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operating license environmental report

VOLUME II

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VOLUME II

1955

APPENDIX 2A

REPORT ON THE BASELINE BIOTIC SURVEY
BROAD RIVER STUDY AREA
PARR, SOUTH CAROLINA
MARCH 1971 TO MAY 1973
FOR SOUTH CAROLINA ELECTRIC & GAS COMPANY

Dames & Moore
Project No. 5182-046-17

DAMES & MOORE

SUITE 200. 455 EAST PACES FERRY ROAD · ATLANTA, GEORGIA 30305 · (404) 262-2915
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February 11, 1974

South Carolina Electric & Gas Company
Post Office Box 764
Columbia, South Carolina 29218

Attn: Mr. E. H. Crews, Jr.
Mr. H. T. Babb
Mr. W. E. Moore
Mr. W. R. Baehr

Gentlemen:

We are pleased to transmit herewith our report entitled "Report on the Baseline Biotic Survey, Broad River Study Area, Parr, South Carolina, March 1971 to May 1973, for South Carolina Electric & Gas Company."

The report presents the results of a comprehensive biotic study performed in connection with the proposed Virgil C. Summer Nuclear Station project and Parr Hydroelectric Project to be constructed near Parr, South Carolina. The baseline characteristics of the ecosystems present in the area of the proposed projects are described in the report.

We have enjoyed preparing this report on your behalf and look forward to being of continuing service.

Yours very truly,

DAMES & MOORE

Robert C. K. Au

Robert C. K. Au
Partner

James D. Knauss

James D. Knauss, Ph.D.
Project Ecologist

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1.0 SCOPE OF WORK

This report presents results of our baseline biotic survey of the Broad River Study Area, Parr, South Carolina, for South Carolina Electric & Gas Company. The study consisted of nine sampling periods between March, 1971, and June, 1973. The purpose of our study was to establish the baseline characteristics of the ecosystems present in the Broad River Study Area. The location of the Study Area is shown on Figure 1.0.1. This baseline information will provide the basis for validating predictions regarding anticipated environmental impact as a result of the construction and operation of the proposed Parr Hydroelectric Project (FPC Project No. 1894) and the proposed Virgil C. Summer Nuclear Station project (AEC Docket No. 50-395).

The proposed Parr Hydroelectric Project and Virgil C. Summer Nuclear Station project are integral parts of a planned electric power generating northwest of Columbia, the state capital. The most important feature of the Parr Hydroelectric Project is the Fairfield Pumped Storage Hydro Facility which will have a total capacity of 480 MWs. The nuclear station will have a generating capacity of approximately 900 MWs.

To provide the necessary lower reservoir capacity for the pumped storage plant, the existing Parr Dam will be raised approximately nine feet to Elevation 266 feet by means of Bascule gates. This will result in an increase in surface area of Parr Reservoir from 1,850 acres to about 4,400 acres and extend the reservoir about 13 miles upstream of Parr Dam. The upper impoundment (Monticello) of the pumped storage plant will be created by constructing four earthen dams (Frees Creek Dam) with a crest elevation of 434 feet across Frees Creek, a tributary of the Broad River. The 6800-acre Monticello Impoundment will also provide cooling water for the nuclear station, which will be constructed along the southern shoreline of the reservoir.

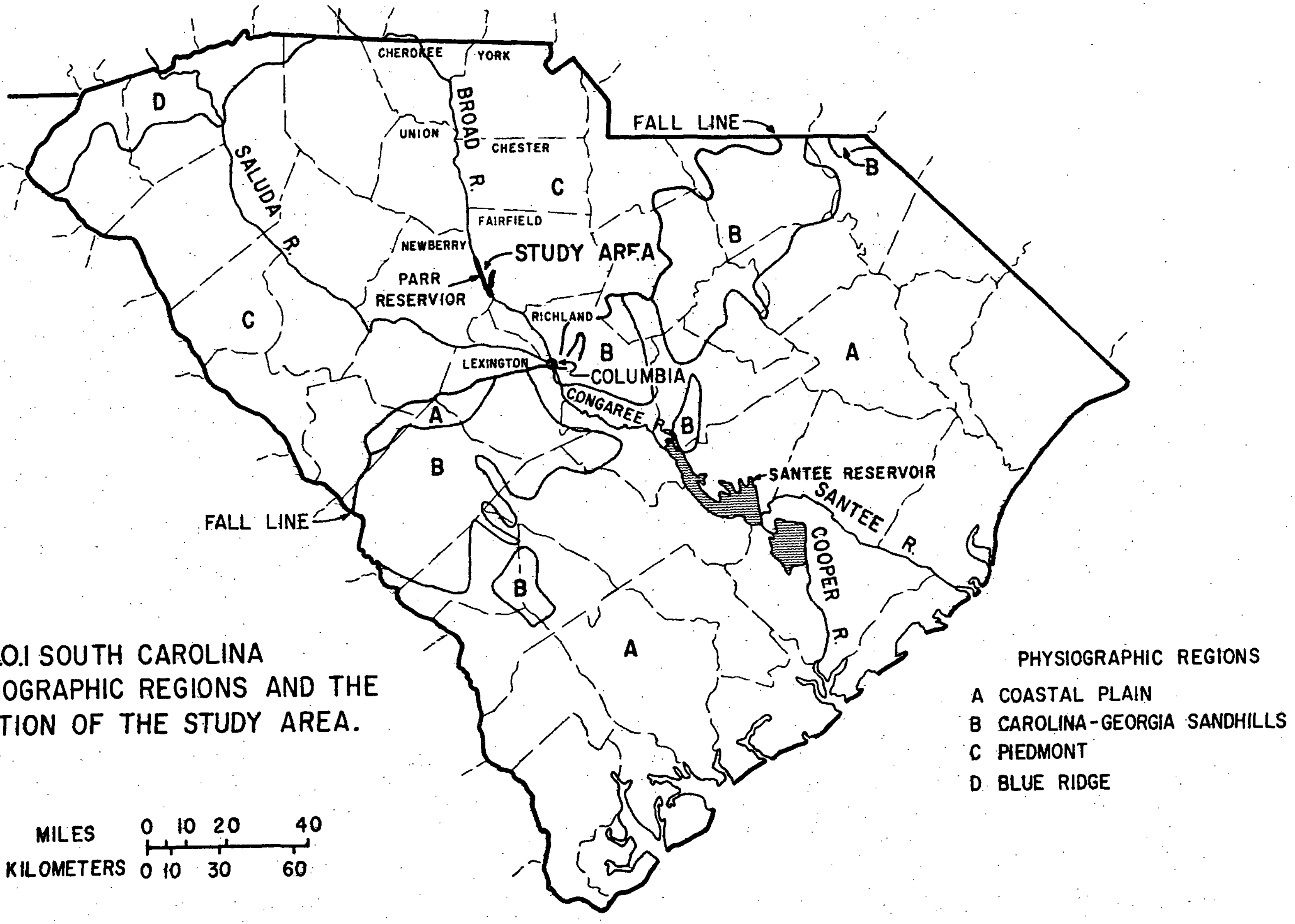


FIGURE 1.0.1 SOUTH CAROLINA PHYSIOGRAPHIC REGIONS AND THE LOCATION OF THE STUDY AREA.

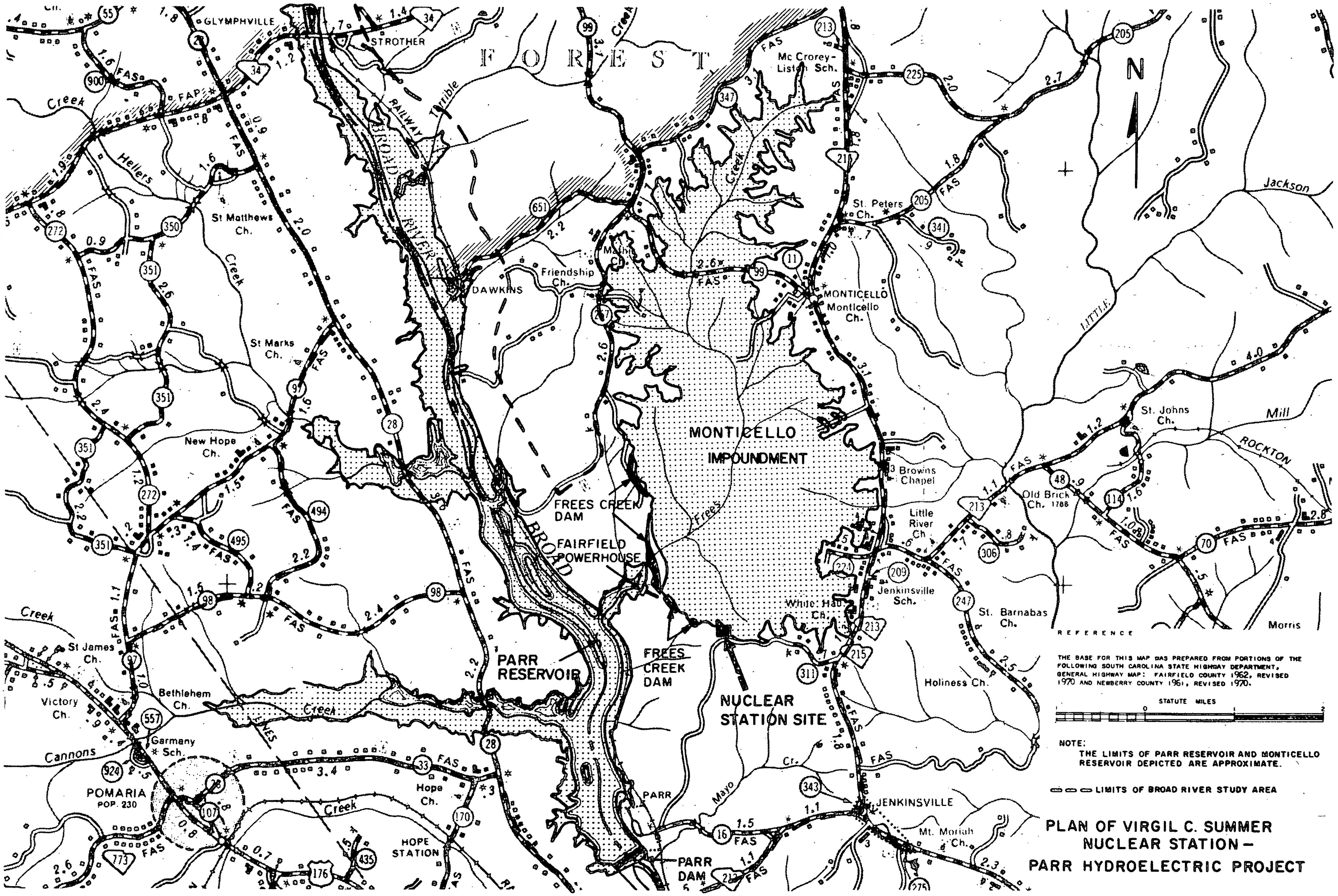
ADAPTED FROM ELLERBE AND SMITH (1964:2)

Monticello Impoundment will have a maximum operating pool level of Elevation 425 feet. During normal pumped storage operations, Monticello Impoundment will fluctuate from Elevation 425 to 420.5 feet, and Parr Reservoir from Elevation 256 to 266 feet. Important features of the proposed projects are shown on Figure 1.0.2.

As outlined in our proposal dated 19 March 1971, our study is to be conducted in two phases, preoperational and operational. The objectives of the preoperational program are: (1) Collect baseline information on aquatic and terrestrial organisms present in the study area; (2) Evaluate ecological relationships and assess key species in evaluating environmental change; (3) Develop programs to determine the effects of construction and operation of the proposed projects on the environment.

Although the baseline studies ended when the construction of the Virgil C. Summer Nuclear Station began last year, baseline information will still be collected in those areas unaffected by construction activities. This additional baseline information will aid in identifying natural population variations within the system.

This report has been divided into aquatic and terrestrial ecosystems. The terrestrial system includes studies on soil, vegetation, insects, birds, and mammals while the aquatic system includes information on water quality, plankton, periphyton, benthos, vascular hydrophytes, and fishes. Specific information on each of these groups are presented in the subsequent sections. A summary of the aquatic and terrestrial ecology appears in Sections 4.0 and 6.0, respectively.



REFERENCE

THE BASE FOR THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING SOUTH CAROLINA STATE HIGHWAY DEPARTMENT, GENERAL HIGHWAY MAP: FAIRFIELD COUNTY 1962, REVISED 1970 AND NEWBERRY COUNTY 1961, REVISED 1970.

NOTE:
THE LIMITS OF PARR RESERVOIR AND MONTICELLO RESERVOIR DEPICTED ARE APPROXIMATE.

⊂⊃⊂⊃⊂⊃ LIMITS OF BROAD RIVER STUDY AREA

PLAN OF VIRGIL C. SUMMER NUCLEAR STATION –
PARR HYDROELECTRIC PROJECT

FIGURE 1.0.2

2.0 INTRODUCTION

2.1 GEOGRAPHIC LOCATION

South Carolina is bordered on the east by the Atlantic Ocean and on the north by North Carolina. The Savannah River separates the state's southwestern border from Georgia.

