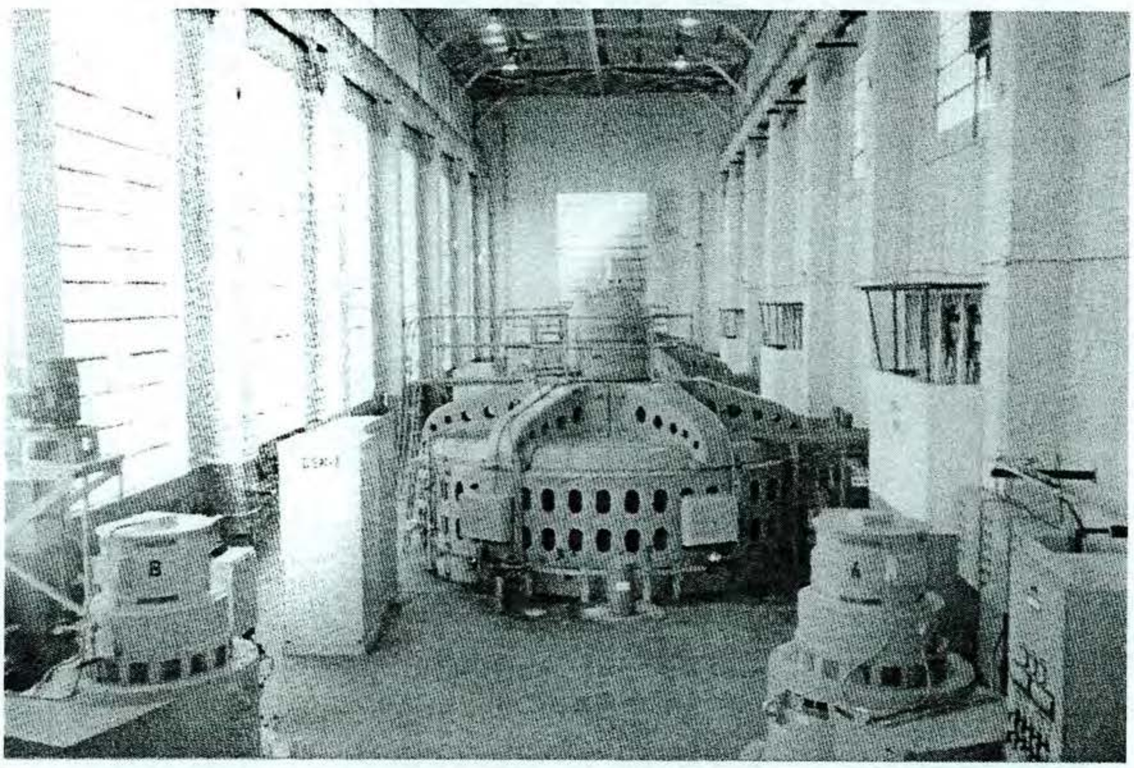

Figure 4.53. Lookout Shoals Development, Lookout Powerhouse; view of generator floor; looking west.

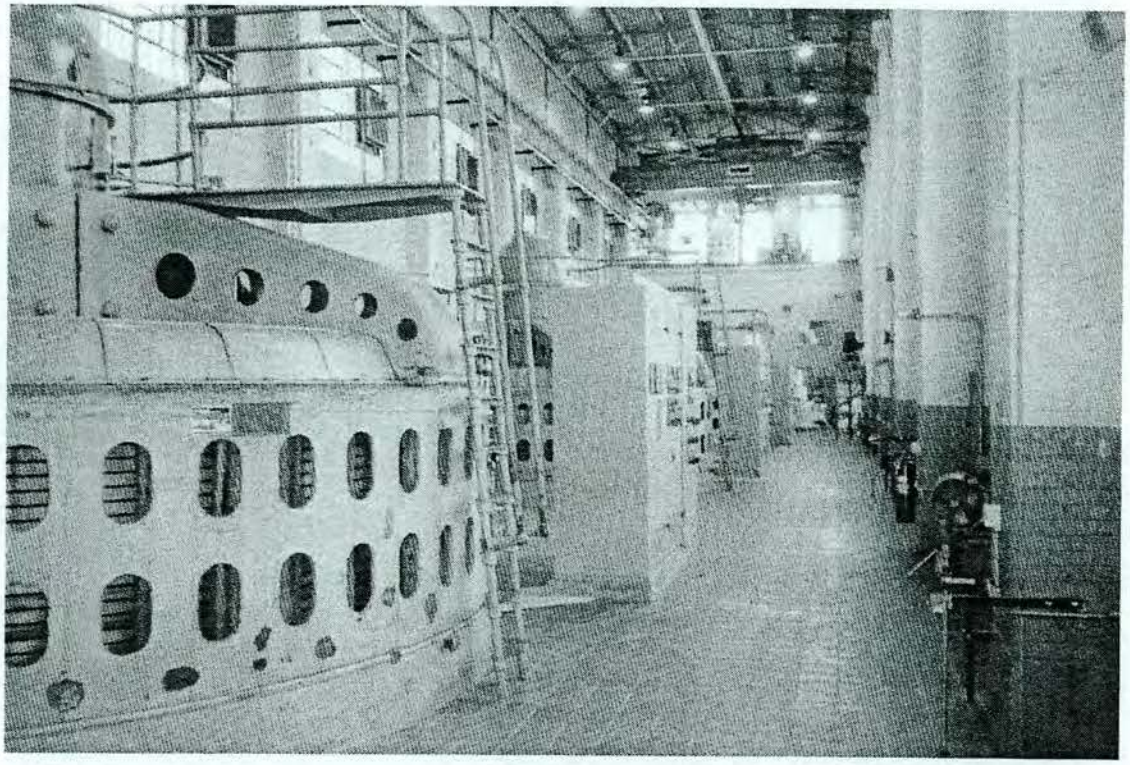

Figure 4.54. Lookout Shoals Development, Lookout Powerhouse; view of generator floor; looking east.

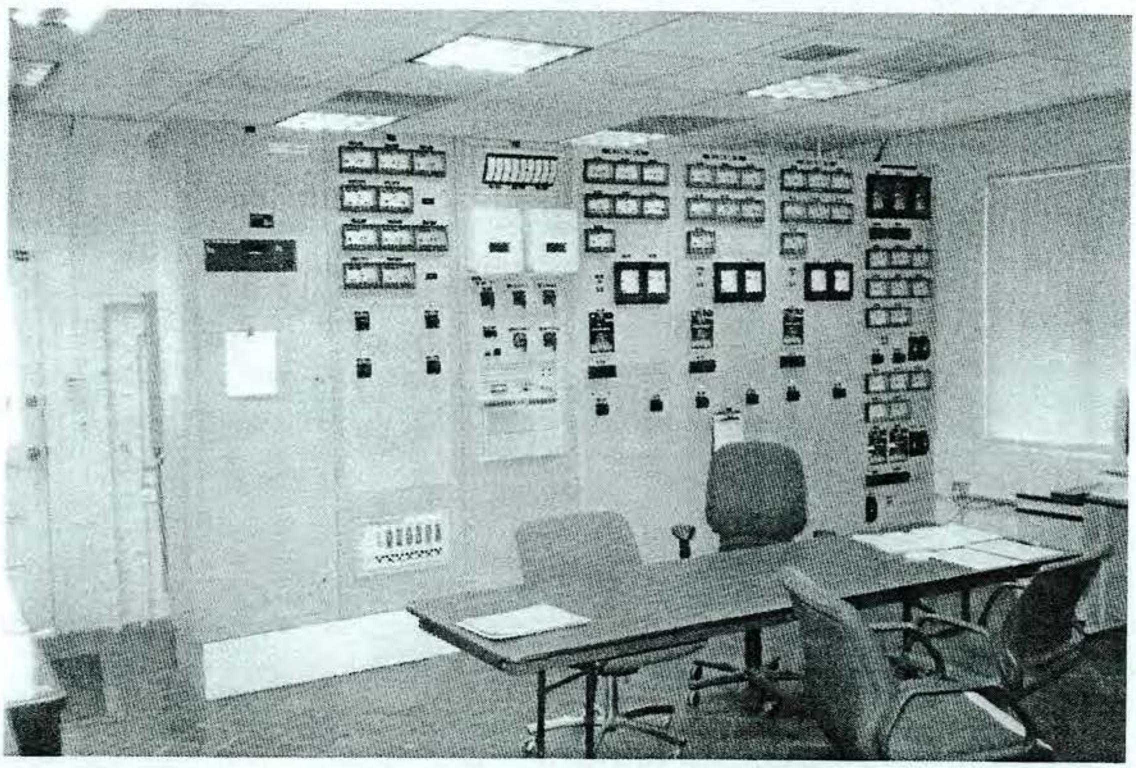

Figure 4.55. Lookout Shoals Development, Lookout Powerhouse; view of control room; looking east.

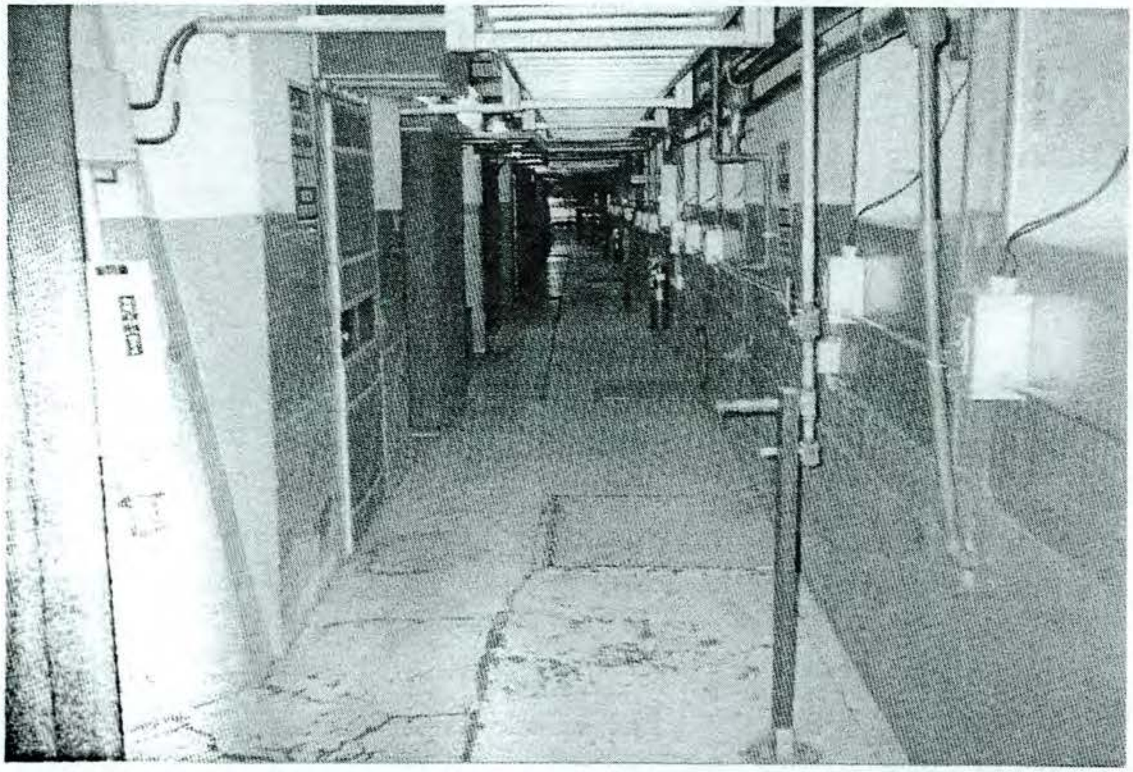

Figure 4.56. Lookout Shoals Development, Lookout Powerhouse; view of basement (generator bases at left); looking east.