Five major river systems dissect South Carolina: the Savannah, the Combahee, the Edisto, the Congaree-Santee-Cooper, and the Pee Dee-Bleak. The Broad River, located approximately in the middle of the state, is a tributary of the Congaree-Santee-Cooper River System (Figure 1.0.1). The Congaree-Santee-Cooper River System lies within two of the three physiographic regions in South Carolina; the Piedmont, Carolina-Georgia Sandhills, and the Coastal Plains. The third region, the Blue Ridge Mountains, is northwest of the system (Figure 1.0.1).

The Piedmont ranges in elevation from 61 m (about 200 ft) in the southeast to nearly 457 m (1,500 ft) in the northwest and is separated from the Carolina-Georgia Sandhills and the Coastal Plain by the Fall Line (Kirk 1970).

The Broad River originates in the mountainous region of western North Carolina. It separates six counties in South Carolina including Newberry and Fairfield, where the study area is located. Approximately 32 km (20 miles) downstream from the southern junction of the two counties, the Broad River is joined by the Saluda River in Columbia to form the Congaree River, which then flows into the Santee Reservoir. The Santee and Cooper Rivers emerge from the Santee Reservoir and flow to the Atlantic Ocean (Figure 1.0.1).

The Broad River was dammed in 1914 at Parr, South Carolina to form Parr Reservoir. Tributaries entering this system at Parr Reservoir include, on the west side, Cannons Creek, Hellers Creek and the Enoree

River, and on the east side, Frees Creek and Terrible Creek. The study area is centered around this system and is approximately 15 airline miles southeast of Winnsboro and Newberry.

2.2 CLIMATOLOGY

The Piedmont of South Carolina has a continental climate with periods of warm, humid weather during the summer months. A U.S. Geological Survey (USGS) weather station was installed at Parr, South Carolina in 1947. This station has recorded temperatures and precipitation for 25 years. This information is assumed to be the best approximation of the norm and the monthly temperature changes in the vicinity of Frees Creek and Parr Reservoir.

Spring days are warm with cool nights, while late spring and summers are hot. The Bermuda high pressure system is the major factor influencing the summers of South Carolina (USDC 1971b). The warmest month, July, averaged 81°F from 1969 to 1971 while the coolest month, January, averaged 44°F during the past four years. The area may experience temperatures below freezing once out of two or three days during the winter (USDC 1971b). The Blue Ridge Mountains, about 160 km (100 miles) northwest of Parr (Figure 1.0.1), modify the polar air outbreaks that reach this area during the winter. These outbreaks have caused temperatures to fall below zero on rare occasions and contribute to the infrequent occurrence of snow fall (USDC 1971b). Snow was not recorded at Parr in 1969 or 1972 but an average of 5.08 cm (2.0 in) water equivalent was recorded in December 1970 and 1971. Unusual climatic conditions produced 16.5 cm (6.5 in) of snow on 25 March 1971. The soil seldom freezes to a depth of more than 6.4 cm (2.5 in) and then only for three or four days (Dames & Moore 1972).

2.2.1 PRECIPITATION

The average annual precipitation is 116 cm (45.7 in) at Parr based on three years of measurements and 131 cm (51.6 in) at Little Mountain (10 km from Parr). The maximum variation in annual precipitation between Parr and Little Mountain of 25.4 cm (10.0 in) occurred in 1970 (Dames & Moore 1972).

Precipitation at four recording locations show two peaks of accumulation; one in the spring (March) and the other during late summer and autumn (July, August, September, and October). The latter peak coincides with a peak in the frequency of thunderstorms during July. Thunderstorms may occur about one day out of three during the late summer. The moisture is supplied by southwesterlies that flow around the semi-permanent offshore Bermuda high pressure system. The incidence of tropical storms and hurricanes may affect the area about once every two years. Precipitation associated with these tropical storms ranged from 19.1 cm (7.5 in) to over 53.3 cm (21 in) in a calendar month (Dames & Moore 1971).

The incidence of passing tropical storms is greatest in September (USDC 1971b), their intensity being related to the distance from the coast.

2.2.2 RIVER STAGE

Stream flow data from a USGS gage at Richtex, South Carolina, were presented in the Preliminary Safety Analysis Report for the Virgil C. Summer Nuclear Station. Historical floods recorded at Richtex indicate two flood seasons; one from January to April and the other from July to October.

The monthly river stage (depth) from January 1969 through March 1972 pertinent to the Broad River and Parr Reservoir was obtained for Blair (USDC 1969, 1970, 1971a; pers. comm.). The river stage at Blair reflect the monthly trend in flow rate that may influence the biota in and along the Broad River.

The maximum peaks occurred in April 1969 at 6.64 m (21.8 ft), August 1971 at 6.55 m (21.5 ft), February and October 1971 at 6.37 m (20.9 ft) each, December 1971 at 6.43 m (21.1 ft), January 1972 at 6.67 m (21.9 ft), and June 1972 at 7.77 m (25.5 ft). The months with frequent river levels above flood stage include January, February, March, August, and October.

2.3 TOPOGRAPHY OF THE BROAD RIVER WATERSHED

The topography of the Broad River watershed in the Piedmont region is a mature plain containing numerous youthful streams, rolling, hilly terrain with few actual rock outcrops. The surface of this peneplain has been dissected by stream rejuvenation forming a dendritic pattern. Although the tributary streams of the Broad River are generally in a youthful stage of stream valley development, the Broad River is in the early maturity stage. The valley is deeply incised with a relatively narrow flood plain, part of which was impounded by Parr Reservoir.

A topographic map of the area surrounding Parr Reservoir and Frees Creek is located inside of the back cover. Surface elevations range from 76 to 152 m (400-500 ft) above mean sea level (msl). Frees Creek ranges in elevation from 122 m (400 ft) at its source to 76 m (250 ft) where it enters the Broad River. The existing Parr Reservoir varies from 82 m (270 ft) elevation south of Henderson Island to 78 m (257 ft) at Parr Dam.

2.4 CLASSIFICATION OF SOILS IN NEWBERRY AND FAIRFIELD COUNTIES

Soil classification depends on the interaction of the soil forming factors; parent materials, climate, topography, organic material, and time. These factors create the distinct horizons which develop during the formation of soils.

The soils of Newberry and Fairfield Counties were formed from the weathering of igneous, metamorphic and migmatitic rocks; generally hornblende, quartz-biotite gneiss, schists, and granite (Johnson 1964). The degree of weathering and depth to bedrock is variable throughout the study area. The surface in the area is relatively free of boulders and smaller stones.

The bottomland soils consist of recently deposited alluvium washed from the uplands and deposited on new flood plains. Deposits of alluvium occurring on old, high terraces were part of the old flood plain now incised by stream erosion and subsequently, have been left above the present flood plain.

Soil classifications recognized in Fairfield and Newberry Counties in the vicinity of the project area include:

Upland Soil

Major Series: Cecil, Davidson, Enon, Wilkes, and Appling.

Minor Series: Helena, Mecklenburg, Vance, Iredell, and Catawba.

Bottomland Soil

Dominant Series: Congaree, Chewacla, and Mixed Alluvial.

Cecil, Davidson, Appling, and Wilkes are the more abundant soil series, occurring primarily on upland ridge tops and moderate to steep slopes in Fairfield County (Craddock and Ellerbe 1966). The major series on uplands in Newberry County include Cecil and Enon soils (Camp, et al. 1960; Craddock and Ellerbe 1967).

Cecil soil is one of the dominant and widely distributed series in both counties. Cecil, Enon, and Davidson soils are deep, well-drained, with a gentle to steep slope, and acid soils. The soils are formed from parent material of igneous (granite, gabbro, and diorite) and metamorphic (gneiss and schist) rocks. Surface soils usually range in color from reddish-brown to brown on the level ridge tops to olive-yellow on the slopes. The subsoils range in color from yellowish-brown to dark red.

The texture of soils on the uplands and side slopes varies from gravelly-sandy loam to clay. Clay loam and clay textured soils occur where the original surface soil has been removed by accelerated erosion. The gravelly soils in these series contain fragments of quartz, gneiss, or granite that may interfere with cultivation (Camp, et al. 1960).

The upland soils are suitable for agriculture for the commonly grown crops such as cotton, corn, sorgum, small grains, legumes, and grasses used for hay and pasture. Applications of lime and fertilizer are required for moderate yields.

The major series that characterize the uplands are variable in slope and consequently the erosion hazard may be variable. The slopes must be managed for forest or pasture and grazing controlled to reduce the erosion hazard. As the slope increases, the rate of runoff will increase. Sheet and gully erosion will occur without proper management.

In contrast to the Cecil, Davidson, Enon, and Appling soils, the Wilkes soil occur primarily on uneven terrain and steep side slopes in Fairfield County (Craddock and Ellerbe 1966). This soil is best suited for timber production and the production of food plants for wildlife and are not suited to cultivation.

The bottomland soils of Fairfield and Newberry Counties consist of Congaree and Chewacla soils and mixed alluvial land (Craddock and Ellerbe 1966 and 1967). These soils are along the major and minor tributaries to the river and are formed by the deposition of alluvium and colluvium. The soils are usually acidic. They are poorly drained to moderately well drained soils. The surface soils are not defineable as horizons. The colors range from light brown to dark yellowish brown. Their texture is sandy loam to silty clay loam. The soils are better suited for agriculture because their organic content and water retaining capacity is better than the upland soils.

2.5 VEGETATION ASSOCIATIONS

The present vegetation in the Broad River watershed includes four vegetative communities; pine, deciduous, mixed, and grassland. Vegetation growth is a result of the interaction between vegetation and the principal environmental factors, climate and soil. The mild and temperate climate is conducive for growth of both coniferous and deciduous trees. The winters are cold enough, however, that hardwoods shed their leaves in the fall.

The major soil association in the Frees Creek drainage is Cecil-Davidson-Wilkes, with Cecil being the major type (Section 2.4). Table 2.5.1 shows the "native vegetation" for the soil types.

Similar vegetation should be expected to be growing on the same soil types when undisturbed. However, clearing of the land for agricultural purposes has altered the composition of natural vegetation. Abandonment of farmlands resulted in stands of loblolly pine (about 75%) on the gentle upper slopes) with a very sparse understory of hardwoods. No hardwood control is necessary for a pure pine stand on the upper slopes (Ellerbe and Smith 1964). The bottomland vegetation is predominately deciduous (about 80%) with scattered pine making up the remainder.

Table 2.5.1 Comparison of native vegetation found in 1971 and 1972 on soil types, Parr, South Carolina.

Soil Type	Oak	Hickory	Dogwood	Beech	Sourwood	Cedar	Elder	Holly	Gum	Poplar	Red Cedar	Red Maple	Pine	Elm	Birch	Cottonwood	Ash	Sycamore	Persimmon	Yellow Poplar	Hop Hornbeam	Hornbeam	Basswood	Redbud	Black Cherry
Upland																									
Major Soils																									
Cecil	X	X	X	0	X	X	0	0	X	X	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
Davidson	X	X	X	0	0	0	0	X	0	0	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0
Wilkes	X	0	0	0	0	X	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
Appling	X	X	0	0	0	0	0	0	X	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
Minor Soils																									
Catawba	0	X	0	0	0	X	0	0	X	0	0	0	X	X	0	0	0	X	0	0	0	0	0	0	0
Helena	X	0	0	0	0	0	0	0	X	0	0	0	X	X	0	0	0	0	0	0	0	0	0	0	0
Enon	X	X	X	0	0	X	0	0	X	0	0	0	X	X	0	0	0	0	X	0	0	0	0	0	0
Mecklenberg	X	X	X	0	0	X	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
Iredell	X	X	X	0	0	0	0	X	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hiwasee	X	X	X	0	X	X	0	X	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
Site 1*	0	0	X	0	0	0	0	0	X	0	X	X	X	0	0	0	0	0	0	X	X	0	0	0	0
Site 2*	0	0	0	0	0	0	0	0	X	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
Site 4*	X	0	X	0	0	0	0	X	X	0	X	X	X	0	0	0	0	0	0	0	X	0	0	0	0
Bottomland																									
Congaree	X	X	0	X	0	0	X	0	X	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0
Chewacla	X	X	0	0	0	0	0	0	X	0	0	0	0	0	X	X	X	X	0	0	0	0	0	0	0
Alluvium	X	X	0	0	0	0	0	0	X	X	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
Site 3*	X	X	X	0	0	0	0	0	0	0	X	X	X	0	0	0	0	0	0	0	X	X	X	X	X

* Terrestrial Study Areas

2.6 THE HISTORICAL AND PRESENT INFLUENCE OF MAN

The area surrounding the project area was occupied by man long before the advent of the Europeans. The Cherokee Indian nation extended to the Broad River; the area between the Broad River and the Catawba River provided excellent hunting grounds for the Cherokee and Catawba Indians. Four archeological sites are known to exist in the vicinity of the project (pers. comm., R. L. Stephenson, Director & State Archeologist, Univ. of S. C., Columbia).

Land clearing by the Europeans was well underway in the Piedmont by 1770. The virgin forest of primarily hardwoods grew on the more productive soils and, therefore, were removed to be replaced by agricultural crops. When crop yields declined, the farmer either cleared adjacent woodland or moved to more productive land. This cycle was in evidence by: (1) a land clearing boom about 1800, following the invention of the cotton gin which stimulated cotton farming, and (2) two major periods of abandonment, one following the Civil War and the other following the appearance of the boll weevil in 1921 (Ellerbe and Smith 1964). The abandoned farmlands followed a natural pattern of succession of vegetation (Oosting 1956). The secondary hardwoods, however, were inferior in quality to the original forest (Ellerbe and Smith 1964).