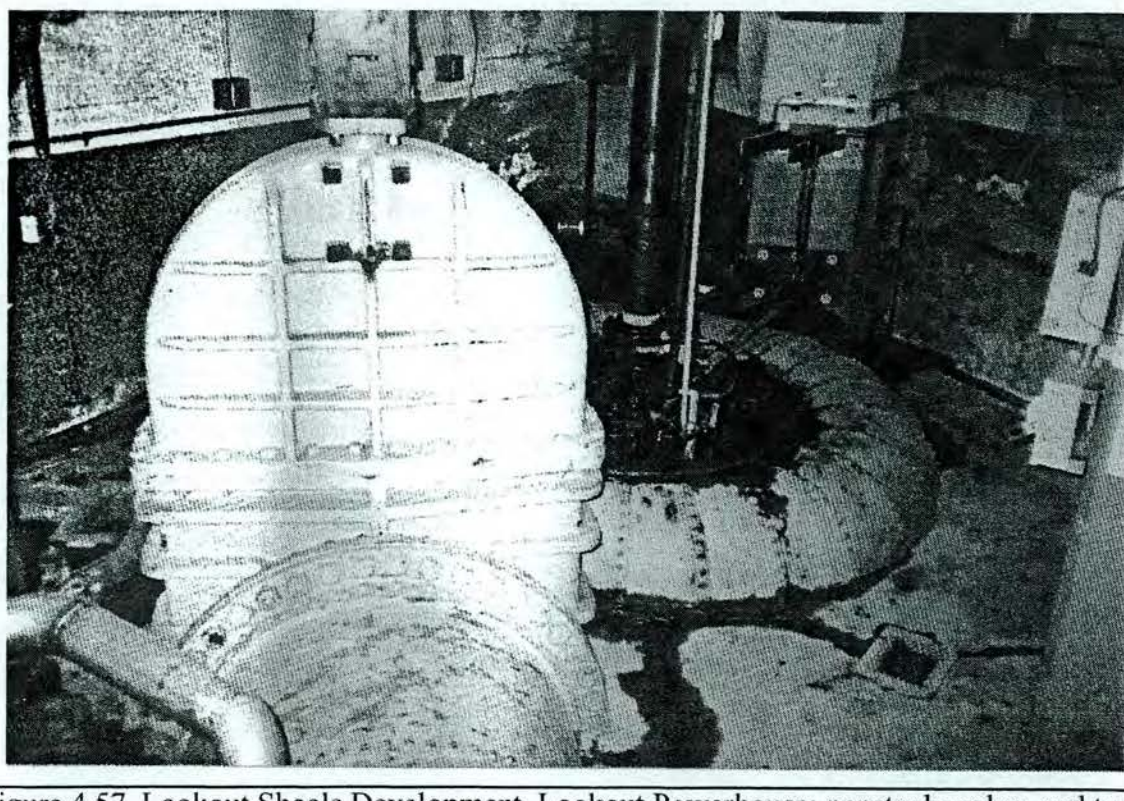

Figure 4.57. Lookout Shoals Development, Lookout Powerhouse; penstock, valve, and turbine housing for synchronous generator; looking southwest.

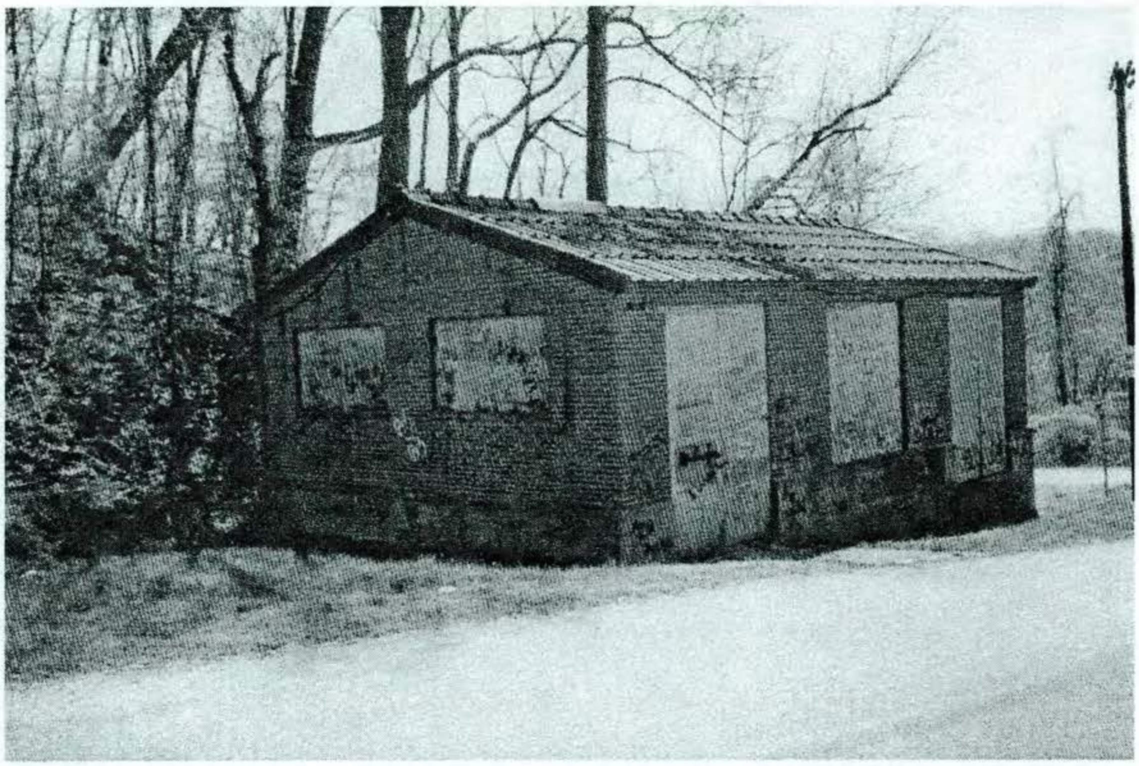

Figure 4.58. Lookout Shoals Development; view of warehouse; looking south-southwest.

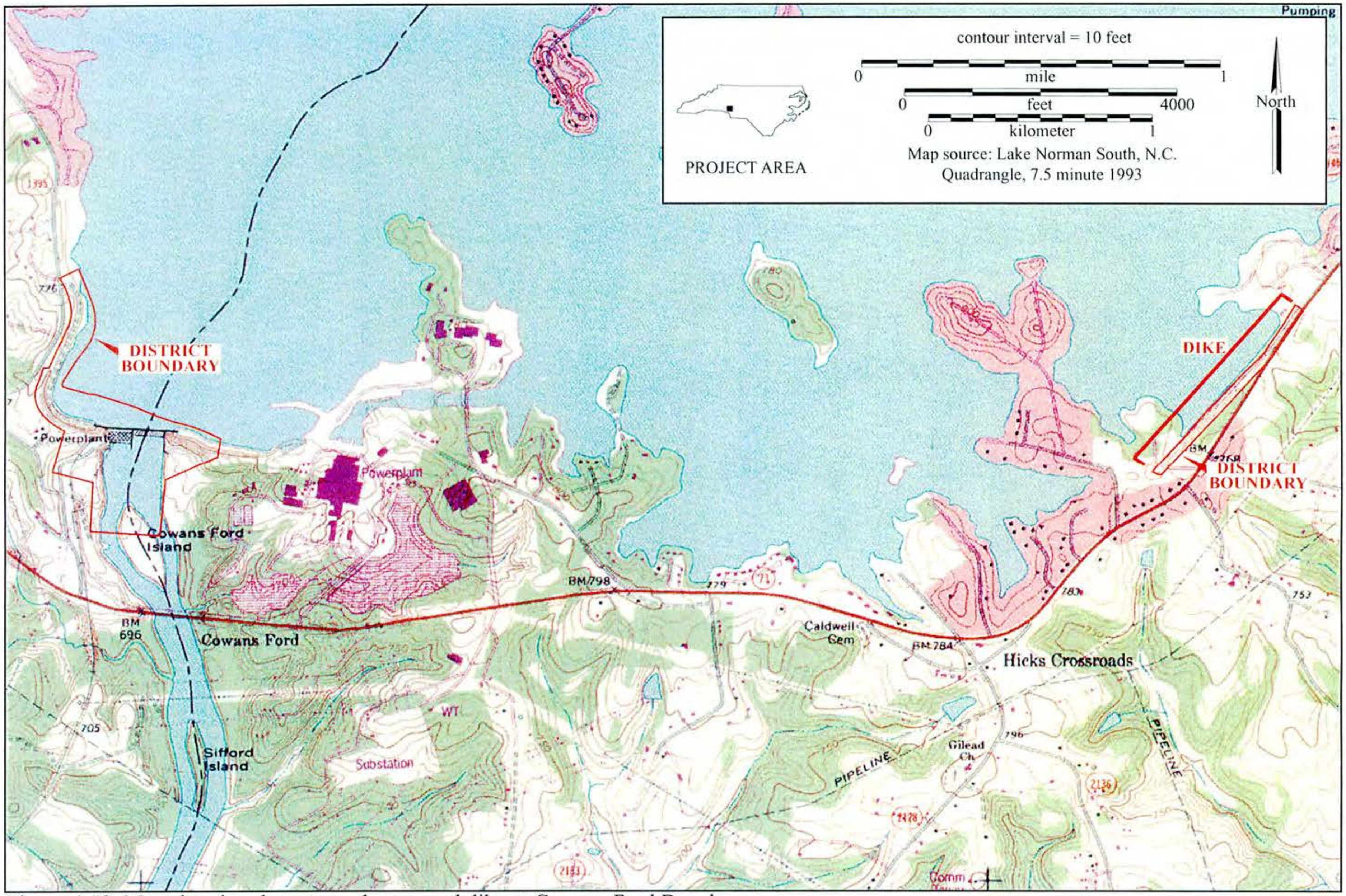

Figure 4.59. Map showing dam, powerhouse, and dike at Cowans Ford Development.

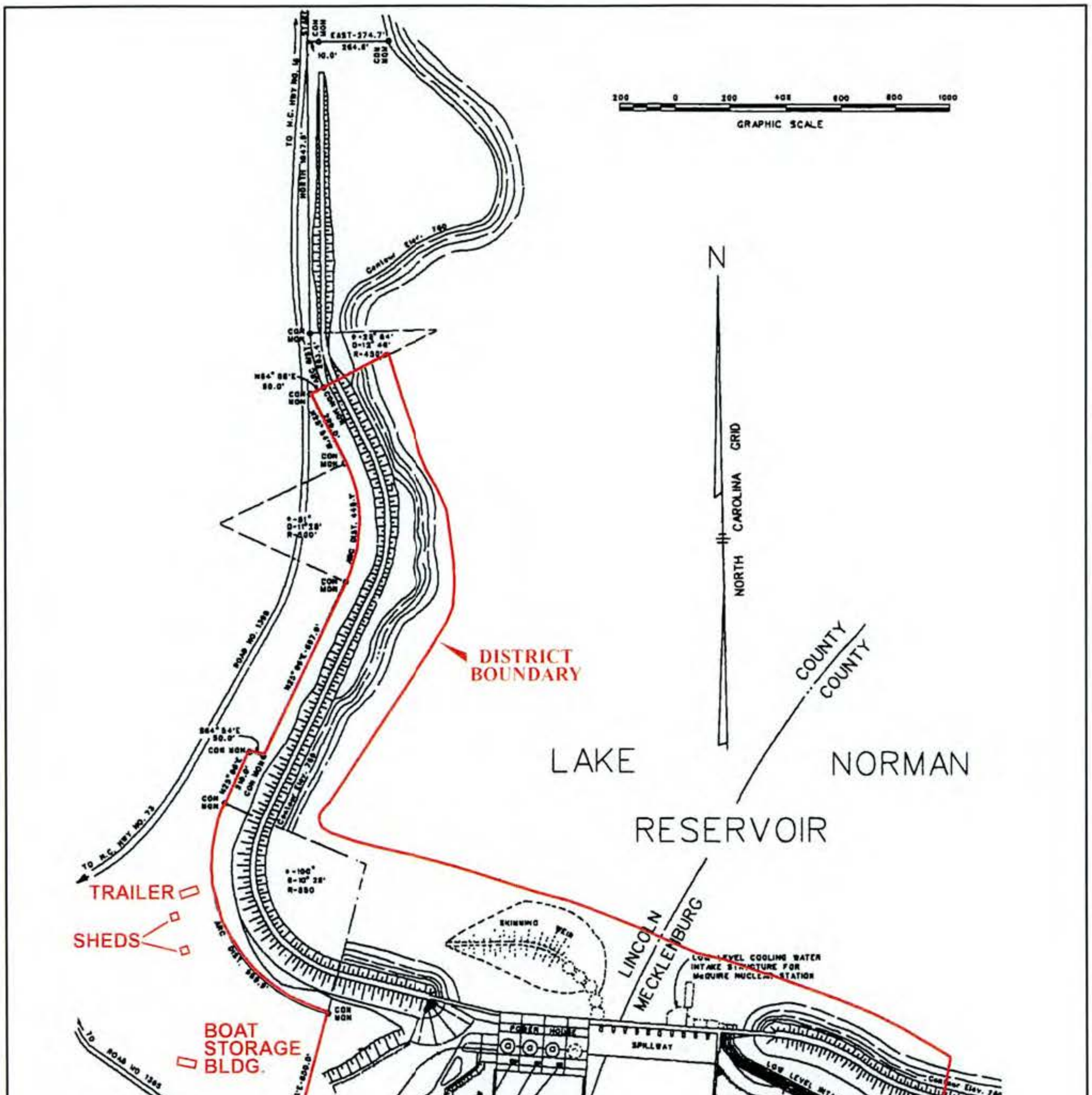

Figure 4.60. Site plan of dam and powerhouse at Cowans Ford Development (Duke Energy Corporation 2003).