Farming methods have changed considerably from its early beginning. Family farms of small size were common in South Carolina by 1770 (Ellerbe and Smith 1964). In 1930, 4.7 million hectares (11.5 million acres) were under cultivation in the state, however, by 1970 this decreased to 3.3 million hectares (8.2 million acres). A similar decline also occurred in Fairfield County. The area cultivated for wheat, corn, oats, barley, and hay had decreased in the county from 7,340 hectares (18,140 acres) in 1955, to 4,900 hectares (12,100 acres) in 1960, to 2,030 hectares (5,020 acres) in 1970 (Farrar and

Garrison 1962; Wiley and Garrison 1967, and 1971a). Much of the abandoned farmland reverted to forest land (Knight and McClure 1969).

Aerial photographs taken in 1970 indicate that nearly two-thirds of the cleared land in the Frees Creek watershed is idle or in pasture, and the remainder is in cropland. This land may have accounted for as much as eight percent of the county's total acreage used for the 1970 production of corn, oats, wheat, barley, and hay, or about 0.05 percent of the total land acreage in the state for the production of these crops. Yields per acre in Fairfield County are lower than in most other counties in the state (Table 2.6.1; Wiley and Garrison 1971a).

The number of beef cattle in Fairfield County declined from a maximum of 17,880 in 1956 to 10,400 in 1970. This represents a 42 percent reduction in beef production. Dairy cows also declined from 3,000 to 600 during the same period (Wiley and Garrison 1967; 1971b). Approximately 150 cattle of all types were observed in the immediate vicinity of the proposed Monticello Impoundment during the March 1972 sampling period.

In 1967, 86 percent of the land in Fairfield County was commercial forest (Haines 1967). Of this, 20 percent is owned by forest industries, 75 percent is owned by farmers and private individuals and the remainder is national forest land or under corporate and county or municipal ownership.

Within the area to be affected by the enlargment of Parr Reservoir and construction of Monticello Impoundment, the Forest Service owns 10 percent, the forest industries own 14 percent, and the remainder is owned primarily by private individuals. This forested area represents two percent of the county's resource. Approximately 54 percent of the forest in Fairfield County (Haines 1967) is commercial saw and pole timber.

Only minor commercial cutting occurred up to 1968, when about

Table 2.6.1 Comparison of acreage and yield of five selected crops in South Carolina and Fairfield County, S. C. in 1970 (Wiley and Garrison 1971a).

	Acreage		County	Yield per Acre		County
Corn	State	County	Rank*	State	County	Rank*
Corn						
Grain	402,000	750	41	27 bu	20 bu	35
Silage	27,000	---		9 T	---	
Wheat	81,000	200	46	35 bu	28 bu	45
Oats	83,000	220	40	38 bu	33 bu	39
Barley	21,000	50	42	42 bu	36 bu	33
Hay	218,000	3,800	24	1.7 T	1 T	45

* Forty-six Counties in South Carolina.

700 acres were cleared by the Champion Paper Company (John White, Forester, Champion Paper Company, pers. comm.). SCE&G purchased or has optioned most of the land in the Frees Creek area for Monticello Impoundment and granted the timber rights to each former owner or tenant. The removal of commercial timber was occurring in the area during the March 1972 Biological Survey.

The Broad River was dammed in 1914 at Parr, South Carolina to form the Parr Reservoir. The reservoir functioned for flood control as well as an energy source for the production of electricity. The dam inundated an estimated 600 acres of bottomland along the Broad River and its tributaries. Based upon the present vegetation associations adjacent to the reservoir, it is estimated that the area was predominantly deciduous forest. Most game species of wildlife prevalent now, except wild turkey, were probably present when the dam was constructed.

No major fires have occurred in the vegetative cover in the environs of Parr Reservoir in more than 20 years. However, burning of scrub wood is done to clear areas after the commercially useful timber has been removed (Walter Schrader, State Game Biologist, Rock Hill, S. C., pers. comm.).

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3.0 AQUATIC SURVEY

3.1 DESCRIPTION OF SAMPLING STATIONS

Seven transects with a total of 15 collecting points were selected for study of the aquatic environs of the Broad River Study Area. Four of these transects were located within the Parr Reservoir, one above the reservoir, one below Parr Dam, and one in upper Frees Creek (map, back cover).

Collecting points were chosen along each transect according to their depth, substrate type, and general habitat conditions. Their locations and characteristics are given as follows:

Transect A and A' Transect A represents the main stream habitat of the Broad River upstream from the influence of Frees Creek and Cannons Creek watersheds. However, during the initial location of the transect, unfamiliarity with the area resulted in the sampling location being located in an impounded area and not in the main stream. This was designated Transect A' on the map (back cover). Transect A' is 5.5 km (3.4 miles) upstream from Parr Dam on the northeast side of the central peninsula of the reservoir. It is 150 m (492 ft) in length and varied in depth from 0 to 1.2 m (3.9 ft). The bottom substrate is composed of silt and muck.

By January 1972, it was determined that the original ecological reasons for location of this transect were not met and it was relocated to the position indicated as "A". It is located 7.0 km (4.3 miles) upstream from Parr Dam in the main river channel and is 150 m (492 ft) long. Transect A has a silt bottom and its depth varies from 0 to 5.5 m (18.0 ft).

Transect B is located in the Frees Creek embayment. The transect is 75 m (246 ft) upstream from the railroad bridge and parallel to it. Transect B is 230 m (755 ft) in length and has three collecting points whose depth varies from 1.0 to 2.0 m (3.3 to 6.5 ft). It has a silt and muck bottom substrate.

This embayment was selected because it will be subjected to dredging during construction and to strong water movements during pumping and drawdowns after plant operations begin.

Transect C is located 460 m (1590 ft) upstream from the Route 28 bridge in Cannons Creek embayment, a major embayment of the west side of the Broad River. Transect C is 230 m (755 ft) in length and has three collecting points whose depth varies from 0.5 to 2.0 m (1.6 to 6.5 ft). It has a silt and muck bottom substrate. Transect C was established to sample an embayment which will be influenced by daily water level fluctuation, however, would not be subjected to water movements as great as expected in Frees Creek (Transect B).

Transect D is located upstream from Parr Dam in the main body of Parr Reservoir. The west end of the transect is 305 m (1000 ft) and the east end is 535 m (1755 ft) upstream from the dam. Transect D is 760 m (2494 ft) in length and has three collecting points whose depth varies from 1.25 to 4.75 m (4.1 to 15.6 ft) with a bottom substrate of silt, sand, and muck. Some samples were also taken from the east shore of the mid-river island just upstream of Transect D. This transect was chosen to represent the open reservoir habitat which would be influenced by water level fluctuations and some water movements.

Transect E is located below Parr Dam in the east channel of the river. The length of this transect is 220 m (722 ft) from the east bank to the tip of the island and has two collecting points whose depths are about one meter. The bottom substrate is detritus, muck, and coarse gravel. This area was selected because it will not be subjected to water level fluctuations as projected in Parr Reservoir. It will, however, receive water from the project operations, thus a monitoring program was necessary for comparative purposes.

Transect F was established in September 1971 approximately 23 km (14.3 miles) upstream from Parr Dam. Transect F is 635 m (2083 ft) downstream from the southern tip of Henderson Island and is a perpendicular extension to the east bank of the river. The width of the transect is approximately 125 m (410 ft). The river bed is fairly uniform along the transect and is characterized by a riffle habitat. The area selected is in the upper limits of the proposed area that will be subjected to impoundment fluctuations and will provide data on the upstream effects of the proposed project.

Transect G was also established in September 1971 in upper Frees Creek, an area which is not currently impounded. The northern limit of this station is approximately 100 m (328 ft) north of the bridge on State Highway 99 and the southern limit extends 400 m (1312 ft) south of the bridge. The substrate is primarily very coarse sand. Many granite rocks, up to 35 cm (13.8 in) in diameter, have washed into the creek from the road bridge riprap. The creek at this location is less than 4 m (13 ft) wide. The effects of the existing impoundment can be assessed by comparing fauna in the upper part of the creek with that of the impounded area at Transect B.

3.2 PHYSICAL AND CHEMICAL CHARACTERISTICS

3.2.1 INTRODUCTION

Water quality can influence species composition or diversity of biota and determine to some degree the population densities of specific organisms. Therefore, a knowledge of physical and chemical characteristics is fundamental to a baseline biological analysis in the study area.

Selected physical and chemical parameters were measured at points along transects in the Broad River Study Area at intervals between June 1971 and May 1973. This investigation was to provide basic information on existing abiotic conditions during the biotic sampling periods.

3.2.2 METHODS AND MATERIALS

Water temperature was measured with a Yellow Springs Instrument Company telethermometer (Model 47). The thermistor probe was lowered to the bottom and allowed to stabilize prior to recording the temperature to the nearest 0.5 degree centigrade (C). Temperatures were then recorded at 0.25 m intervals with the final measurement taken one centimeter below the water surface.

A Secchi disc (20 cm [7.9 in] diameter) was employed to measure light penetration in the water. The maximum water depth at which the disc was visible was determined to the nearest 0.05 m (2 in) at each station.

Substrate grab samples were collected with an Ekman dredge for sediment analysis (see Section 3.5.2). In the laboratory, the sediment from each grab was washed into a container, mixed thoroughly by stirring, and allowed to settle for two or more days. When the sample was completely settled, a random core was removed, placed in a sieve series, and washed with distilled water until separation was complete. The sieve series allowed designation of sediment components according to millimeter diameter ranges as follows: pebble, 4 to 64;

granule, 2 to 4; very coarse sand, 1 to 2; coarse sand, 0.5 to 1.0; medium sand, 0.25 to 0.50; fine sand, 0.125 to 0.250; very fine sand, 0.062 to 0.125; and silt-clay, 0.004 to 0.062. Each sediment type from a sample was washed from the retaining sieve into a crucible of known weight, dried at 60°C and ashed at 500°C to constant weight. An analytical balance was used to weigh samples to the nearest 0.01 mg.

Bottom sediment samples used for heavy metals and pesticide analyses were collected from all aquatic transects in February, 1973. Samples, obtained with an Ekman dredge, were placed in glass jars that had previously been washed with petroleum ether, rinsed with acetone, and air dried. The jar opening was covered with aluminum foil before closing with a screw lid. The sample was later air dried and sent to the Environmental Science and Engineering Corporation at Mt. Juliet, Tennessee for analysis of heavy metals and residual chlorinated hydrocarbon pesticides. A hot 6N hydrochloric acid was used to extract heavy metals from the sediments.

Water for dissolved oxygen analysis was collected with a 1.2 liter Kemmerer water sampler. Artificial aeration of the sample was prevented by placing the rubber emptying tube at the bottom of a ground-glass stoppered bottle and allowing water to fill and overflow the bottle volume. Dissolved oxygen was measured to the nearest part per million with a Hach Model OX-2-P test kit.

Water was also collected with the Kemmerer sampler for pH determinations. A Hach portable colorimetric pH test kit was used to measure pH to the nearest 0.1 unit.

Other water quality parameters were supplied by SCE&G from samples obtained from the Broad River.

3.2.3 FINDINGS

3.2.3.1 Temperature

Water temperature data were recorded at six collection points between June 1971 and May 1973 (Table 3.2.1). Collection points on Transects A and B were relocated beginning with the November 1972 sample period in order to correspond with revised biological sampling points. Other parameters discussed later follow the same site revision described above.

Maximum surface temperature of 31.5°C was recorded at Station A-1 in June 1971, while a minimum of 7.0°C was recorded at Station F-1 in January 1972. Seasonal surface temperatures at stations ranged as follows for combined 1971 to 1973 data: winter (January and February), 7.0 to 12.0°C; early spring (March), 12.5 to 17.0°C; late spring (May), 20.0°C at all stations; early summer (June), 27.0 to 31.5°C; early fall (September), 22.0 to 27.5°C; and late fall (November), 14.5 to 15.0°C. Maximum variation in surface temperatures between stations occurred during September 1971, when Station B-2 was 5.5°C warmer than Station D-1.

Differences were also noted between surface and bottom temperatures at some stations. Stations A-1, A-2, B-2, B-3, and C-3 usually exhibited lower temperatures at the bottom than at the surface. Surface temperatures at these sites were also generally higher than at Stations D-1 and E-1. Differences between surface and bottom temperatures at D-1 and E-1 were almost non-existent regardless of sampling period.

3.2.3.2 Transparency

Secchi disc visibility determinations were conducted at six collection points between June 1971 and May 1973 (Table 3.2.2). Light penetration, as measured using the limit of Secchi disc visibility, varied by season. Seasonal Secchi disc visibility readings ranged as follows for combined

Table 3.2.1 Water temperature at the surface (S) and bottom (B) at collection points along transects in the Broad River Study Area in 1971-73.