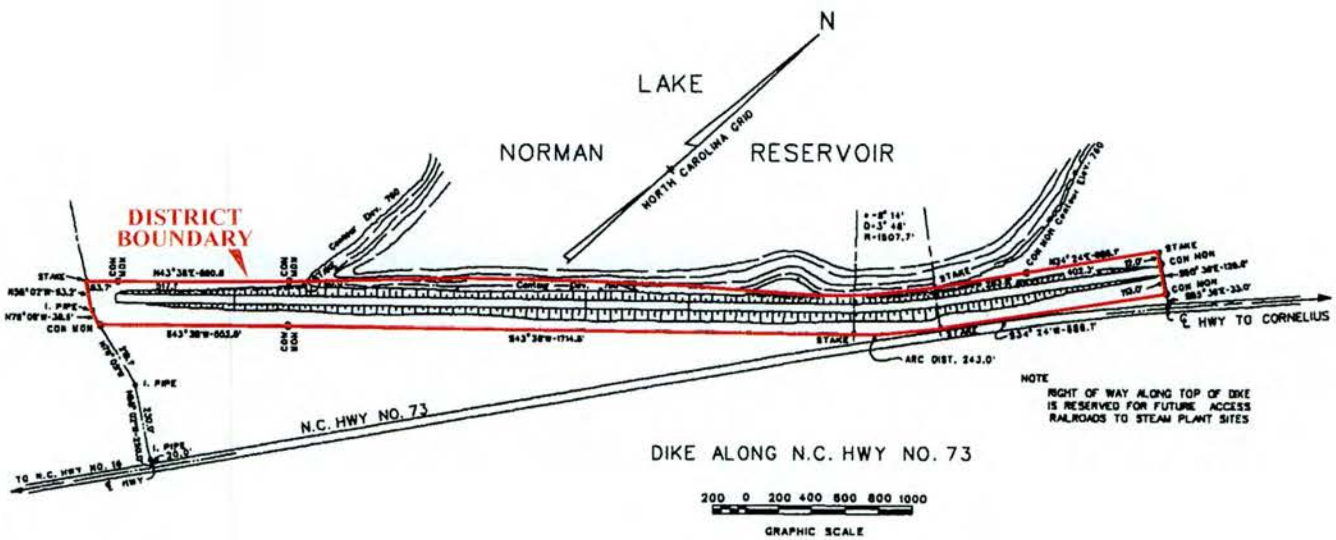

Figure 4.61. Site plan of Hicks Cross Roads Dike at Cowans Ford Development (Duke Energy Corporation 2003).

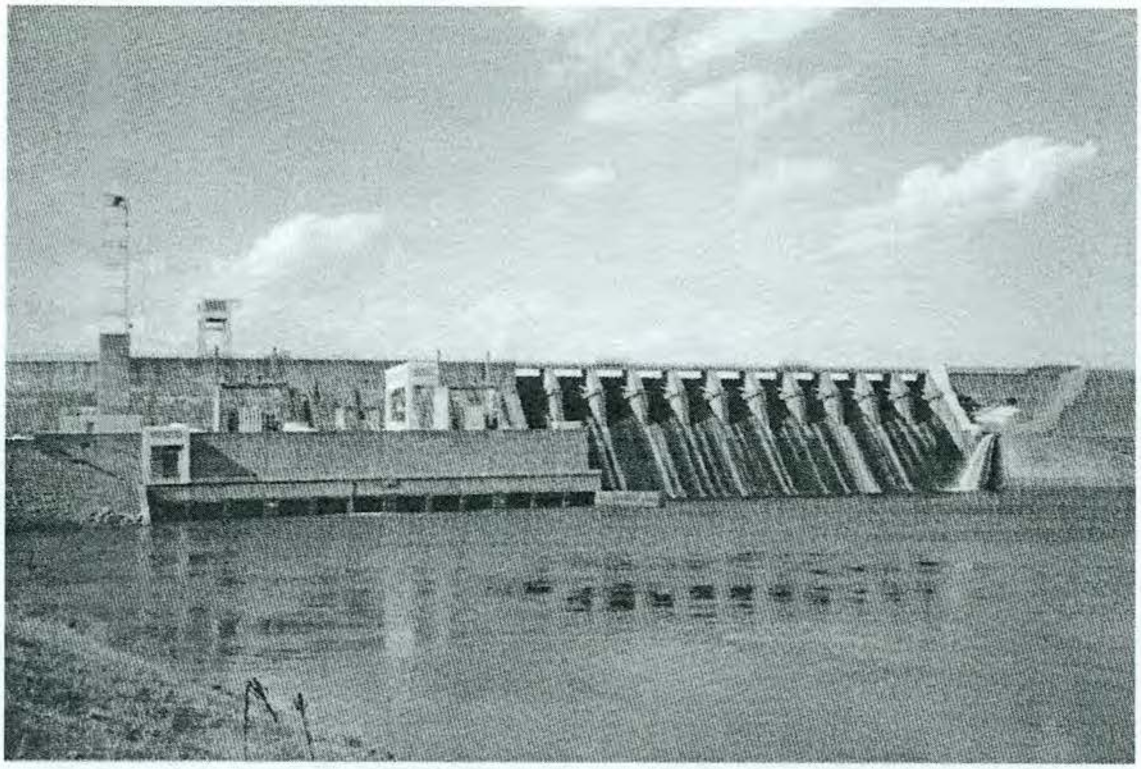

Figure 4.62. Cowans Ford Development; view of dam, powerhouse, and spillway; looking north-northeast.

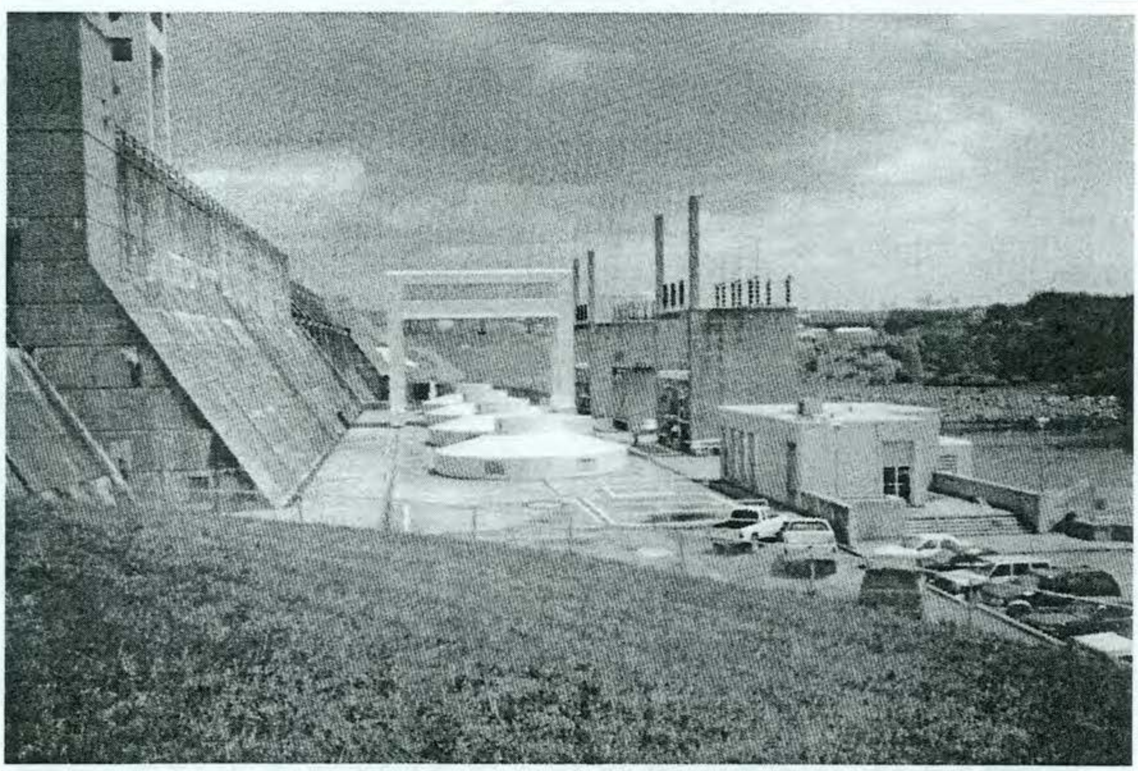

Figure 4.63. Cowans Ford Development; view of dam and powerhouse; looking east.

Figure 4.64. Cowans Ford Development; view of spillway gates; looking north-northeast.

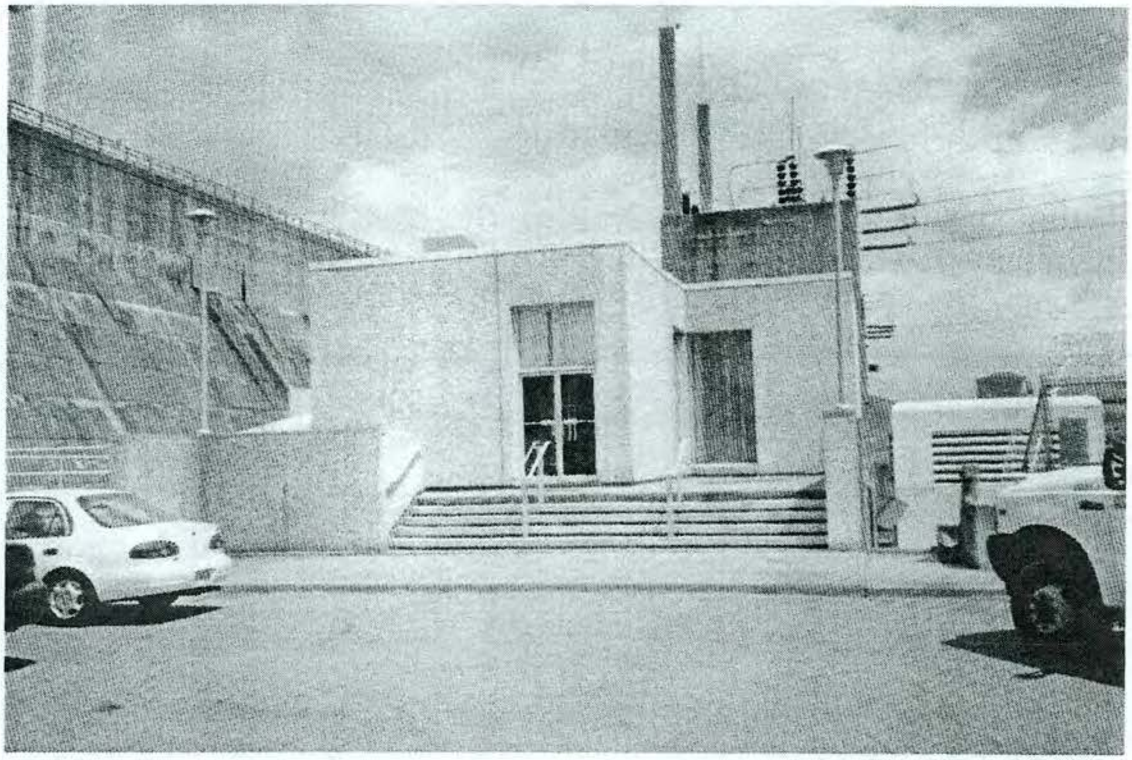

Figure 4.65. Cowans Ford Development; view of visitor center/entry point; looking east-northeast.

Figure 4.66. Cowans Ford Development; view of interior of visitor center/entry point; looking east.

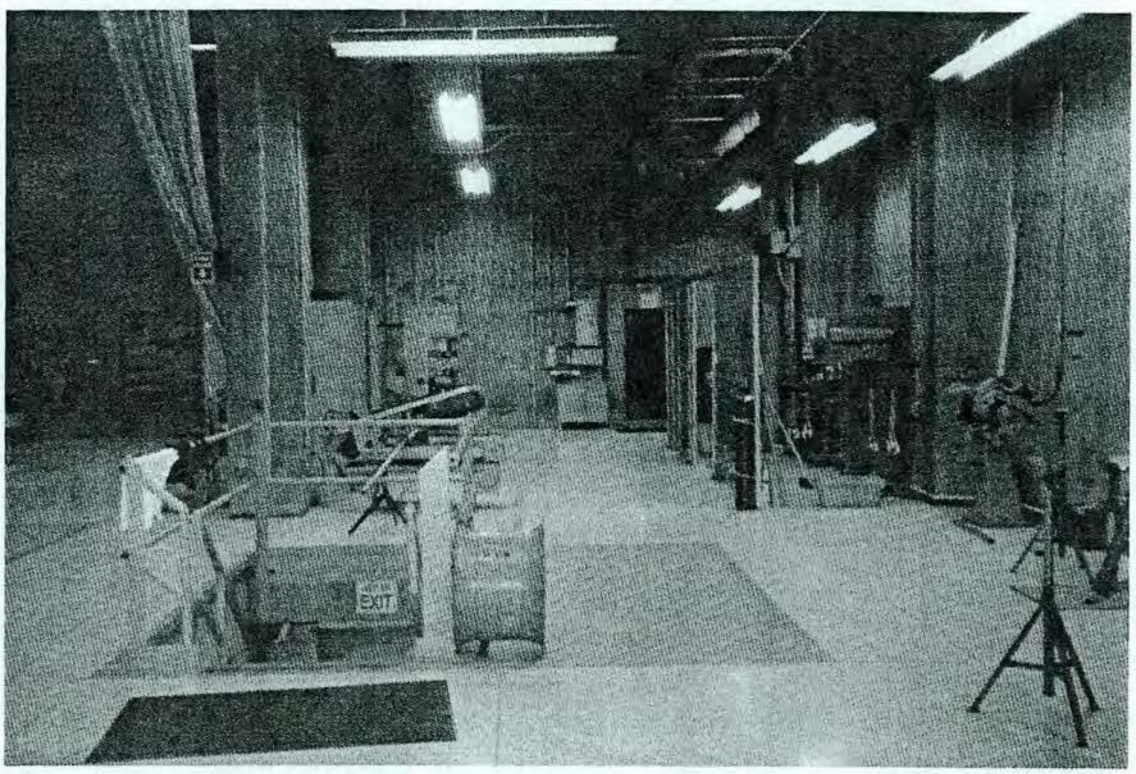

Figure 4.67. Cowans Ford Development, Cowans Ford Powerhouse; view of workroom; looking north.

Figure 4.68. Cowans Ford Development, Cowans Ford Powerhouse; view of dam/spillway inspection tunnel; looking east.

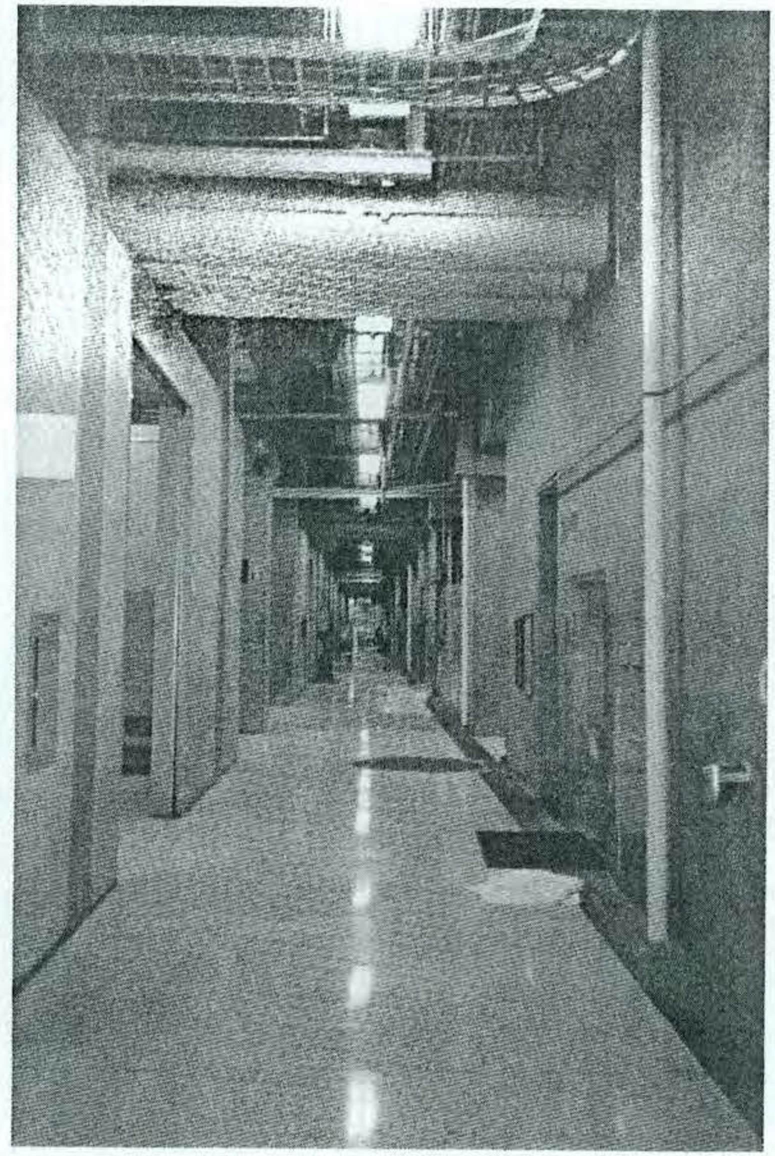

Figure 4.69. Cowans Ford Development, Cowans Ford Powerhouse; view of generator floor (generator bases at right); looking west.

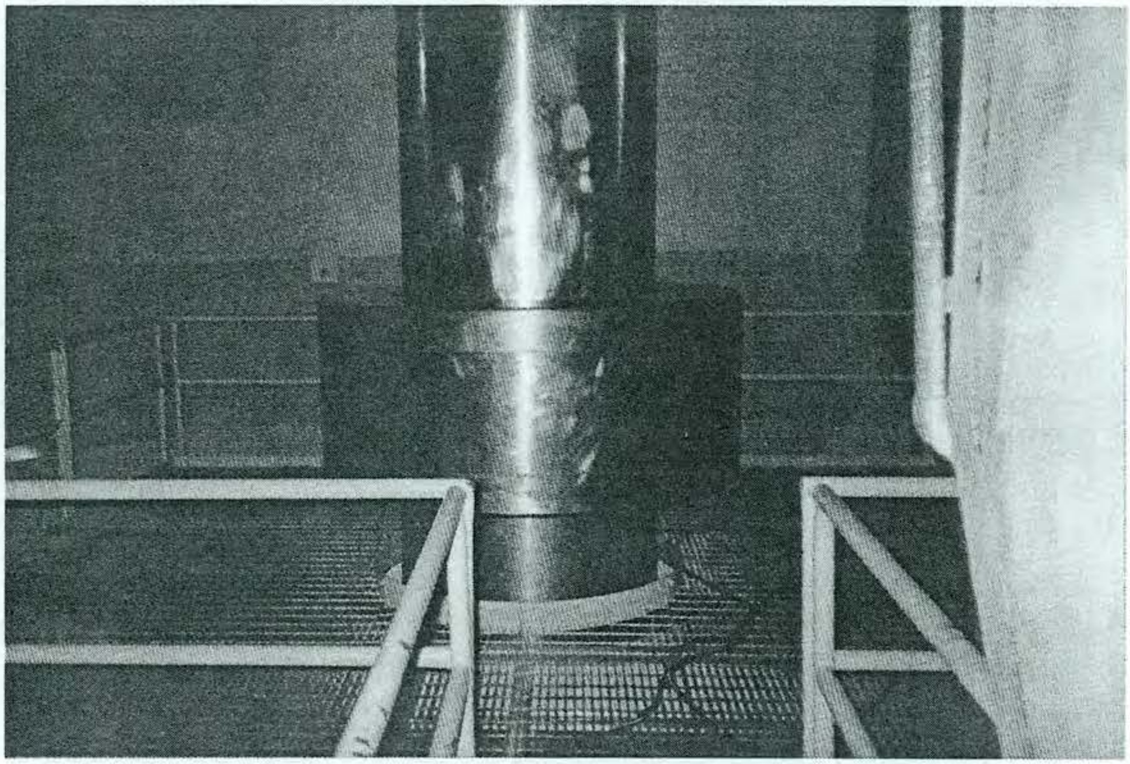

Figure 4.70. Cowans Ford Development, Cowans Ford Powerhouse; view of interior of generator base; looking north at generator-turbine shaft.

Figure 4.71. Cowans Ford Development; view of office building; looking northwest.


Figure 4.72. Cowans Ford Development; view of warehouse; looking west-northwest.


Figure 4.73. Cowans Ford Development; view of tractor shed; looking northwest.

Figure 4.74. Cowans Ford Development; view of boat storage building; looking north.

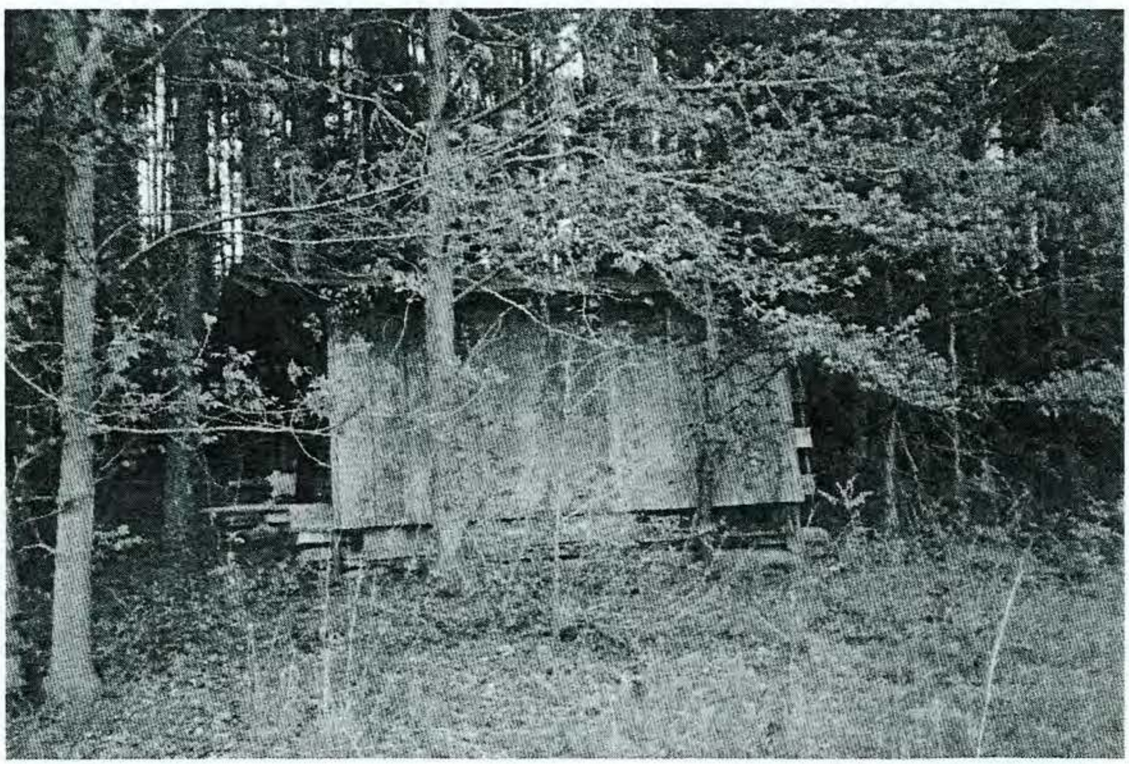

Figure 4.75. Cowans Ford Development; view of frame and metal shed; looking east.

Figure 4.76. Cowans Ford Development; view of clapboard shed; looking northeast.

Figure 4.77. Cowans Ford Development; view of trailer; looking north.

Figure 4.78. Cowans Ford Development; view of west embankment; looking north-northeast.

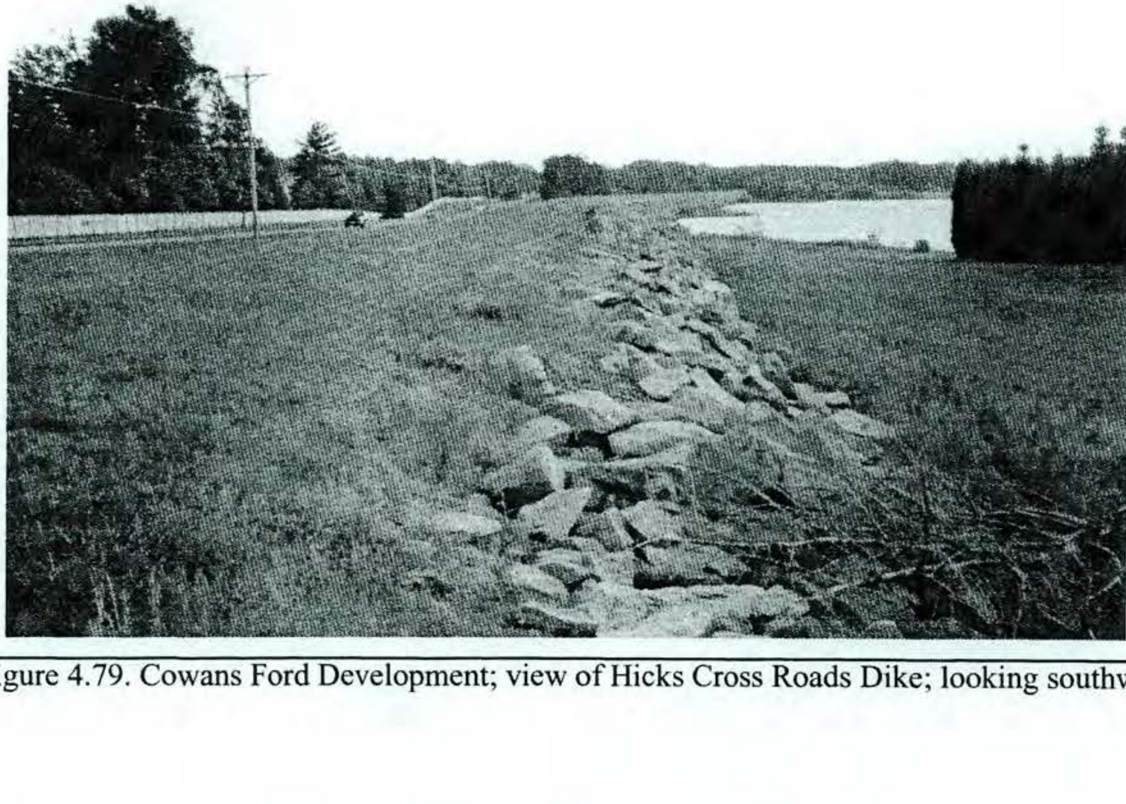

Figure 4.79. Cowans Ford Development; view of Hicks Cross Roads Dike; looking southwest.