Date (1971-72)	Sample	Collecting Points*					
		A-1	B-2	C-3	D-1	E-1	F-1
June	S	31.5	30.0	30.0	27.0	28.5	NS***
	B	27.0	21.0	23.0	26.0	28.5	NS
September	S	25.5**	27.5	27.0	22.0	24.0	24.0
	B	23.0**	21.5	23.0	22.0	NS	NS
January	S	10.0	9.0	12.0	9.0	7.5	7.0
	B	10.0	9.0	11.0	9.0	7.5	NS
March	S	17.0	12.5	17.0	14.5	14.0	16.0
	B	15.0	10.0	16.0	14.0	14.0	NS
Date (1972-73)		A-2	B-3	C-3	D-1	E-1	F-1
November	S	NS	15.0	14.5	14.5	14.5	14.5
	B	NS	14.0	14.0	14.5	NS	NS
February	S	10.0	10.0	10.0	9.5	9.5	9.5
	B	9.0	NS	9.0	9.5	NS	NS
May	S	NS	20.0	20.0	NS	20.0	NS
	B	NS	NS	NS	NS	NS	NS

* Letter denotes transect, numeral denotes station.
** Temperature at Station 2 for this date.
*** Not sampled.

Table 3.2.2 Secchi readings along the transects in the Broad River Study Area in 1971-73.

Date (1971-72)	Collecting Points					
	A-1	B-2	C-3	D-1	E-1	F-1*
June	0.20	0.25	0.60	0.25	0.15	NS**
September	0.15***	0.25	0.35	0.10	0.20	NS
January	0.70	0.50	0.30	0.40	0.40	0.40
March	0.20***	0.30	0.50	0.10	0.50	NS
Date (1972-73)	A-2	B-3	C-3	D-1	E-1	F-1
November	0.35	0.45	0.35	0.25	0.35	NS
February	0.60	0.25	0.60	0.60	0.60	NS
May	NS	0.20	0.60	0.15	NS	NS
Mean	0.36	0.31	0.47	0.26	0.37	---

* Current velocity usually too great for reading at this site.
** Not Sampled
*** Secchi at Station 2 for this date.

1971 to 1973 data: winter (January and February), 0.25 to 0.70 m (0.8 to 2.3 ft); early spring (March), 0.10 to 0.50 m (0.3 to 1.6 ft); late spring (May), 0.15 to 0.60 m (0.5 to 2.0 ft); early summer (June), 0.15 to 0.60 m (0.5 to 2.0 ft); early fall (September), 0.10 to 0.35 m (0.3 to 1.2 ft); and late fall (November), 0.25 to 0.45 m (0.8 to 1.5 ft). The maximum light penetration of 0.70 m (2.3 ft) Secchi depth occurred in January 1972 at Station A-1 while least penetration of 0.10 m (0.8 ft) occurred in September 1971 and March 1972 at Station D-1. Winter (January and February) Secchi disc readings were slightly greater than those recorded on other dates.

Mean Secchi disc visibility readings for the more lentic (static water or lake-like) conditions present at Transects A, B, and C ranged from means of 0.31 to 0.47 m (1.0 to 1.6 ft) while means for the more lotic (running water or river-like) conditions at Transects D and E ranged from 0.26 to 0.37 m (0.8 to 1.2 ft). Secchi disc readings were lowest at Transect D and highest at Transect C. Differences, however, were usually small and light penetration at all sites was restricted by silt and clay turbidity.

3.2.3.3 Sediment

Sediment samples were collected at selected stations during February and May 1973 (Table 3.2.3). The bottom sediments of Stations B-3, C-3, D-1, and D-3 were the most homogeneous of all sample sites on the study area. Silt and clay comprised from about 65 to 98 percent of the sediment from these stations. Station D-3, however, had pebbles present in small quantities.

Coarse and medium sand made up from about 69 to 89 percent of the sediment from Stations A-1 and F-1. Silt and clay were also important at the F-1 station and comprised about 15 percent of the total. The substrate composition of these stations makes them moderately homogeneous when compared with the predominately silt and clay stations discussed above

Table 3.2.3 Percent of ash weight sediment components* at stations on transects in the Broad River Area in February and May 1973.

Transect & Station	Date	Pebble	Granule	Very Course Sand	Course Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt-Clay
A-1 (Shallow)	May	0.0	0.0	6.7	35.2	53.4	3.5	0.4	0.9
B-1 (Shallow)	Feb.	0.4	2.6	4.3	13.0	25.6	20.6	13.2	20.2
	May	0.0	0.0	1.1	3.1	20.9	26.6	19.8	28.5
B-3 (Deep)	Feb.	0.0	0.0	0.0	0.3	0.2	1.3	8.5	89.7
	May	0.0	0.0	0.2	0.1	0.1	0.4	1.4	97.7
C-1 (Shallow)	May	0.0	2.2	11.2	22.0	29.3	21.4	9.1	4.7
C-3 (Deep)	May	0.0	0.0	0.1	0.1	0.2	0.7	2.4	96.5
D-3 (Shallow)	Feb.	1.5	0.0	3.0	1.0	0.8	3.4	24.5	65.8
	May	11.6	0.0	0.4	0.9	0.5	1.9	20.0	64.7
D-1 (Deep)	Feb.	0.0	0.0	0.0	0.0	0.0	1.9	1.5	96.5
	May	0.0	0.0	0.0	1.3	2.5	14.3	12.3	69.7
F-1 (Shallow)	May	0.0	0.0	9.0	43.7	25.4	3.7	3.4	14.6

*See 3.2.2 for description of diameter size classes of designated components

The sediment composition at Stations B-1 and C-1 was moderately heterogeneous. The C-1 station had four components, each comprising over 10 percent of the sample; very course sand, coarse sand, medium sand, and fine sand. Station B-1 had four components each comprising over 10 percent of the May sample; medium sand, fine sand, very fine sand, and silt and clay. In Februar coarse sand also constituted over 10 percent of the sample at Station B-1. The four substrate constiuents in May accounted for over 98 percent of the total while in February the five components accounted for about 80 percent.

3.2.3.4 Sediment Chemistry

Concentrations of DDE, DDD, and DDT from all samples were generally very low and were often below the detectable limits of 0.005 ppm. No other pesticides were detected in the bottom sediments. Similar findings were made for surface soils of the surrounding study area, although the frequency occurrence of samples containing no pesticide residue was greater (see Section 5.2). Concentrations (in ppm) of pesticides found in the bottom sediments are as follows:

Transect	DDE	DDD	DDT
A	<0.005	0.005	0.005
B	0.009	0.007	0.012
C	0.007	<0.005	<0.005
D	0.007	0.007	0.009
E	0.005	0.008	0.009
F	<0.005	<0.005	<0.005

Polychlorinated bi-phenyls (PBCs) were present in moderate concentrations ranging from 0.010 to 0.044 ppm. The highest concentration was found at Transect E, directly below Parr Dam.

Boron was present in the highest concentration (100-194 ppm) of the minerals measured in bottom sediments (Table 3.2.4). Concentrations of all other minerals measured were low. Lithium and zinc concentrations were generally low, but in all cases higher than those in the surrounding topsoil.

Table 3.2.4 Concentration of minerals in bottom sediment samples from the Broad River Study Area at Parr, South Carolina, February 1972. All values are in parts per million.

Transect	Arsenic	Copper	Zinc	Lead	Mercury	Boron	Chromium	Lithium
A	0.020	6.96	27.0	6.24	0.008	100	22.80	3.92
B	0.020	13.90	30.2	18.40	0.042	142	36.50	2.80
C	0.020	21.70	30.3	20.20	0.033	160	25.20	2.32
D	0.027	25.20	30.4	14.60	0.038	174	35.40	3.64
E	0.160	10.70	36.9	8.83	0.017	168	24.60	8.28
F	0.107	5.40	24.9	5.42	0.021	108	20.40	4.20

With the exception of lithium, mineral concentrations were highest in and below the reservoir. Lithium, zinc, and arsenic concentrations were greatest at Transect E, directly below Parr Dam.

3.2.3.5 Dissolved Oxygen

Dissolved oxygen analyses were conducted at six collection points between June 1971 and May 1973 (Table 3.2.5). Seasonal variations in surface samples for 1971 to 1973 data were as follows: winter (January and February), 6 to 13 ppm; early spring (March), stable at 9 ppm; late spring (May), 9 to 11 ppm; early summer (June), 9 to 11 ppm; early fall (September), 7 to 10 ppm; and late fall (November), 9 to 11 ppm. Daytime dissolved oxygen levels near Parr Dam throughout August, 1972, reached a minimum concentration of 4.8 ppm (SCE&G Water Quality Program 1972). Nighttime levels may well have been even lower.

Percent saturation of dissolved oxygen, which corrects for temperature effects, was near or above 100 percent at the surface except in the January 1971 and August 1972 samples (Table 3.2.6). During the mid-winter period, saturation ranged from about 50 to 80 percent in both surface and bottom samples. Saturation values during August 1972 ranged from 51 to 90 percent. Percent saturation of dissolved oxygen in bottom water samples never exceeded surface values.

3.2.3.6 pH

Analyses for pH were also conducted routinely between June 1971 and May 1973 at six collecting points (Table 3.2.7). Seasonal pH values for 1971 to 1973 at all stations and depths ranged from 6.9 to 8.0. Mean pH values, however, ranged from 7.0 to 7.2 for combined surface and bottom samples. Values for pH at the surface were slightly greater than bottom values for several sample sites; particularly in early summer (June) and early fall (September) 1971.

Table 3.2.5 Dissolved oxygen at the surface (S) and bottom (B) at collecting points along transects in the Broad River Study Area in 1971-73.

Date (1971-72)	Sample	Collecting Points					
		A-1	B-2	C-3	D-1	E-1	F-1
		ppm of Dissolved Oxygen ± 1.0 ppm					
June	S	10	11	10	9	9	NS**
	B	8	6	7	7	NS	NS
September	S	10*	10	7	7	9	NS
	B	8*	8	7	7	NS	NS
January	S	6	6	9	7	6	7
	B	6	6	9	6	6	7
March	S	9	9	9	9	9	9
	B	9	9	9	9	NS	NS

Date (1972-73)		A-2	B-3	C-3	D-1	E-1	F-1
November	S	9	10	10	10	10	11
	B	NS	NS	NS	NS	NS	NS
February	S	13	11	13	13	11	12
	B	13	NS	12	12	NS	NS
May	S	NS	11	11	NS	9	NS
	B	NS	NS	NS	NS	NS	NS

* Dissolved oxygen at Station 2 for this date

** Not Sampled

Table 3.2.6 Estimated percent saturation of dissolved oxygen at collecting points along transects in the Broad River Study Area in 1971-73.

Date (1971-72)	Sample	Percent Saturation*					
		A-1	B-2	C-3	D-1	E-1	F-1
June	S	135	145	132	112	115	NS***
	B	100	67	80	85	NS	NS
September	S	120**	125	87	79	106	NS
	B	93**	90	80	79	NS	NS
January	S	52	54	83	60	50	57
	B	52	54	80	54	50	NS
March	S	92**	84	93	87	86	90
	B	89**	79	90	86	NS	NS

Date (1972-73)		A-2	B-3	C-3	D-1	E-1	F-1
November	S	NS	98	97	97	97	106
	B	NS	NS	NS	NS	NS	NS
February	S	114	96	114	112	95	105
	B	111	NS	105	105	NS	NS
May	S	NS	120	120	NS	97	NS
	B	NS	NS	NS	NS	NS	NS

* Estimated from nomograph on oxygen saturation present in Welch (1948)

** Percent saturation at Station 2 for this date

*** Not Sampled

Table 3.2.7 Measured pH at the surface (S) and bottom (B) at collecting points along transects in the Broad River Study Area in 1971-73.

Date (1971-72)	Sample	pH*					
		A-1	B-2	C-3	D-1	E-1	F-1
June	S	7.5	7.7	7.7	7.0	7.0	NS***
	B	7.0	6.9	7.0	NS	NS	NS
September	S	7.0**	7.5	7.5	7.0	7.0	7.0
	B	7.0**	7.0	7.0	7.0	NS	NS
January	S	7.0	7.0	7.0	7.0	7.0	7.0
	B	7.0	7.0	7.0	7.0	7.0	7.0
March	S	7.0**	7.0	7.5	7.0	7.0	8.0
	B	7.0**	7.0	7.0	7.0	NS	NS
Date (1972-73)		A-2	B-3	C-3	D-1	E-1	F-1
November	S	7.0	7.3	7.1	7.0	7.0	7.0
	B	NS	NS	NS	NS	NS	NS
February	S	7.2	7.0	7.0	7.0	7.0	6.9
	B	7.2	NS	7.0	7.0	NS	NS
May	S	NS	7.0	7.5	NS	7.0	NS
	B	NS	NS	NS	NS	NS	NS
Mean		7.1	7.1	7.2	7.0	7.0	7.2

* Measured to the nearest 0.1 pH unit

** pH at Station 2 for this date

*** Not Sampled

3.2.3.7 Other Water Quality Parameters

Chemical analyses of the Broad River at Parr indicate that the river is very low in dissolved solids (Table 3.2.8). The water is soft and has a low buffering capacity. Silica and nitrogen concentrations are high while phosphates are present only in trace quantities. Biological oxygen demand (BOD) is generally low but has been recorded as high as 13 ppm (John Foley pers. comm.).[1] Chemical oxygen demand (COD) measurements are usually high and range from 1.9 to 46.9 ppm with a mean value of 16.8 ppm.