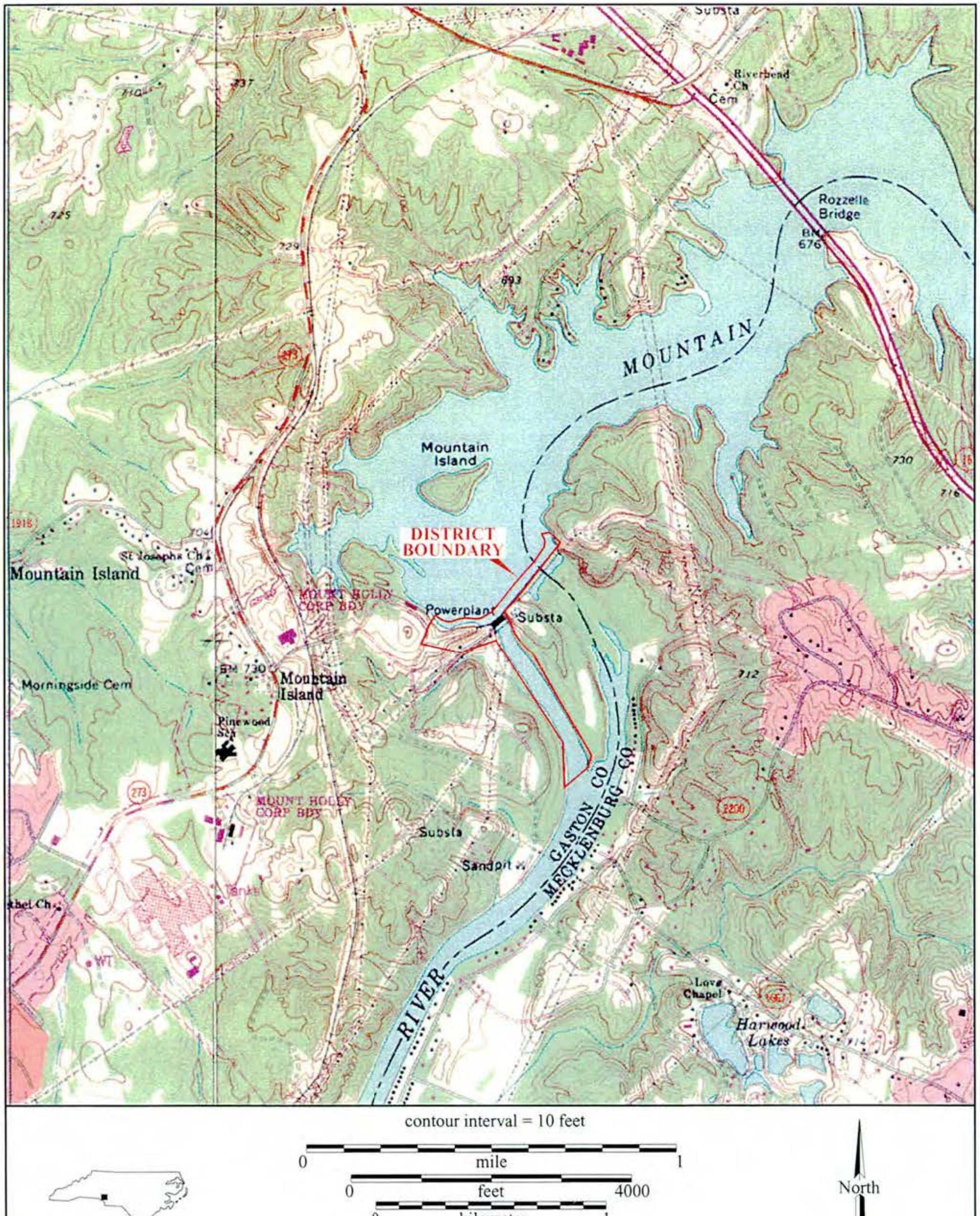

Figure 4.80. Map showing dam and powerhouse at Mountain Island Development.

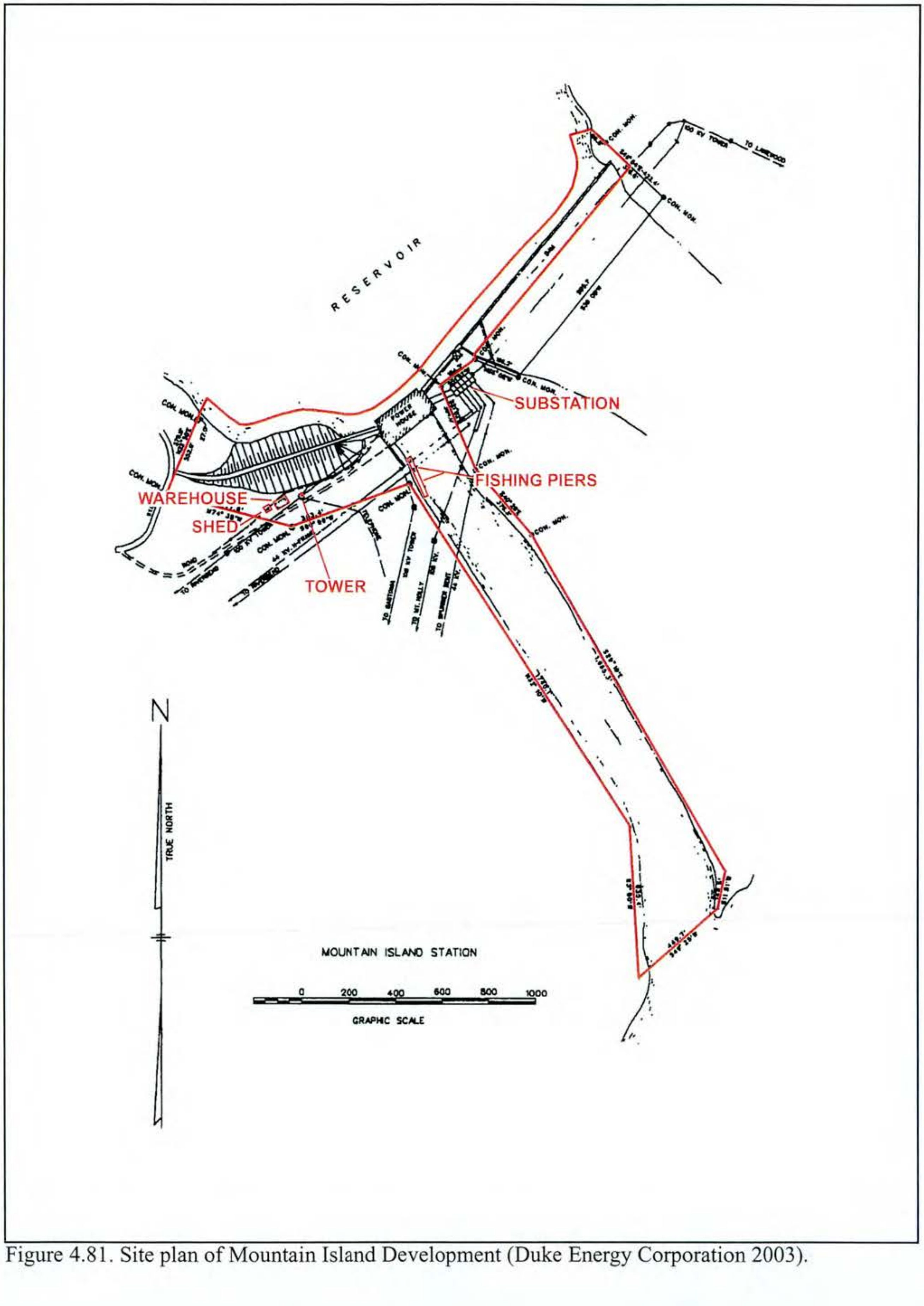

Figure 4.81. Site plan of Mountain Island Development (Duke Energy Corporation 2003).

Figure 4.82. Mountain Island Development; view of dam (west abutment), powerhouse, and substation; looking northeast.

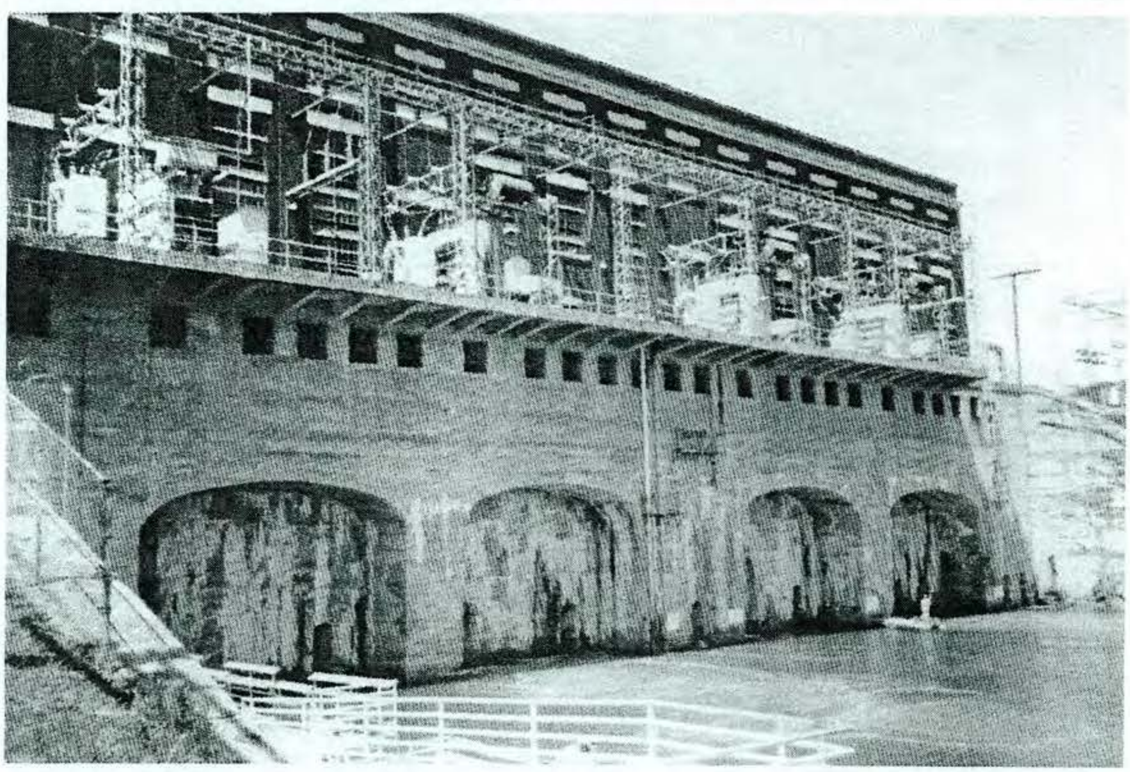

Figure 4.83. Mountain Island Development; Mountain Island Powerhouse (notice transformer ledge above basement openings and fishing piers at tailrace); looking north.

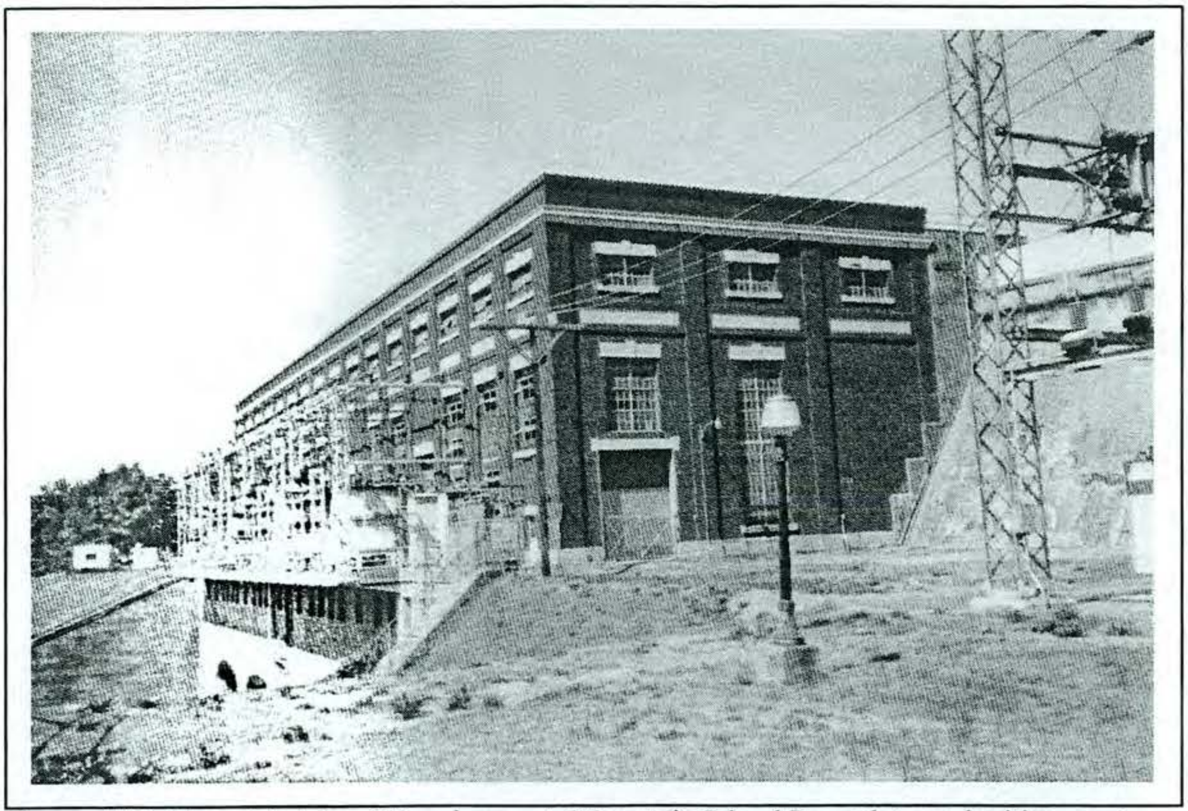

Figure 4.84. Mountain Island Development; Mountain Island Powerhouse; looking west.