3.2.4 DISCUSSION

Seasonal water temperature changes on the Broad River Study Area are typical of lotic waters strongly influenced by air temperature. The temperature data suggest a more lentic condition at Transects A, B, and C while a more lotic condition exists at Transects D and E. Undoubtedly the lentic water conditions at A-1, A-2, B-2, B-3, and C-3 allow for rapid surface heating and the establishment of thermally related density gradients between the surface and bottom of the river. Turbulence and mixing, characteristic of lotic conditions at D-1 just above Parr Dam and E-1 just below, create general homothermous conditions.

Secchi disc visibility readings in the Broad River Study Area, regardless of sample date or transect, were low. Low readings were related to silt and clay turbidity.

An indication of the depth to which major photosynthesis will occur may be obtained with Secchi readings since Secchi disc transparency represents the depth at which about 95 percent of solar radiation is absorbed (Odum 1971). Minimum and maximum Secchi readings on the study area were 0.10 and 0.70

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[1] John Foley, University of South Carolina, Belle Baruch Institute

Table 3.2.8 Chemical analyses of the Broad River, Parr, South Carolina.*

	Average	Minimum	Maximum
Total Dissolved Solids	71 ppm	36	178
Conductivity	63 µmhos	43	92
Total Alkalinity	24 ppm	15	33
Total Hardness	17 ppm	12	24
Calcium Hardness	12 ppm	6	18
Magnesium Hardness	5 ppm	2	8
Chlorides	6 ppm	4	9
Sulfates	4 ppm	2	13
Soluble SiO_2	12 ppm	7	24
Nitrates	0.8 ppm	0.55	1.0
Phosphate	Trace	Trace	Trace
Chemical Oxygen Demand	16.8 ppm	1.9	46.9

*From SCE&G Broad River Sampling Program; mean of 21 samples from 8 June 1971 to 8 August 1972.

(0.3 to 2.3 ft) respectively, and mean Secchi readings by site ranged from 0.26 to 0.47 (0.8 to 1.5 ft). Autotrophic production by primary producers (planktonic algae) is therefore generally restricted to near-surface water where light intensity is sufficient for phytosynthesis.

The sediment composition of the study area in general reflects the distribution of finely divided materials deposited in relation to changes in stream velocity. These materials are easily erodable and may shift and be redeposited with periodic changes in stream velocity. Smaller particles are usually a characteristic of river substrates as the distance downstream from the source increases (Hynes 1972).

The predominance of finely divided sediment likely limits the benthic fauna to species tolerant of silting conditions. Silt is known to inhibit development of certain insect and mollusc species (Van der Schalie and Van der Schalie 1950; Lauff and Cummins 1964; Scott 1958). However, species such as the mayfly, Hexagenia limbata, an important component of the benthic fauna in the study area, are known to prefer a soft silty substrate (Swanson 1967). Although the number of species in the typical silt-sand substrate of the study area is restricted, Hynes (1972) indicates that this substrate type is capable of supporting considerable biomass of benthic forms.

The dectectable but low concentrations of residual DDE, DDD, and DDT in bottom sediments indicate a low level of insecticide contamination. Although sediment samples were taken in February, the low concentrations of these basically refractory compounds suggests the absence of chronic contamination from topsoil applications and subsequent runoff.

Minerals in the bottom sediments are within the range of concentrations found in the surrounding watershed, with the exception of lithium, zinc, and copper, which were generally higher. The higher levels of lithium, zinc, and copper reflect a combination of differential solubility during leaching from the soil, differential adsorption to seston[1], and precipitation and concentration in the bottom sediments. With the exception of lithium, all heavy metals analyzed were found in slightly higher concentrations in the reservoir than in the river. This is due, in part, to adsorbed metals being precipitated with the seston as the terminal water velocity is reduced within the reservoir.

Polychlorinated bi-phenyls (PCBs) are persistant, ubiquitous environmental contaminants that are used in industrial and agricultural applications. The source of PCB contamination in the bottom sediments of the Broad River is unknown.

Seasonal dissolved oxygen concentrations were near or above saturation during the sampling periods except in January 1971 and August 1972. Photosynthetic activity during June and September 1971 probably accounts for greater surface concentrations of dissolved oxygen especially at the lentic-like Stations A-1 and B-2 where saturation was 120 percent or greater. Surface and bottom concentrations were more similar at C-3 than at A-1 and B-2, and typical lotic oxygen conditions (homogeneous mixing) occurred at the D-1, E-1, and F-1 sites. A reduction in oxygen saturation was evident in January 1971 and August 1972 at all sites and ranged from about 50 to 90 percent. In addition, dissolved oxygen was lower in bottom samples on several sample dates. The lowered dissolved oxygen levels observed were probably the result of oxygen consumption for decomposition coupled with reduced phytosynthetic activity. Although dissolved oxygen levels near the bottom were sometimes lower than

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[1] all material, both inorganic and organic, suspended in the waterway

those at the surface, the relatively high levels indicate that the bottom sediments have only moderate oxygen demand.

The differences in surface and bottom pH values in early summer and early fall (June and September 1971) at the more lentic-like sites (A, B, and C) are probably related to increased phytosynthetic activity near the surface and increased CO_2 production in bottom sediments.

Nutrients in the water of the Broad River are generally in high enough concentrations to support large algae populations. Phosphorus, though found in trace quantities in the Broad River, is not expected to be a limiting nutrient, as very low quantities (one part per billion) are known to support large algae blooms. The low calcium hardness of the water may be an important factor limiting the density of plankton crops. All other factors being equal, streams with higher calcium hardness produce appreciably higher standing crops (Williams 1964). Other dissolved solids are present in low concentrations as evidenced by the low specific conductivity as well as the low level of total dissolved solids. In addition, the low buffering capacity of the water may allow the pH to decrease somewhat in localized areas in response to runoff from the surrounding acid soils.

The high levels of COD with concurrently high DO levels appear to be related to the presence of allochthonous materials such as cellulose that have undergone partial biological degredation, and hence exert a low BOD. There is also a possibility that certain organic materials leached from the surrounding watershed are adsorbed on colloidal clay particles where they become more resistant to biological degredation. In addition, the occurrence of moderate levels of PCBs in the bottom sediments as well as high COD levels suggest the possibility of upstream industrial contamination of the water.

3.2.5 SUMMARY

Selected physical and chemical characteristics of water on the Broad River Study Area were examined between June 1971 and May 1973. The purpose of this investigation was to provide information on seasonal abiotic conditions existing during periods of biotic sampling.

Temperatures for the periods measured ranged from a maximum of 31.5°C to a minimum of 7.0°C. Vertical temperature gradients at Transects A, B, and C were related to the more lentic-like conditions existing at these sites. Relative homothermy, found at Transects D, E, and F, was typical of more lotic-like conditions.

Water transparency was low and light penetration was restricted due to silt and clay turbidity. Minor differences in transparency occur with season and site. Photosynthetic activity is probably restricted to near surface waters because of low transparency.

Sediments from most sites examined were homogeneous to moderately homogeneous compositions of finely divided materials, mainly silt, clay, and coarse to medium sand. Only sediments from Stations B-1 and C-1 were moderately heterogeneous, usually composed of coarse sand, medium sand, fine sand, very fine sand, and silt and clay. Larger particles such as pebbles and granules were generally lacking with the exception of Station D-3 where pebbles comprised about 12 percent of the sediment in May. The homogeneous nature of finely divided materials in the substrate probably is a major factor in limiting diversity of the benthic fauna although substrates of this type may be capable of supporting considerable biomass.

Data on bottom sediment chemistry indicated a low level of DDD, DDE, and DDT contamination and moderate concentration of PCBs. Minerals and heavy metals were present in concentrations that reflected differential solubility and adsorption to soil particles and subsequent deposition in bottom sediments.

Seasonal dissolved oxygen concentrations were usually near or above saturation at all transects. A period of lowered dissolved oxygen in mid-winter, 1971, and late summer, 1972, was probably related to decomposition and reduced photosynthesis. Elevated dissolved oxygen levels in June and September, 1971, on Transects A, B, and C were probably due to the more lentic-like conditions and photosynthetic activity.

The pH values recorded were usually near 7.0 regardless of season or station. Slightly elevated pH levels at the surface on Transects A, B, and C in June and September, 1971 were likely produced by elevated photosynthetic activity in the more lentic-like conditions.

The Broad River at the study area is low in dissolved solids and has a low buffering capacity. Nutrient levels are probably high enough to support large algae populations under conditions of low turbidity. High levels of biologically degredated allochthonous materials probably account for most of the observed high COD levels although the possibility of upstream industrial contamination is not discounted.

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3.3 PLANKTON

3.3.1 INTRODUCTION

Photoplankton and zooplankton analyses are fundamental to the examination of trophic relationships existing in the Broad River Study Area. In addition, they are important biological indicators of environmental conditions. Pre-operational examination of the plankton community is essential to subsequent post-operational analyses to determine any impact of the project.

Phytoplankton and zooplankton populations in the Broad River Study Area were examined qualitatively and quantitatively between June 1971 and May 1973. The purpose of these analyses was to provide basic information on species composition, density, diversity, and biomass of the plankton.

A detailed examination of the phytoplankton in the project area was conducted for SCE&G by John Foley, a graduate student from the University of South Carolina, Belle W. Baruch Coastal Research Institute. Some of his preliminary work appears in this report.

3.3.2 METHODS AND MATERIALS

A modified Wisconsin tow net with a diameter of 12 cm (4.7 in) and a length of 55 cm (21.8 in) was used for all plankton sampling. The net frame and detachable bucket were fitted with No. 20 nylon bolting cloth with a mesh size of about 76 microns.

Plankton samples for qualitative and quantitative analyses were collected using two methods. The first method involved sampling surface waters by dipping to a depth of about 25 cm (9.8 in) with a bucket and pouring 100 liters of water through the plankton net. The second method involved sampling the water column from the bottom to the surface by lowering the plankton net into the water until the bottom of the net mouth touched the substrate whereupon the net was retrieved steadily at a rate of approximately 0.5 m/sec. The remainder of the procedure for both methods involved washing the inside of the net with filtered water to concentrate all organisms in the net bucket, rinsing the plankton concentrate into small jars, and preserving the labeled samples with about 10 percent formalin for later laboratory analysis.

In the laboratory, bottles containing plankton samples were filled to a volume of 50 ml. A one milliliter aliquot was taken from each thoroughly mixed sample with a Hensen-Stemple pipette and placed in a Sedgwick-Rafter counting chamber. All organisms in the chamber were examined microscopically under 200X magnification and enumerated. Slides were prepared as necessary for diatom identification using procedures outlined by Weber (1970). Appropriate computations were made to convert the sample into organisms or cells per liter. Plankton were identified by using Patrick and Reimer (1966), Pennak (1953 and 1963), Prescott (1962), Smith (1950), Ward and Whipple (1959), Weber (1971), and Whitford and Schumacher (1969).

Beginning in November 1972, plankton biomass was estimated from surface samples concentrated with a plankton net as previously described. After enumeration of organisms, the sample was collected on a Millipore HA filter of known weight using a standard Millipore apparatus. The samples were dried to constant weight at 60°C, ashed at 600°C for one hour, reweighed, and the ash-free dry weight computed. All weights were determined with an analytical balance to the nearest 0.01 mg.

3.3.3 FINDINGS

3.3.3.1 Phytoplankton

3.3.3.1.1 Qualitative Analysis

A total of 102 phytoplankton taxa were collected on the Broad River Study Area between June 1971 and May 1973 in surface samples and vertical plankton net tows (Table 3.3.1). The number of species in each major taxonomic

Table 3.3.1 Species list of phytoplankton present (P) in quarterly surface (S) and vertical tow (VT) plankton samples between June 1971 and May 1973 on the Broad River Study Area.