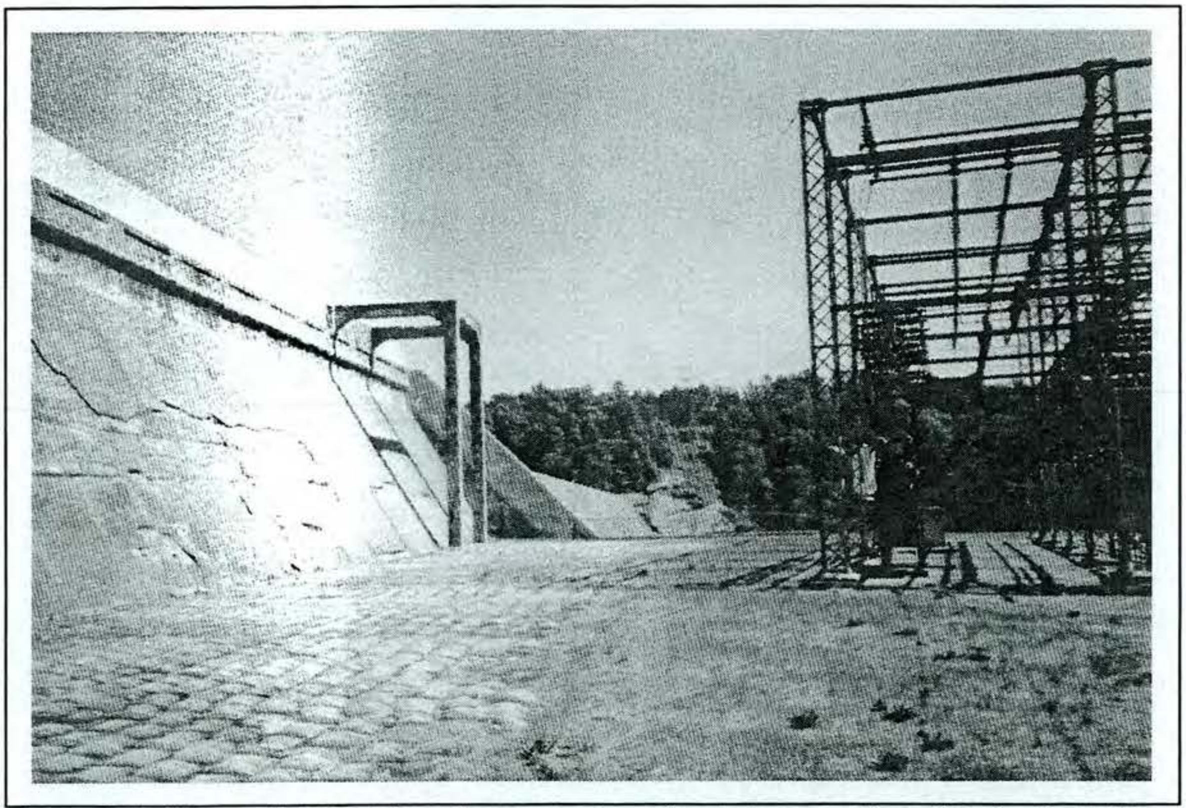

Figure 4.85. Mountain Island Development; view of east abutment (new floodwall visible at crest and matting visible at ground) and substation; looking northeast.

Figure 4.86. Mountain Island Development; view of spillway; looking northeast.

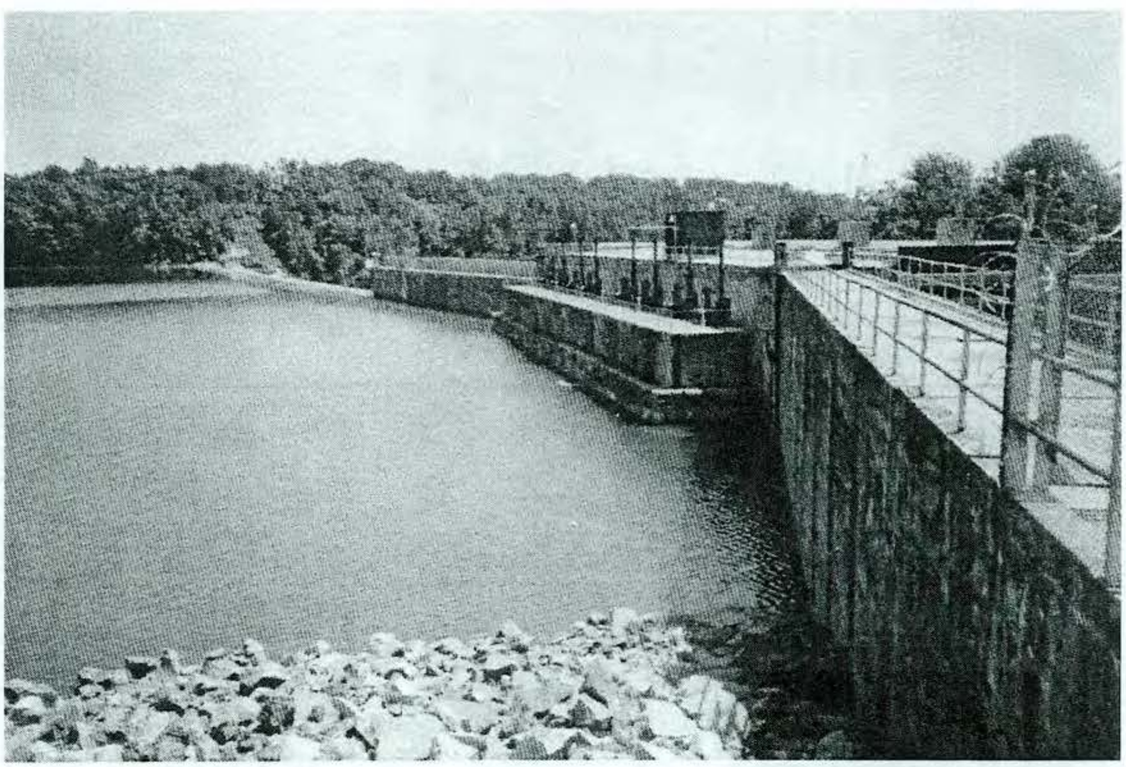

Figure 4.87. Mountain Island Development; east and west abutments with intake deck at center; looking east-northeast.

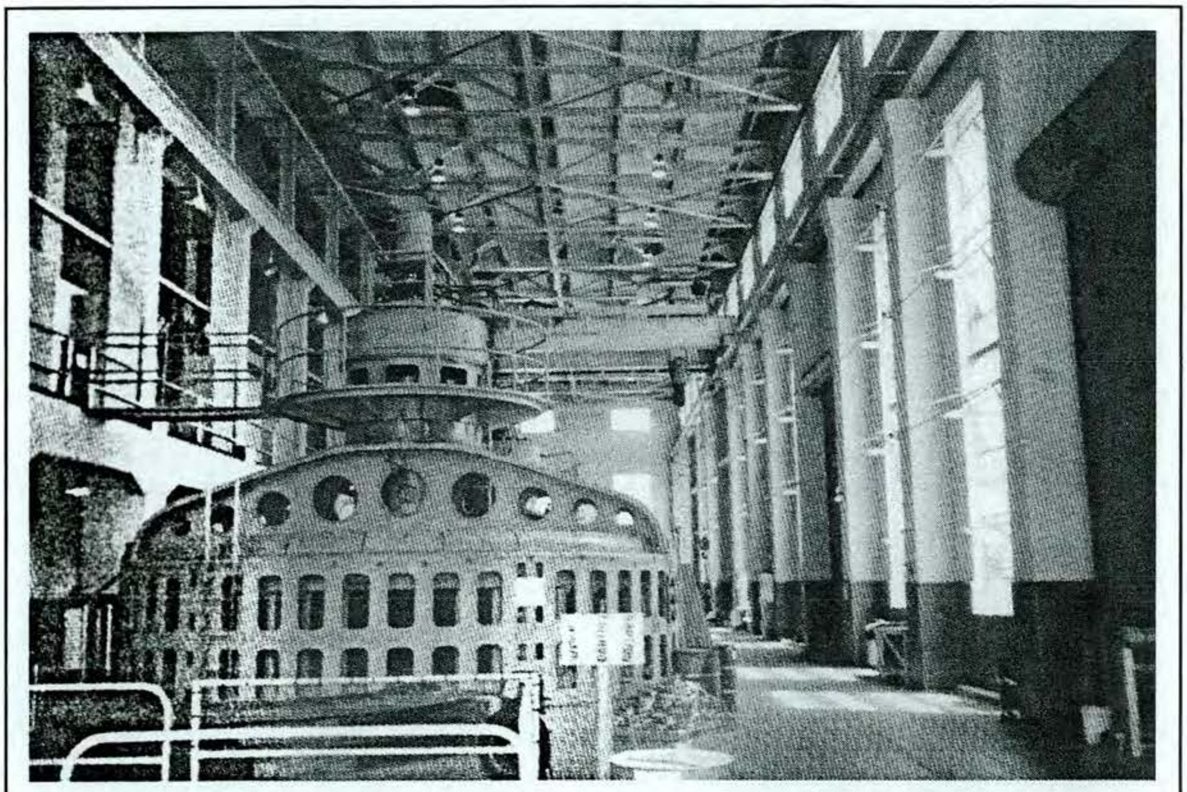

Figure 4.88. Mountain Island Development; Mountain Island Powerhouse; view of generator floor; looking east.

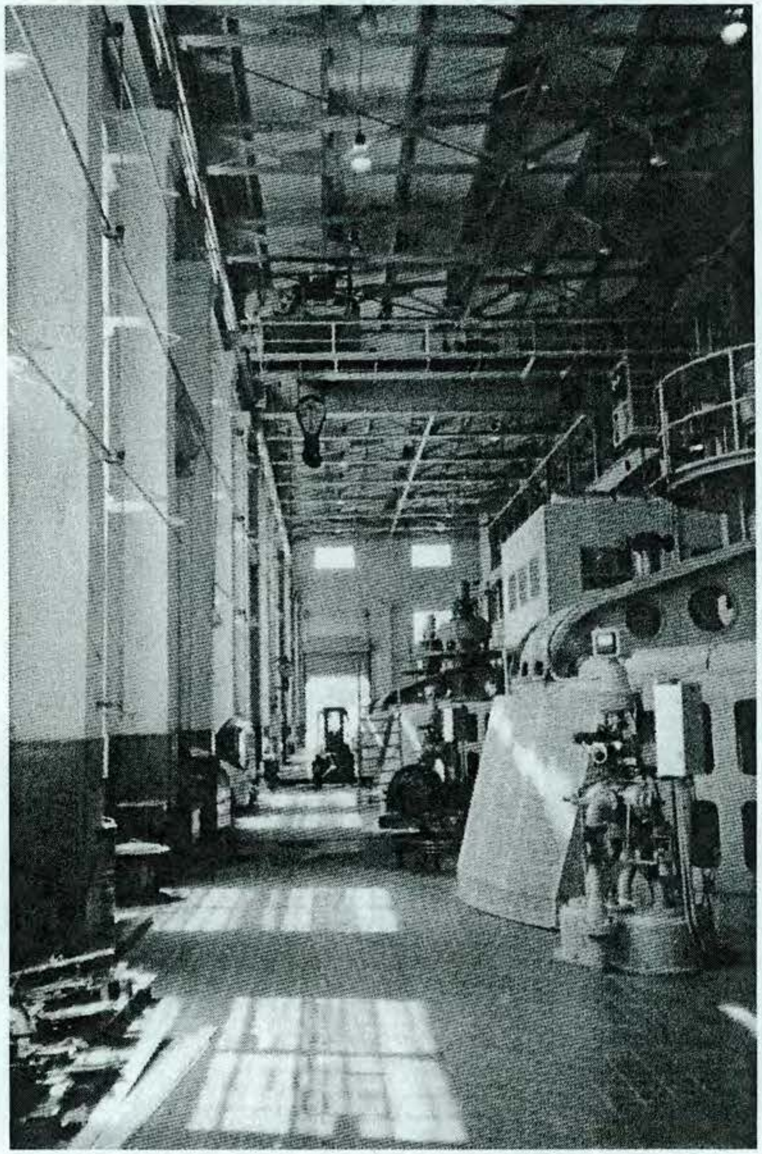

Figure 4.89. Mountain Island Development; Mountain Island Powerhouse; view of generator floor; looking west-southwest.

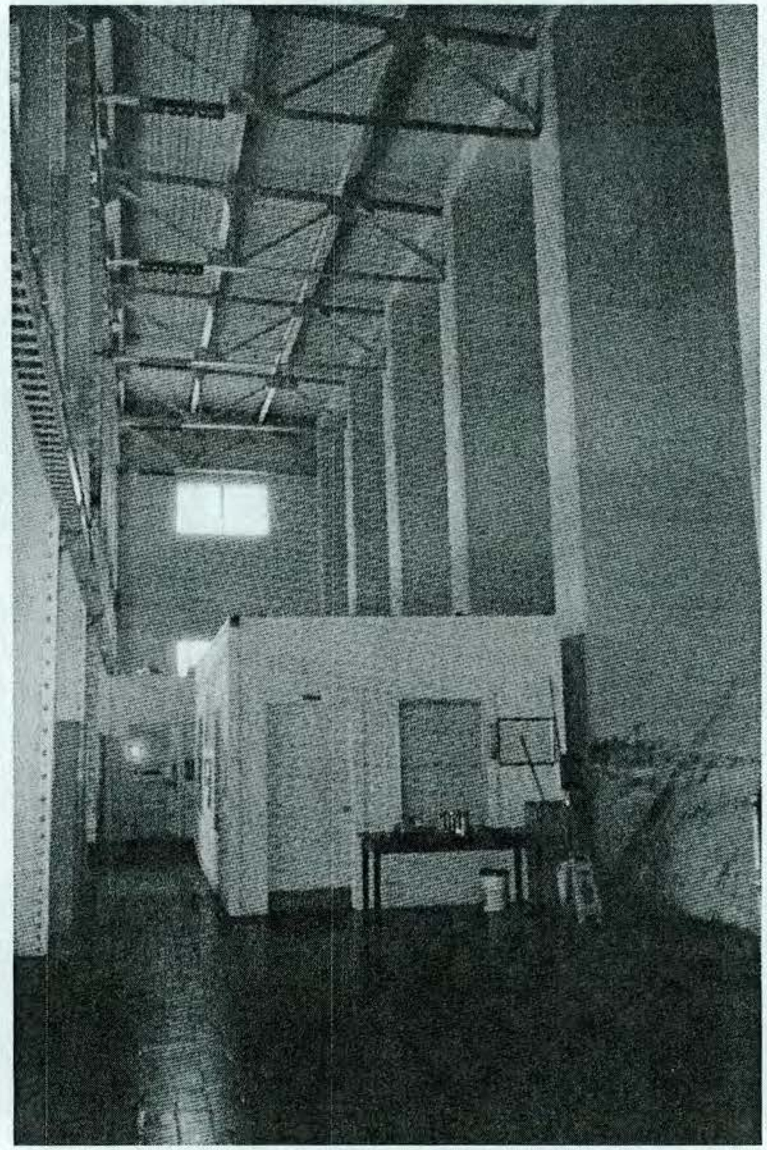

Figure 4.90. Mountain Island Development; Mountain Island Powerhouse; view of mezzanine showing office/ restroom and kitchen/break room; looking west-southwest.

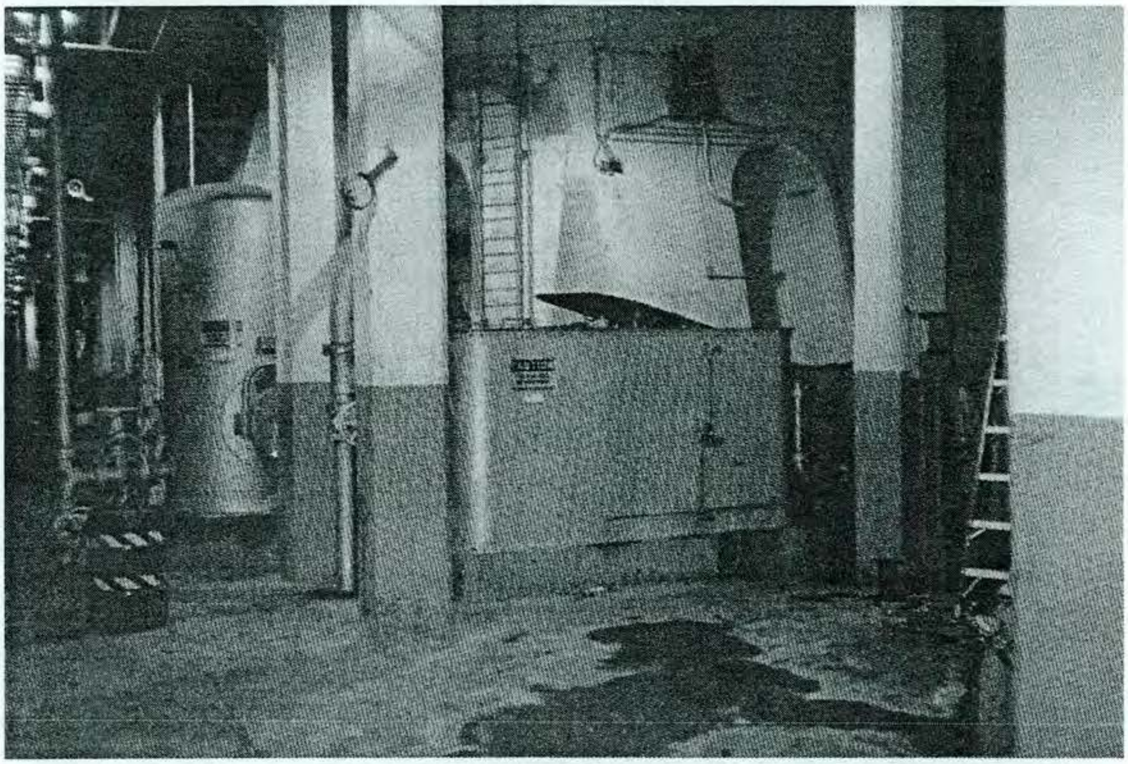

Figure 4.91. Mountain Island Development; Mountain Island Powerhouse; view of basement; looking west at exterior of generator base.

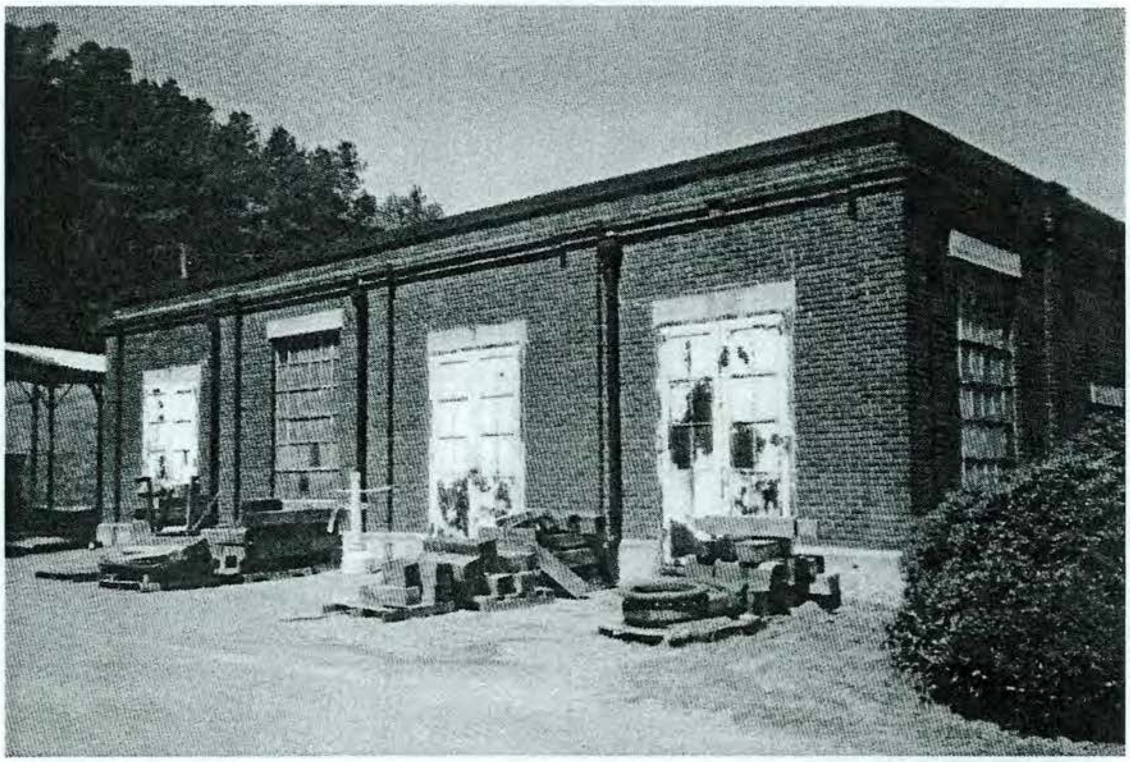

Figure 4.92. Mountain Island Development; view of warehouse; looking northwest.

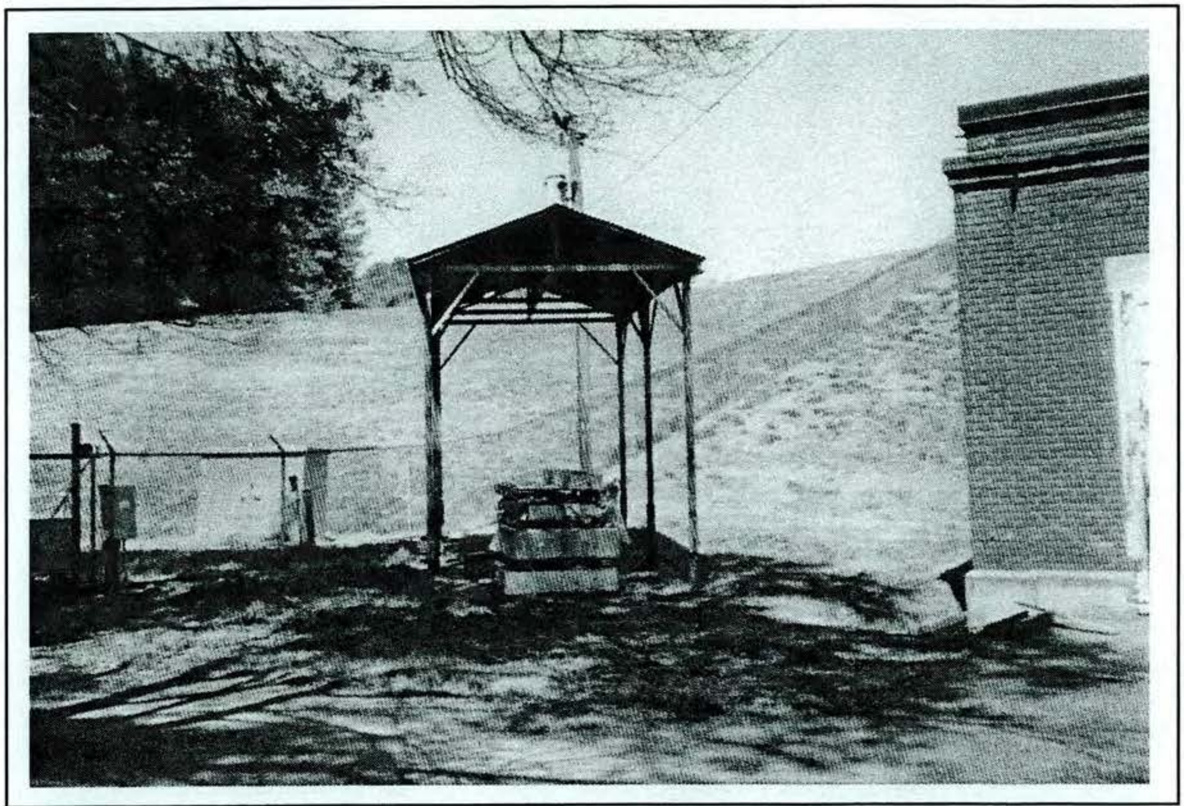

Figure 4.93. Mountain Island Development; view of open shed; looking northwest.