	1971				1972					1973	
	June		Sept.		Jan.		March		Nov.	Feb.	May
Taxa	S	VT	S	VT	S	VT	S	VT	S	S	S
Chlorophyta											
Actinastrum sp.	P	P	P	P	P	P	P	0	P	0	0
Ankistrodesmus sp.	0	0	0	0	0	0	0	0	P	P	P
Ankistrodesmus falcatus	P	0	P	0	0	0	0	0	0	0	P
Arthrodesmus sp.	0	0	0	0	0	0	0	0	0	P	0
Chlamydomonas sp.	0	0	0	0	0	0	0	0	0	P	0
Chlorella sp.	0	0	0	0	0	0	P	0	P	0	0
Cladophora sp.	0	0	0	0	0	0	0	0	0	0	P
Closterium sp.	0	P	P	0	P	0	P	P	P	0	0
Closterium pronum	0	0	0	0	0	0	0	0	0	P	0
Cosmarium sp.	0	0	0	0	0	0	P	0	P	P	P
Eudorina sp.	P	P	P	P	P	P	P	P	0	0	0
Gloeocapsa sp.	0	0	0	0	0	0	0	0	0	0	P
Gloeocystis gigas	0	0	0	0	0	0	0	0	0	0	P
Golenkinia sp.	0	0	0	0	0	0	0	0	0	0	P
Hyalotheca sp.	0	0	0	0	0	0	P	0	0	0	0
Micrasterias sp.	0	0	P	0	0	0	0	0	0	0	0
Mougeotia sp.	0	0	0	0	0	0	0	0	0	P	P
Onychonema sp.	0	0	0	0	0	0	P	0	P	0	0
Pachycladon sp.	0	P	P	0	0	0	P	0	0	0	0
Pachycladon umbrinus	0	0	0	0	0	0	0	0	0	P	0
Pediastrum sp.	P	P	P	P	P	0	P	P	P	0	0
Pediastrum boryanum	0	0	0	0	0	0	0	0	0	0	P
Pediastrum duplex	0	0	0	0	0	0	0	0	0	0	P
Penium sp.	0	0	0	0	0	0	P	0	0	0	0
Scenedesmus sp.	P	P	P	P	0	0	P	P	P	P	P
Scenedesmus dimorphus	0	0	0	0	0	0	0	0	0	0	P

Table 3.3.1 (Continued)

Taxa	1971				1972					1973	
	June		Sept.		Jan.		March		Nov.	Feb.	May
	S	VT	S	VT	S	VT	S	VT	S	S	S
Scenedesmus protuberans	0	0	0	0	0	0	0	0	0	0	P
Scenedesmus quadricauda	0	0	0	0	0	0	0	0	0	P	P
Salenastrum sp.	0	0	0	0	0	0	0	0	0	0	P
Sphaerocystis schroeteri	0	0	0	0	0	0	0	0	0	0	P
Staurastrum sp.	0	0	P	P	P	0	P	0	0	P	0
Staurastrum quadricuspidatum	0	0	0	0	0	0	0	0	0	P	0
Tetraedron sp.	0	0	0	0	0	0	0	0	P	P	0
Tetraspora sp.	0	0	0	0	0	0	0	0	0	0	P
Treubaria crassispina	0	0	0	0	0	0	0	0	0	0	P
Ulothrix sp.	0	0	0	0	0	0	0	0	0	P	0
Volvox sp.	0	0	0	0	P	0	P	P	P	0	0
Total Chlorophyta	5	6	9	5	6	2	13	5	10	13	18
Chrysophyta											
Achnanthes sp.	0	0	0	0	0	0	0	0	0	P	0
Achnanthes lanceolata	0	0	0	0	0	0	0	0	0	P	0
Asterionella sp.	P	P	P	P	P	P	P	P	P	0	0
Asterionella formosa	0	0	0	0	0	0	0	0	0	P	P
Cyclotella sp.	0	0	0	0	0	0	0	0	0	0	P
Cyclotella menghiniana	0	0	0	0	0	0	0	0	0	P	0
Cyclotella stelligera	0	0	0	0	0	0	0	0	0	P	0
Cymbella sp.	0	0	0	0	0	0	0	0	P	P	P
Dinobryon sp.	P	P	P	P	P	P	P	P	P	0	P
Dinobryon cylindricum	0	0	0	0	0	0	0	0	0	P	0
Dinobryon sociale	0	0	0	0	0	0	0	0	0	0	P
Epithema sp.	0	0	0	0	0	0	0	0	0	P	0
Eunotia sp.	0	0	0	0	0	0	0	0	0	P	0
Eunotia curvata	0	0	0	0	0	0	0	0	0	P	0
Fragilaria sp.	P	P	P	P	P	P	P	P	P	P	0

Table 3.3.1 (Continued)

Taxa	1971				1972					1973	
	June		Sept.		Jan.		March		Nov.	Feb.	May
	S	VT	S	VT	S	VT	S	VT	S	S	S
Fragilaria crotonesis	0	0	0	0	0	0	0	0	0	P	P
Frustulia vulgaris	0	0	0	0	0	0	0	0	0	P	0
Gomphonema sp.	0	0	P	P	P	P	P	P	P	0	0
Gyrosigma sp.	0	0	0	0	0	0	0	0	0	0	P
Gyrosigma obtusatum	0	0	0	0	0	0	0	0	0	P	0
Melosira distans	0	0	0	0	0	0	0	0	0	P	P
*Melosira granulata**	P	P	P	P	P	P	P	P	P	P	P
*Melosira varians**	P	P	P	P	P	P	P	P	P	P	P
Meridinion sp.	0	0	0	0	0	0	0	0	0	0	P
Meridinion circulare	0	0	0	0	0	0	0	0	0	P	0
Navicula sp.	P	0	P	P	P	P	P	P	P	P	P
Navicula mutica	0	0	0	0	0	0	0	0	0	P	0
Nedium sp.	0	0	0	0	0	0	0	0	0	0	P
Nitzschia sp.	0	0	0	0	0	0	0	0	0	P	P
Nitzschia acicularis	0	0	0	0	0	0	0	0	0	P	P
Nitzschia palea	0	0	0	0	0	0	0	0	0	P	0
Pinnularia sp.	0	0	0	0	0	0	0	0	0	P	P
Pleurosigma sp.	P	P	P	0	P	P	P	P	P	0	0
Rhizosolenia eriensis	0	0	0	0	0	0	0	0	0	0	P
Stauroneis sp.	0	0	0	0	0	0	0	0	0	0	P
Stephanodiscus	0	0	0	0	0	0	0	0	0	0	P
Surrirella sp.	0	0	0	0	0	0	0	0	0	0	P
Synedra sp.	P	P	P	P	P	P	P	P	P	P	P
Synedra puchella	0	0	0	0	0	0	0	0	0	P	0
Synedra ulna	0	0	0	0	0	0	0	0	0	P	0
Tabellaria sp.	P	P	P	P	P	P	P	P	P	0	0
Tabellaria fenestrata	0	0	0	0	0	0	0	0	0	P	P
Total Chrysophyta	9	8	10	9	10	10	10	10	11	28	22

**Melosira granulata* designated *Melosira* "A" and *Melosira varians* designated *Melosira* "B" in previous reports.

Table 3.3.1 (Continued)

	1971				1972					1973	
	June		Sept.		Jan.		March		Nov.	Feb.	May
Taxa	S	VT	S	VT	S	VT	S	VT	S	S	S
Cyanophyta											
Anabena sp.	P	P	P	P	P	0	P	0	P	P	P
Aphanocapsa sp.	0	0	0	0	0	0	0	0	0	0	P
Arthrospira sp.	0	0	0	0	P	P	P	0	0	0	0
Chroococcus sp.	P	P	P	P	P	0	P	0	P	P	0
Coelosphaerium sp.	0	0	0	0	0	0	0	0	P	0	0
Gloeocapsa sp.	0	0	P	0	0	0	0	0	P	0	0
Gomphosphaerium sp.	0	0	P	0	0	0	0	0	0	0	0
Merismopedia sp.	0	0	0	0	0	0	0	0	0	P	0
Microcystis sp.	P	P	P	P	P	0	P	P	P	0	0
Oscillatoria sp.	0	0	0	0	0	0	0	0	0	P	P
Oscillatoria "A"	P	P	P	P	P	P	P	P	P	0	0
Oscillatoria "B"	P	P	P	P	P	P	P	P	P	0	0
Phormidium sp.	0	0	0	P	0	0	0	0	0	0	0
Spirulina sp.	P	P	P	P	0	0	0	0	P	0	0
Spirulina princeps	0	0	0	0	0	0	0	0	0	P	0
Total Cyanophyta	6	6	8	7	6	3	6	3	8	5	3
Euglenophyta											
Euglena sp.	0	0	0	0	0	0	P	P	P	P	0
Phacus sp.	0	0	0	0	0	0	P	0	0	0	0
Trachelomonas sp.	0	0	0	0	0	0	0	0	P	P	0
Trachelomonas hispida	0	0	0	0	0	0	0	0	0	P	0
Trachelomonas armata	0	0	0	0	0	0	0	0	0	P	0
Total Euglenophyta	0	0	0	0	0	0	2	1	2	4	0

Table 3.3.1 (Continued)

	1971				1972					1973	
	June		Sept.		Jan.		March		Nov.	Feb.	May
Taxa	S	VT	S	VT	S	VT	S	VT	S	S	S
Pyrrophyta											
Ceratium sp.	0	P	0	0	0	0	P	0	0	0	0
Ceratium hirundinella	0	0	0	0	0	0	0	0	0	0	P
Peridinium sp.	0	0	0	0	0	0	0	0	0	0	P
Total Pyrrophyta	0	1	0	0	0	0	1	0	0	0	2
Total Taxa	20	21	27	21	22	15	32	19	31	50	45

Table 3.3.2 Total phytoplankton species by phyla found on transects and stations on the Broad River Study Area between June 1971 and May 1973

	A*		B			C			D			E		F
	1	2	1	2	3	1	2	3	1	2	3	1	2	1
June 1971														
Chlorophyta	3	3	2	1	0	1	0	0	3	3	6	4	4	NS**
Chrysophyta	5	4	4	2	1	1	0	0	6	6	5	8	4	NS
Cyanophyta	4	4	2	3	3	0	0	0	4	4	5	3	3	NS
Total/Station	12	11	8	6	4	2	0	0	13	13	16	15	11	NS
Total/Transect	13		10			2			18			17		
September 1971														
Chlorophyta	4	1	4	3	4	0	1	2	0	0	1	4	3	6
Chrysophyta	5	5	4	4	3	2	2	3	5	2	4	8	8	9
Cyanophyta	6	4	3	6	4	2	2	2	1	1	3	4	4	5
Total/Station	15	10	11	13	11	4	5	7	6	3	8	16	15	20
Total/Transect	16		18			13			11			17		20
January 1972														
Chlorophyta	2	2	1	1	1	2	1	0	2	2	2	1	3	1
Chrysophyta	9	9	6	7	6	7	7	2	9	8	9	10	10	10
Cyanophyta	5	0	2	1	1	3	1	1	1	2	3	4	4	2
Total/Station	16	11	9	9	8	12	9	3	12	12	14	15	17	13
Total/Transect	16		10			15			15			17		13
March 1972														
Chlorophyta	4	8	2	2	5	2	0	1	9	6	4	6	3	8
Chrysophyta	10	10	5	7	8	10	8	8	10	10	10	10	10	10
Cyanophyta	2	3	2	3	3	5	2	1	4	5	1	3	2	4
Euglenophyta	0	2	0	0	0	1	0	0	0	0	1	1	0	1
Pyrrhophyta	0	1	0	0	0	1	0	0	0	0	1	0	0	0
Total/Station	16	24	9	13	16	19	10	10	23	21	17	20	15	23
Total/Transect	24		19			20			29			20		23

* June & September samples are from Transect A'

** Not sampled

Table 3.3.2 (Continued)

	A		B			C			D			E		F
	1	2	1	2	3	1	2	3	1	2	3	1	2	1
November 1972														
Chlorophyta	3	NS	5	NS	NS	6	NS	6	2	NS	3	4	NS	2
Chrysophyta	7	NS	5	NS	NS	9	NS	10	10	NS	9	8	NS	7
Cyanophyta	3	NS	1	NS	NS	2	NS	3	2	NS	2	2	NS	1
Euglenophyta	1	NS	2	NS	NS	2	NS	1	1	NS	0	1	NS	1
Total/Station	14		13			19		20	15		14	15		11
Total/Transect	14		13				30			18		15		11
February 1973														
Chlorophyta	2	NS	4	NS	NS	3	NS	1	2	NS	4	4	NS	0
Chrysophyta	11	NS	13	NS	NS	14	NS	4	10	NS	5	4	NS	6
Cyanophyta	3	NS	3	NS	NS	0	NS	0	1	NS	0	1	NS	0
Euglenophyta	0	NS	0	NS	NS	1	NS	0	0	NS	2	0	NS	1
Total/Station	16		20			18		5	13		10	9		7
Total/Transect	16		20				20			19		9		7
May 1973														
Chlorophyta	4	NS	6	NS	2	2	NS	3	2	NS	1	2	NS	5
Chrysophyta	12	NS	10	NS	8	6	NS	8	4	NS	7	7	NS	9
Cyanophyta	2	NS	0	NS	0	0	NS	0	0	NS	0	0	NS	1
Pyrrophyta	0	NS	1	NS	0	1	NS	0	0	NS	0	0	NS	1
Total/Station	18		17		10	9		11	8		8	9		16
Total/Transect	18			19			17			12		9		16

* June & September samples are from Transect A

** Not sampled.

group was: Chlorophyta, 37; Chrysophyta, 42; Cyanophyta, 15; Euglenophyta, 5; and Pyrrhophyta, 3. Foley (1972), in his in-depth examination of phytoplankton in the Broad River Study Area between August and December 1971, found a total of 151 species. The species composition in major taxonomic groups was: Chlorophyta, 51; Chrysophyta (including Bacillariophyta), 70; Cyanophyta, 22; Euglenophyta, 7; and Pyrrhophyta, 1.

The number of phytoplankton taxa collected between June 1971 and March 1972 in surface samples was equal to or greater than the number of taxa in vertical tow plankton net samples (Table 3.3.1). Evaluation of phytoplankton species is therefore restricted to surface samples.

A comparison of the total phytoplankton taxa collected from Transects A through F reveals minor differences within a particular sample period (Table 3.3.2). The number of taxa collected from each transect between June 1971 and May 1973 ranged from 7 to 20 with two exceptions. Transect C taxa ranged from 2 to 30 during this period and all transects had taxa ranging from 19 to 29 during March 1972. The general increase in taxa during March was due primarily to a pulse of chlorophyte and chrysophyte species.

Seasonal fluctuations in the total phytoplankton species between June 1971 and May 1973 were as follows by transect: A', 13 to 16; A, 16 to 24; B, 10 to 20; C, 2 to 30; D, 11 to 29; E, 12 to 20; and F, 7 to 23 (Table 3.3.2). Significant seasonal changes in number of species occurred on Transect C and Transect D just above Parr Dam in the reservoir. In all cases the greatest phytoplankton species complex occurred in March.