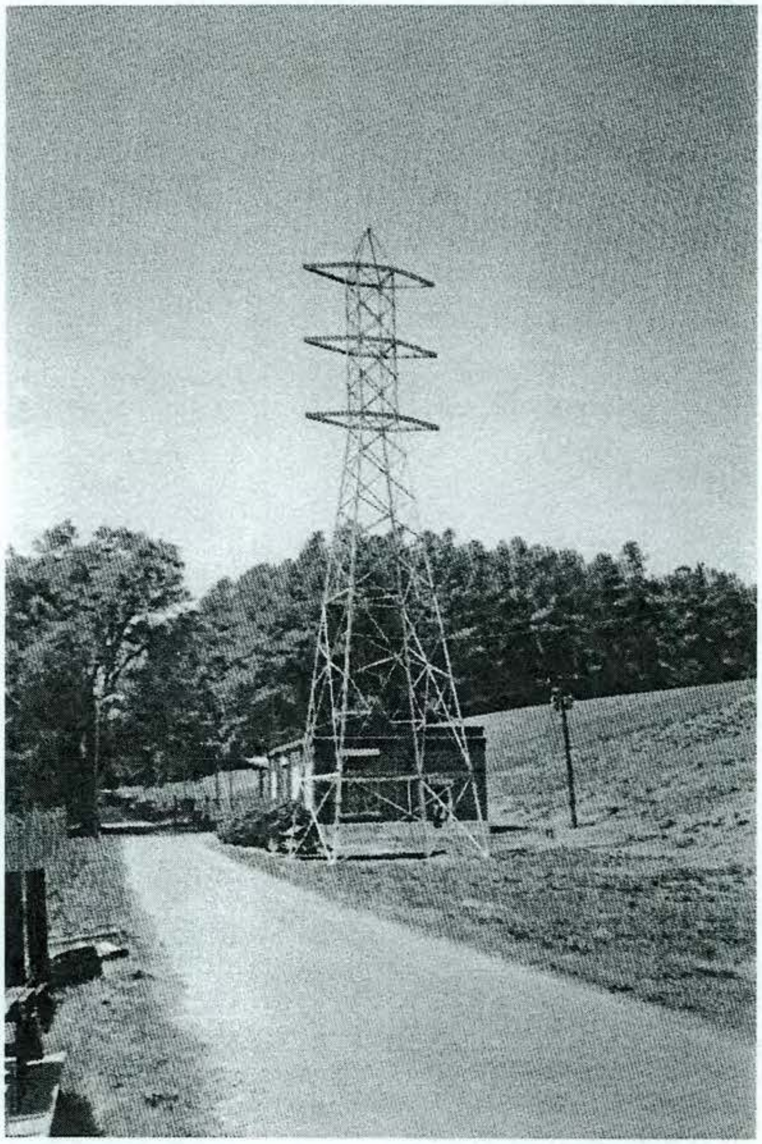

Figure 4.94. Mountain Island Development; view of historic transmission tower; looking west.

APPENDIX 2: LISTING OF DAMS

Listing of Dams in the United States.

Year Built	Dam Type*	Dam Use(s)*	Additional Uses	State	Region	Initial Ower/Operator and/or Builder
1821	timber	navigation, water supply		PA	Mid-Atlantic	Schuylkill Navigation Co./Philadelphia Water Co.
1834	masonry	hydropower	later hydroelectric use	VT	New England	Ascutney Mill Dam Company
1848	masonry	hydropower		MA	New England	Essex Company
1853	earthen	navigation, recreation		PA	Mid-Atlantic	PA State Canal Co./So. Fork Hunting & Fishing Club
1860	masonry	navigation	later hydroelectric use	WV	Mid-Atlantic	Chesapeake and Ohio Canal Company
1870	earthen	water supply		MD	Mid-Atlantic	Baltimore Water Works
1875	masonry	hydropower		MA	New England	private business interests
1884	arch (masonry)	irrigation		CA	West	Bear Valley Mutual Water Company
1888	arch (unknown material)	irrigation, water supply		CA	West	San Diego Land and Town Company
1888	concrete gravity	water supply	updated in 1911	CA	West	Spring Valley Water Company
1892	masonry	hydroelectricity		TX	Southwest	City of Austin
1893	rock, earthen	irrigation	updated in 1937	NM	Southwest	private interests, then U.S. Bureau of Reclamation
1894	timber	mining		MI	Midwest	Atlantic Mining Company
1894	earthen	water supply		TX	Southwest	Tyler Water Company
1895	masonry	irrigation		OK	Southwest	J. William Fullerton
1899	masonry	hydropower	later hydroelectric use	MA	New England	private business interests
1901	masonry	water supply		CT	New England	City of Waterbury
1901	steel	mining		MI	Midwest	Atlantic and Baltic mining companies
1904	concrete gravity	water supply	updated in ca. 1965	VA	South	City of Lynchburg
1904	masonry	water supply		CO	West	Denver Union Water Company
1904	rock	irrigation		ID	West	private interests

Year Built	Dam Type*	Dam Use(s)*	Additional Uses	State	Region	Initial Ower/Operator and/or Builder
1905	concrete gravity	irrigation		NV	West	U.S. Reclamation Service
1905	masonry	water supply		MA	New England	Metropolitan Water Board (Boston)
1906	earthen, rock	irrigation, hydroelectricity		ID	West	U.S. Reclamation Service
1907	Ambursen (concrete)	hydroelectricity		ME	New England	Bar Harbor and Union River Power Company
1907	masonry	water supply		NY	Mid-Atlantic	City of New York
1907	masonry	water supply (industrial and domestic)		OH	Midwest	Youngstown Sheet and Tube Company
1908	masonry	hydroelectricity		GA	South	Columbus Power Company
1908	earthen	hydroelectricity		MI	Midwest	Grand Rapids-Muskegon Power Company
1908	concrete gravity	water supply		AZ	Southwest	U.S. Reclamation Service
1909	rock	irrigation		AZ	Southwest	U.S. Reclamation Service
1909	multiple-arch (concrete)	logging		CA	West	Hume-Bennett Lumber Company
1909	Ambursen (concrete)	irrigation		WY	West	La Prele Ditch and Reservoir Company
1909	concrete gravity	industry		PA	Mid-Atlantic	Bayless Pulp and Paper Company
1910	concrete gravity	hydroelectricity		PA	Mid-Atlantic	McCall Ferry Power Co./PA Power and Light Co.
1910	arch (masonry)	irrigation		WY	West	U.S. Reclamation Service
1910	arch (concrete)	irrigation		WY	West	U.S. Reclamation Service
1911	concrete gravity	hydroelectricity		GA	South	Columbus Power Company (?)
1911	concrete gravity	hydroelectricity		TN	South	East Tennessee Power Company
1911	earthen	irrigation		SD	Midwest	U.S. Reclamation Service

Year Built	Dam Type*	Dam Use(s)*	Additional Uses	State	Region	Initial Ower/Operator and/or Builder
1911	masonry	irrigation, water supply, hydroelectricity		AZ	Southwest	U.S. Reclamation Service
1912	concrete gravity	hydroelectricity		MT	West	Helena Power and Transmission Company
1913	Ambursen (concrete)	hydroelectricity		GA	South	Georgia Railway and Power Company
1913	concrete gravity	hydroelectricity		GA	South	Georgia Railway and Power Company
1913	concrete gravity	hydroelectricity, navigation		IA	Midwest	Mississippi River Power Company
1913	earthen	irrigation		UT	West	U.S. Reclamation Service
1913	earthen	hydroelectricity	updated in 1927	CA	West	Great Western Power Company
1914	concrete gravity	water supply		CT	New England	Hartford Board of Water Commissioners
1914	constant-angle (concrete)	hydroelectricity		AK	West	Alaska-Juneau Mining Company
1914	multiple-arch (concrete)	irrigation		OR	West	U.S. Reclamation Service
1915	earthen	irrigation, hydroelectricity		NV	West	U.S. Reclamation Service
1916	concrete gravity	water supply		NY	Mid-Atlantic	City of New York
1916	concrete gravity	water supply		NY	Mid-Atlantic	City of New York
1916	concrete gravity	irrigation		NM	Southwest	U.S. Reclamation Service
1916	concrete gravity	irrigation		ID	West	U.S. Reclamation Service
1917	Ambursen (concrete)	navigation, hydroelectricity		MN	Midwest	U.S. Army Corps of Engineers
1917	multiple-arch (concrete)	water supply	updated in 1925	UT	West	City of Salt Lake
1918	multiple-arch (concrete)	irrigation		CA	West	Atchison, Topeka and Santa Fe Railway
1919	constant-angle (concrete)	hydroelectricity		CA	West	Pacific Gas and Electric Company
1920	arch (concrete)	irrigation		NM	Southwest	Charles Springer

Year Built	Dam Type*	Dam Use(s)*	Additional Uses	State	Region	Initial Ower/Operator and/or Builder
1920	multiple-arch (concrete)	irrigation		ID	West	Mormon farming interests
1921	earthen	flood control		OH	Midwest	Miami Conservancy District
1923	multiple-arch (concrete)	flood control		AZ	Southwest	City of Phoenix/Salt River Valley Water Users Assn./Maricopa County/Santa Fe Railway/other parties
1923	concrete gravity	water supply	updated in 1938	CA	West	City of San Francisco
1924	Ambursen (concrete)	water supply		TX	Southwest	City of Cisco
1924	multiple-arch (concrete)	irrigation		CA	West	Littlerock Creek and Palmdale irrigation districts
1924	concrete gravity	water supply		CA	West	City of Los Angeles
1925	concrete gravity	hydroelectricity, navigation		AL	South	U.S. Government
1925	concrete gravity	irrigation	a diversion dam	WY	West	U.S. Bureau of Reclamation
1926	earthen	water supply, hydroelectricity		RI	New England	City of Providence
1926	concrete gravity, earthen	hydroelectricity		PA	Mid-Atlantic	Pennsylvania Power and Light Company
1926	concrete gravity	hydroelectricity		WV	Mid-Atlantic	West Virginia Power and Transmission Company
1926	concrete gravity	water supply		CA	West	Los Angeles Bureau of Water and Power
1928	concrete gravity	hydroelectricity		MD	Mid-Atlantic	Philadelphia Electric Company
1928	dome (concrete)	irrigation		AZ	Southwest	U.S. Indian Service
1928	Ambursen (concrete)	irrigation		CA	West	U.S. Bureau of Reclamation
1929	arch (concrete)	irrigation		MT	West	U.S. Bureau of Reclamation
1929	constant-angle (concrete)	hydroelectricity		WA	West	City of Seattle
1930	arch (concrete)	hydroelectricity		NC	South	Carolina Power and Light
1930	earthen	hydroelectricity		SC	South	Lexington Water Power Company

Year Built	Dam Type*	Dam Use(s)*	Additional Uses	State	Region	Initial Ower/Operator and/or Builder
1930	arch (concrete)	hydroelectricity		TN	South	ALCOA
1931	multiple-arch (concrete)	hydroelectricity		MI	Midwest	Copper Range Company
1931	concrete gravity	hydroelectricity		MO	Midwest	Union Electric Company
1931	earthen	irrigation		NE	Midwest	Central Nebraska Public Power and Irrigation District
1931	earthen	irrigation		UT	West	U.S. Bureau of Reclamation
1932	concrete gravity	irrigation		OR	West	U.S. Bureau of Reclamation
1935	concrete gravity	hydroelectricity, irrigation, water supply		NV	West	U.S. Bureau of Reclamation
1936	concrete gravity	hydroelectricity, navigation		AL	South	TVA
1936	concrete gravity	hydroelectricity, flood control		TN	South	TVA
1937	steel	navigation		OH	Midwest	U.S. Army Corps of Engineers
1937	concrete gravity	hydroelectricity, navigation		OR	West	U.S. Army Corps of Engineers
1938	arch (concrete)	water supply		AZ	Southwest	Metropolitan Water District of Southern California
1938	concrete gravity	flood control, irrigation		NM	Southwest	U.S. Army Corps of Engineers
1938	multiple-arch (concrete)	hydroelectricity		TX	Southwest	Central Texas Hydro-Electric Company/Lower Colorado River Authority (state)
1939	multiple-arch (concrete)	flood control, irrigation		AZ	Southwest	Salt River Valley Water Users Association/U.S. Bureau of Reclamation
1940	earthen	water supply		MA	New England	Metropolitan District Commission (Boston)
1940	concrete gravity	hydroelectricity		NC	South	TVA
1940	multiple-arch (concrete)	hydroelectricity		SC	South	Abbeville Power Company/City of Abbeville

Year Built	Dam Type*	Dam Use(s)*	Additional Uses	State	Region	Initial Ower/Operator and/or Builder
1940	multiple-arch (concrete)	hydroelectricity, flood control		OK	Southwest	Grand River Dam Authority (state)
1940	earthen	flood control, navigation		MT	West	U.S. Army Corps of Engineers
1941	earthen	hydroelectricity, flood control, navigation, water supply		SC	South	South Carolina Public Service Authority
1941	rock	irrigation		UT	West	U.S. Bureau of Reclamation
1942	concrete gravity	water supply		TX	Southwest	Lower Colorado River Authority (state)
1942	concrete gravity	irrigation		CA	West	U.S. Bureau of Reclamation
1942	concrete gravity	hydroelectricity, irrigation		WA	West	U.S. Bureau of Reclamation
1944	concrete gravity	hydroelectricity, flood control, navigation		KY	South	TVA
1944	earthen	irrigation		NE	Midwest	U.S. Bureau of Reclamation
1945	concrete gravity	hydroelectricity		NC	South	TVA
1945	concrete gravity	irrigation		CA	West	U.S. Bureau of Reclamation
1954	earthen	hydroelectricity, flood control		ND	Midwest	U.S. Army Corps of Engineers
1954	earthen	hydroelectricity		SD	Midwest	U.S. Army Corps of Engineers
1958	earthen	hydroelectricity		SD	Midwest	U.S. Army Corps of Engineers
1963	arch (concrete)	hydroelectricity		AZ	Southwest	U.S. Bureau of Reclamation
1964	arch (concrete)	hydroelectricity		UT	West	U.S. Bureau of Reclamation

Source: Jackson 1988.

* With multiple types or uses, the first type or use listed is considered predominant.

TRC

Customer-Focused Solutions