The following phytoplankton are considered common on the Broad River Study Area because they occurred in at least five of seven surface samples between June 1971 and May 1973: Chlorophyta Actinastrum sp., Pediastrum spp., and Scenedesmus spp.; Chrysophyta Asterionella spp., Dinobryon spp., Fragilaria spp., Melosira granulata, M. Varians, Navicula spp., Pleurosigma sp., Synedra spp., and Tabellaria spp; Cyanophyta - Anabaena sp., Chroococcus sp., Microcystis sp., and Oscillatoria spp., (Table 3.3.1). Melosira granulata and M. varians were designated As species "A" and "B", respectively, in previous reports.

3.3.3.1.2 Quantitative Analysis

The examination of surface phytoplankton populations sampled from 1971 to 1973 revealed that the chrysophyte flora, including Asterionella spp., Fragilaria spp., Melosira granulata, M. varians, and Tabellaria spp., were the only species in consistently high enough numbers for evaluation. These were the only species present in at least one sample collected on each transect with a density of 100/liter or more. Seven species of desmids were collected throughout the study period but population densities were always low. The abundance of cyanophytes was also very low, however, density estimates are minimal since some loss of organisms probably occurred because of the plankton net mesh size.

The density of the predominant chrysophytes varied among transects but no definite trends were evident (Table 3.3.3). Transect C, however, did show a reduction in the number of chrysophytes during the June and September collections.

Seasonal changes in abundance were evident for Asterionella sp., Fragilaria sp., Melosira varians, and Tabellaria sp. Melosira granulata did not show consistent seasonal changes in abundance (Table 3.3.3).

Asterionella sp. appeared to peak in February and March. The greatest sample density occurred during March on Transect E when over 1550/liter were found. Less than 100/liter were found at other times.

Large populations of Fragilaria spp. occurred during February,

TABLE 3.3.3 Mean density (number/milliliter) of major diatom species sampled on Transects A to F on the Broad River Study Area between June 1971 and May 1973.

	A*	B	C	D	E	F
June 1971						
Asterionella sp.	0	0	0	50	50	NS**
Fragilaria sp.	450	50	0	2000	2000	NS
*Melosira granulata****	225	55	0	145	140	NS
*Melosira varians****	100	100	0	150	150	NS
Tabellaria sp.	20	0	0	20	20	NS
September 1971						
Asterionella sp.	0	0	0	25	25	25
Fragilaria sp.	50	50	50	50	575	50
Melosira granulata	40	55	5	5	130	55
Melosira varians	150	150	0	150	150	100
Tabellaria sp.	0	20	0	0	30	50
January 1972						
Asterionella sp.	50	50	50	50	50	25
Fragilaria sp.	50	50	0	50	50	50
Melosira granulata	10	390	35	35	115	10
Melosira varians	900	150	100	800	100	600
Tabellaria sp.	25	50	15	80	20	15
March 1972						
Asterionella sp.	150	75	100	75	1550	350
Fragilaria sp.	300	100	200	200	1050	150
Melosira granulata	55	160	125	135	260	50
Melosira varians	4500	100	100	1200	2350	7000
Tabellaria sp.	265	95	315	175	315	180

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* Transect A' for June and September, 1971.

** Not sampled.

*** *Melosira granulata* designated *Melosira* "A" and *Melosira varians* designated *Melosira* "B" in previous reports.

Table 3.3.3 (Continued)

	A	B	C	D	E	F
November 1972						
Asteriorella sp.	21	15	39	18	0	0
Fragilaria sp.	0	0	2	2	3	0
Melosira granulata	9	361	316	9	3	36
Melosiran varians	37	0	8	19	109	277
Tabellaria sp.	20	0	1	14	0	9
February 1973						
Asterionella sp.	382	106	0	135	0	255
Fragilaria sp.	170	2110	10	106	0	552
Melosira granulata	0	0	69	0	107	0
Melosira varians	255	4175	199	0	77	128
Tabellaria sp.	524	0	0	156	50	113
May 1973						
Asterionella sp.	83	0	0	22	42	22
Fragilaria sp.	52	4	0	8	0	9
Melosira granulata	63	57	13	0	0	0
Melosira varians	4	0	26	4	4	8
Tabellaria sp.	21	0	4	0	0	0

March, and June. The greatest density occurred at Transect B in February and Transects D and E in June when about 2000/liter were present. Populations of Fragilaria spp. were usually below 100/liter during other sample periods.

Consistent changes in population density of Melosira granulata were not evident. Concentrations ranged between 0 and about 400/liter but were usually lower than 200/liter.

The highest measured density of Melosira varians about 7000/liter, occurred in March on Transect F, however, the population appeared to be expanding in January when concentrations ranged from 100 to 900/liter. Population levels during other periods were usually less than 200/liter.

The density for Tabellaria spp. peaked during February and March at all transects in the study area. The maximum numbers recorded were only about 300/liter but populations were usually 50/liter or less.

3.3.3.2 Zooplankton

3.3.3.2.1 Qualitative Analysis

A total of 35 zooplankton species were collected in surface samples and vertical plankton net tows on the Broad River Study Area between June 1971 and May 1973 (Table 3.3.4). An equal or greater number of taxa were collected in surface samples compared with vertical plankton net tows between June 1971 and March 1972. The composition for major taxonomic groups was as follows: Protozoa, 4; Rotifera, 21; Copepoda, 2; and Cladocera, 8.

The following zooplankters are considered common in the Broad River Study Area because they occurred in at least five of seven surface samples between June 1971 and May 1973: Rotifera - Asplanchna sp., Brachionus sp., Filinia spp., Keratella spp., Polyarthra sp., and Trichocera sp.; and Copepoda - Cyclops spp. (Table 3.3.4). No single cladoceran species occurred in all sample periods and no cladoceran species were collected during January and February.

TABLE 3.3.4 Species list of zooplankton present (P) in quarterly surface (S) and vertical tow (VT) plankton samples between June 1971 and May 1973 on the Broad River Study Area.

	1971				1972					1973	
	June		Sept.		Jan.		March		Nov.	Feb.	May
Taxa	S	VT	S	VT	S	VT	S	VT	S	S	S
Rotifera											
Asplanchna sp.	P	P	P	P	P	P	P	P	P	0	P
Brachionus sp.	P	P	P	P	P	0	P	P	P	0	P
Chonochiloides sp.	0	0	P	P	P	P	P	P	P	0	0
Chonochilus sp.	0	0	P	P	P	P	0	0	P	0	0
Filinia sp.	P	P	P	P	P	P	P	P	0	0	0
Filinia longiseta	0	0	0	0	0	0	0	0	0	0	P
Gastropus sp.	0	0	0	0	0	0	P	P	0	P	P
Kellicottia sp.	0	0	0	0	0	0	P	P	0	0	0
Kellicottia bostoniensis	0	0	0	0	0	0	0	0	0	P	0
Kellicottia longispina	0	0	0	0	0	0	0	0	0	0	P
Keratella sp.	P	P	P	P	P	P	P	P	P	0	0
Keratella cochlearis	0	0	0	0	0	0	0	0	0	P	P
Lecane sp.	0	0	0	0	0	0	P	P	0	0	0
Lepadella sp.	0	0	0	0	0	0	P	0	P	0	0
Monostyla sp.	0	0	0	0	0	0	P	P	P	P	P
Notholca sp.	0	0	0	0	0	0	P	P	P	P	0
Philodina sp.	0	0	0	0	0	0	0	0	0	P	0
Polyarthra sp.	P	P	P	P	P	P	P	P	P	0	P
Rotaria sp.	0	0	0	0	0	0	0	0	0	P	0
Synchaeta sp.	0	0	P	P	P	0	P	P	P	0	0
Trichocera sp.	0	0	P	P	P	P	P	P	P	P	P
Total Rotifera	5	5	9	9	9	7	14	13	11	8	9
Copepoda											
Cyclops sp.	P	P	P	P	P	P	P	P	P	0	0
Diaptomus sp.	P	P	P	0	0	0	0	0	0	0	P
Total Copepoda	2	2	2	1	1	1	1	1	1	0	1

TABLE 3.3.4 (Continued)

	1971				1972					1973	
	June		Sept.		Jan.		March		Nov.	Feb.	May
Taxa	S	VT	S	VT	S	VT	S	VT	S	S	S
Cladocera											
Acantholeberis sp.	0	0	0	0	0	0	P	0	0	0	0
Acantholeberis curvirostris	0	0	0	0	0	0	0	0	P	0	0
Alonella sp.	0	0	0	0	0	0	0	0	P	0	0
Bosmina sp.	0	0	0	0	0	0	P	0	0	0	P
Bosmina longirostris	0	0	0	0	0	0	0	0	0	0	P
Daphnia sp.	0	0	P	P	0	0	0	0	0	0	P
Pseudosida sp.	P	P	P	P	0	0	P	0	0	0	0
Scaphelebris sp.	P	0	0	0	0	0	0	0	0	0	0
Total Cladocera	2	1	2	2	0	0	3	0	2	0	3
Protozoa											
Astrameba radiosa	0	0	0	0	0	0	0	0	0	0	P
Centropuxis aculeata	0	0	0	0	0	0	0	0	0	P	0
Codonella crotera	0	0	0	0	0	0	0	0	0	P	0
Difflugia sp.	0	0	P	P	P	P	P	P	0	P	0
Total Protozoa	0	0	1	1	1	1	1	1	0	3	1
Total Taxa	9	8	14	13	11	9	19	15	14	11	13

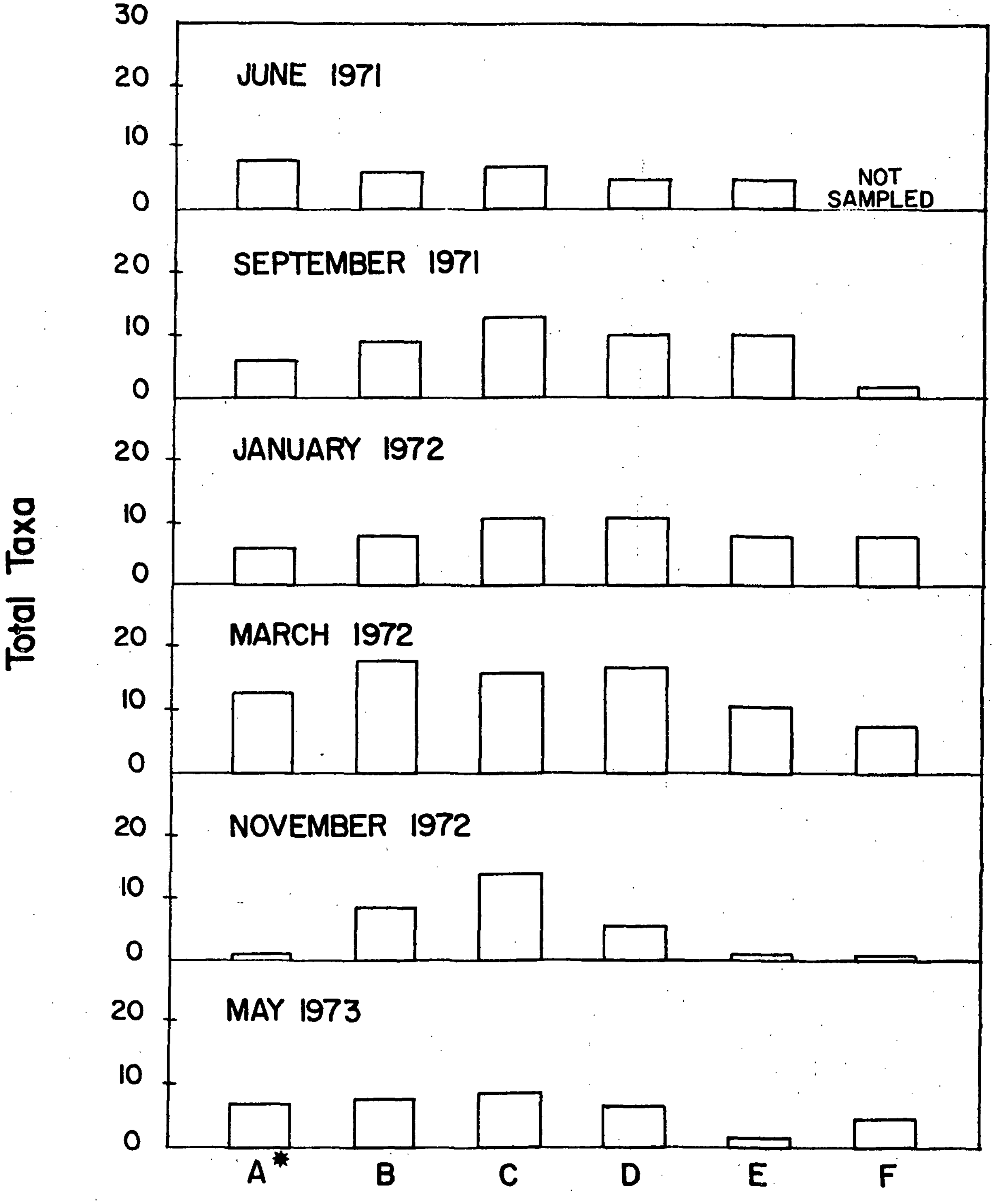
A comparison of the total zooplankton taxa reveals minor differences within particular sampling periods (Figure 3.3.1). Taxa numbers were lowest in June and ranged from 5 to 8 species. The number of taxa present in September and January was slightly greater than June and ranged from 6 to 13 with the exception of Transect F in September when only two taxa were collected. The greatest number of taxa occurred during March on Transects A and E and ranged from 11 to 18. Transect F was again lower than the others and only eight species were found. November samples showed greatest variability. The number of taxa ranged from 6 to 14 on Transects B, C, and D while only one was present on F, and none on A and E. The number of taxa in May was similar to June levels and ranged from 5 to 9, except on Transect E where only two were collected.

The range of zooplankton species occurring at each transect between June 1971 and May 1973 was as follows: A', 6 to 8; A, 6 to 13; B, 6 to 18; C, 7 to 16; D, 5 to 17; E, 0 to 11; and F, 0 to 8 (Figure 3.3.1). The number of taxa on Transect C was usually greater than other transects, regardless of period. Transects E and F usually had fewer taxa than other transects during periods sampled.

3.3.3.2.2 Quantitative Analysis

The zooplankton population on the Broad River Study Area was composed mainly of rotifers, copepods, and cladocerans. Densities from surface samples were generally low regardless of transect or season (Table 3.3.5).

Rotifers were the most abundant group of zooplankters with no single species predominating. The mean density was usually fewer than 50/liter regardless of transect or season. Exceptions to this generally low density level did not appear to follow a pattern, although all exceptions occurred on Transects B and C. The rotifer genera which were most numerous, the sample period, and transects having a density greater than 50/liter were: September



*Transect A' For June and September, 1971

Figure 3.3.1 Total zooplankton taxa by Transect (A-F) in the Broad River Study Area between June 1971 and May 1973.

Table 3.3.5 Mean density (number/liter) of major zooplankton groups sampled on Transects A to F on the Broad River Study Area between June 1971 and May 1973.

	A*	B	C	D	E	F
June 1971						
Rotifers	20	20	10	10	10	NS**
Copepoid nauplii	2	3	1	3	1	NS
Cladocerans	2	1	1	0	1	NS
September 1971						
Rotifers	10	30	190	10	10	10
Copepoid nauplii	2	3	1	1	1	0
Cladocerans	2	2	1	1	1	0
January 1972						
Rotifers	10	240	25	15	20	10
Copepoid nauplii	0	1	2	1	2	1
Cladocerans	0	0	0	0	0	0
March 1972						
Rotifers	15	65	35	20	15	15
Capepoid nauplii	2***	1	2	3	1	2
Cladocerans	0	1	0	2	1	0
November 1972						
Rotifers	0	34	73	4	0	1
Copepoid nauplii	0	3	2	1	0	0
Cladocerans	0	0	1	0	0	0
February 1973						
Rotifers	1	7	11	2	1	2
Copepoid nauplii	0	1	3	0	0	0
Cladocerans	0	2	0	0	0	0

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* Transect A' for June and September, 1971

** Not Sampled

*** Adults

Table 3.3.5 (Continued)

	A	B	C	D	E	F
May 1973						
Rotifera	10	170	99	1	1	4
Capepoid nauplii	0	0	4	0	0	0
Cladocerans	0	0	2	1	0	0

at C (190/liter), Brachionus; January at B (240/liter), Polyarthra and Keratella; March at B (65/liter), Brachionus; November at C (73/liter), Asplanchna, Chonochilus, and Polyarthra; and May at B and C (170 and 99/liter, respectively), Filinia, Keratella, and Polyarthra. Environmental conditions of Transects B and C appear to periodically allow the pulses noted for several species, particularly Brachionus, Keratella and Polyarthra, while on other transects the populations are restricted to low static levels.

The copepod populations were very low regardless of season and did not exceed a mean density of 4/liter (Table 3.3.5). Cyclopoid nauplii (probably Cyclops spp.) predominated over all other instar stages, including adults. No seasonal or transect trends in population density were evident.

The cladoceran populations were also very low regardless of season or transect and did not exceed a mean of 4/liter (Table 3.3.4). No species predominated although Pseudosida sp. occurred most frequently. In January, Cladocera were not collected at any station.

3.3.3.3 Net Plankton Biomass

Plankton standing crop ranged from 0.3 to 22.8 milligrams ash-free dry weight per 100 liters for sampling periods in November 1972 and February and May 1973 (Table 3.3.6). The biomass was greater in February than either November or May regardless of transect or station. The mean biomass values for November, February, and May were 2.1, 10.2, and 5.5 mg/100 liters, respectively.

3.3.4 DISCUSSION

3.3.4.1 Phytoplankton

Diatoms predominated on the Broad River Study Area both quantitatively and qualitatively. Certain diatom genera occurred with great regularity regardless of season. The diatoms Asterionella, Fragilaria, Melosira, and Tabellaria, found here, are among the most frequently encountered diatoms in

Table 3.3.6 Ash-free dry weight biomass in milligrams for 100 liters of plankton found in surface samples at stations on transects in the Broad River Study Area in 1972-73.

Transect and Station	1972	1973	
	November	February	May
A - 1 (Shallow)	1.2	11.8	9.2
B - 1 (Shallow)	1.5	11.6	4.3
C - 1 (Shallow)	2.6	7.1	0.1
C - 3 (Deep)	0.3	8.2	3.4
D - 3 (Shallow)	2.0	6.9	0.1
D - 1 (Deep)	4.8	5.5	3.9
E - 1 (Shallow)	1.6	14.5	0.1
F - 1 (Shallow)	2.9	16.2	22.8
Mean	2.1	10.2	5.5

large rivers and are considered true plankters (Hynes 1972). Nutrient enrichment is indicated by the dominant diatoms, Asterionella formosa, Fragilaria crotonensis, and Melosira granulata (Hutchinson 1967).

Asterionella sp. populations showed maxima in spring as expected. Spring maxima for Asterionella sp. are common and seem to be influenced by light, nutrients, and temperature (Hutchinson 1967). Asterionella formosa was identified in February and May 1973 samples and was likely the predominant species in 1971 and 1972 samples also. Asterionella spp. is strictly a planktonic form (Hynes 1972).

Fragilaria crotoninsis, a typical planktonic form (Hynes 1972), commonly has temperature related spring and fall maxima in lakes (Hutchinson 1967). However, only spring maxima occurred in the study area. The species noted above was identified in February and May 1973 samples on the study area and was likely predominant in earlier 1971 and 1972 samples.

Melosira granulata, a dominant diatom on the study area possibly has both spring and fall population pulses limited by temperature. This species showed some trend to spring and fall peaks but there were numerous exceptions. Late winter and early spring population peaks of some species of Melosira in lakes are associated with cold water and increasing light (Meier 1927; Schuurman 1932; Lund 1954, 1955). Seasonal changes in turbulence are also known to limit population levels in some Melosira species (Lund 1954).

The two dominant Melosira species on the study area, M. granulata and M. varians, are typical of two different zones in the ecosystem. M. granulata is a typical free-water zone (euplanktonic) diatom (Hustedt 1945). M. varians is a typical inhabitant of the silt substrate (epipelic) (Hynes 1972). The latter species is sluffed or lost from the bottom silt in proportion to population levels present, but flooding or scouring may influence densities

(Hynes 1972). The population trends of M. varians noted on the study area are probably influenced by sluffing rate in relation to actual benthic population levels.

Tabellaria fenestrata was identified in February and May 1973 samples and probably was the main species in 1971 and 1972 samples. This species is also typically planktonic (Hutchinson 1967). Strong spring peaks and weak fall peaks, common for Tabellaria sp. in lakes (Birge and Juday 1922; Chandler 1944), were not observed in the study area.

The genera Synedra, Nitzschia, Navicula, and Surirella, common benthic diatoms (Williams 1964; Hynes 1972), were found only in low numbers in the study area. Seven desmid species were collected although their abundance was also low. Desmids are a common alga of soft waters (Prescott 1968). Foley (1972) collected 25 species of desmids from the Broad River in the fall of 1971.

Phytoplankton populations are dependent on a number of environmental factors including temperature, light, turbulence, inorganic and organic substances, parasitism, predation, and competition. These factors regulate existance and density of species in a particular body of water.

Foley (1972), reported a greater number of algae species for the Broad River than those collected for this study. The difference is primarily due to methods of collection. Foley concentrated the phytoplankton from four liters of sample water to 200 ml by settling the organisms and removing the upper volume of water. Few organisms would be lost using his method and many species he reported obviously were not retained by the No. 20 bolting cloth net used in the present study. Foley's preparation time, procedure, and analytical time in examining samples in depth was many times that of the present study. Further, the objective of this investigation was to find predominant species of phytoplankton as retained by the No. 20 bolting cloth net and thus provide a general overview of the phytoplankton.

Patrick and Reimer (1966) point out that diatom flora in muddy rivers may be limited when compared to a clear river or stream. Turbid waters and resultant low light penetration in the Broad River system limit primary production. Studies on high-nutrient reservoirs in eastern Nebraska (Hergenrader et al. 1972) reveal effects of persistent clay turbidities. Turbid reservoirs had higher nutrient levels, lower primary production, and lower standing crops of phytoplankton, zooplankton, and benthos than clear reservoirs. Diatoms were also found to be a major contributor to the phytoplankton population in these systems while primary production rates were two to three times lower. It appears that a similar reduction in primary production may occur in the Broad River system.

Nutrient analysis of the Broad River indicates phosphorus could be a limiting factor, although other features suggest the system is not nutrient limited. For example, blue-green algae species, such as those identified from the study area, are typical of organically enriched waters (Palmer 1962). Also, the periodic occurrence of abnormally high river B.O.D. (See Chapter 3.2) in conjunction with somewhat reduced dissolved oxygen concentration during the winter, implies that this sytem is organically rich. The occurrence of blue-green algae species in each sample period may be important as indicators of nutrient load. If turbidity conditions associated with currents in the Parr Reservoir and Broad River remain as they are presently, there probably will not be great changes in primary production levels or species composition and density. If, however, conditions are created where currents and associated turbidity decline, primary production will probably increase. A potential problem would then exist because the nutrient level of the river in combination with seasonal high temperatures may allow expansion of undesirable blue-green algae. If currents and turbidity increase, primary production will probably decline.

3.3.4.2 Zooplankton

The common zooplankton species collected in the Broad River Study Area are wide spread limnetic plankters found in a variety of physical and chemical conditions (Edmondson 1959; Hutchinson 1967). The dominance of rotifers in the Broad River is a characteristic of large rivers (Williams 1966; Hynes 1972). The genera Keratella, Polyarthra, Brachionus, and Trichocerca are four of the five most widely distributed and dominant rotifers in the U.S. (Williams 1966). Crustaceans, normally dominant in reservoir systems, were only of secondary importance in the study area. The low storage ratio of Parr Reservoir and high flow rates likely limit abundance of crustecans, as they are unable to maintain themselves against flows greater than a few millimeters per second (Hynes 1972).

The distribution of zooplankton within the study area reflect the influence of water velocity. The more lentic areas of the reservoir contained somewhat greater numbers of taxa and higher population densities than the more lotic areas. The low number of taxa collected at Transect F is probably representative of upstream river zooplankton fauna.

Zooplankton as well as phytoplankton taxa were present in greatest abundance in March. Increased spring phytoplankton abundance may play a role in the maintenance of increased zooplankton diversity in the system. Cladoceran absence in January is related in part, to a typical lack of winter reproduction and an extremely low population of overwintering adults (Hutchinson 1967; Pennak 1953).

Zooplankton densities in the Broad River Study Area were very low in comparison to the mean values reported for U.S. rivers by Williams (1966).

Observations by Williams indicated that small rotifer populations were probably a result of their intolerance to turbulence and silt. Williams also found that stations with high phytoplankton populations generally have high rotifer populations, while low rotifer populations were found with low phytoplankton population. These findings suggested a dependence of rotifers on phytoplankton for food, or upon other factors that also favor phytoplankton growth. The low zooplankton densities found in the study area may be the result of prevailing turbid conditions and limited primary productivity, although zooplankton production may be characteristically low in lotic situations (Odum 1959). Other factors such as detrital and bacterial concentrations, and physical and chemical characteristics of the water influence zooplankton composition and abundance.

A possible food web was constructed for the seven species common in surface samples during each sample period (Figure 3.3.2). Cyclops spp. is a well known predator (Pennak 1953; McQueen 1969) and it probably preys on Keratella sp. (McQueen 1969), nauplius larvae (Anderson 1970), and other rotifers of appropriate size. Asplanchna sp. and Trichocera sp. are the other prominent predators in the food web probably feeding on algae, Keratella spp., other rotifers, and small crustacea (Hutchinson 1967). The genera Brachionus, Filinia, Keratella (Pennak 1953), and Polyarthra (Hutchinson 1967) are typical omnivorous rotifers feeding upon all organic particles of appropriate size.

3.3.4.3 Net Plankton Biomass

Standing crop biomass of plankton is an index of the overall productive capacity of an ecosystem. It will vary by season in relation to population fluctuations of phytoplankton and zooplankton. A common, simple method of biomass measurement is ash-free dry weight which accounts only for organic biomass present and therefore serves as an index to organic biosynthesis and true population growth.

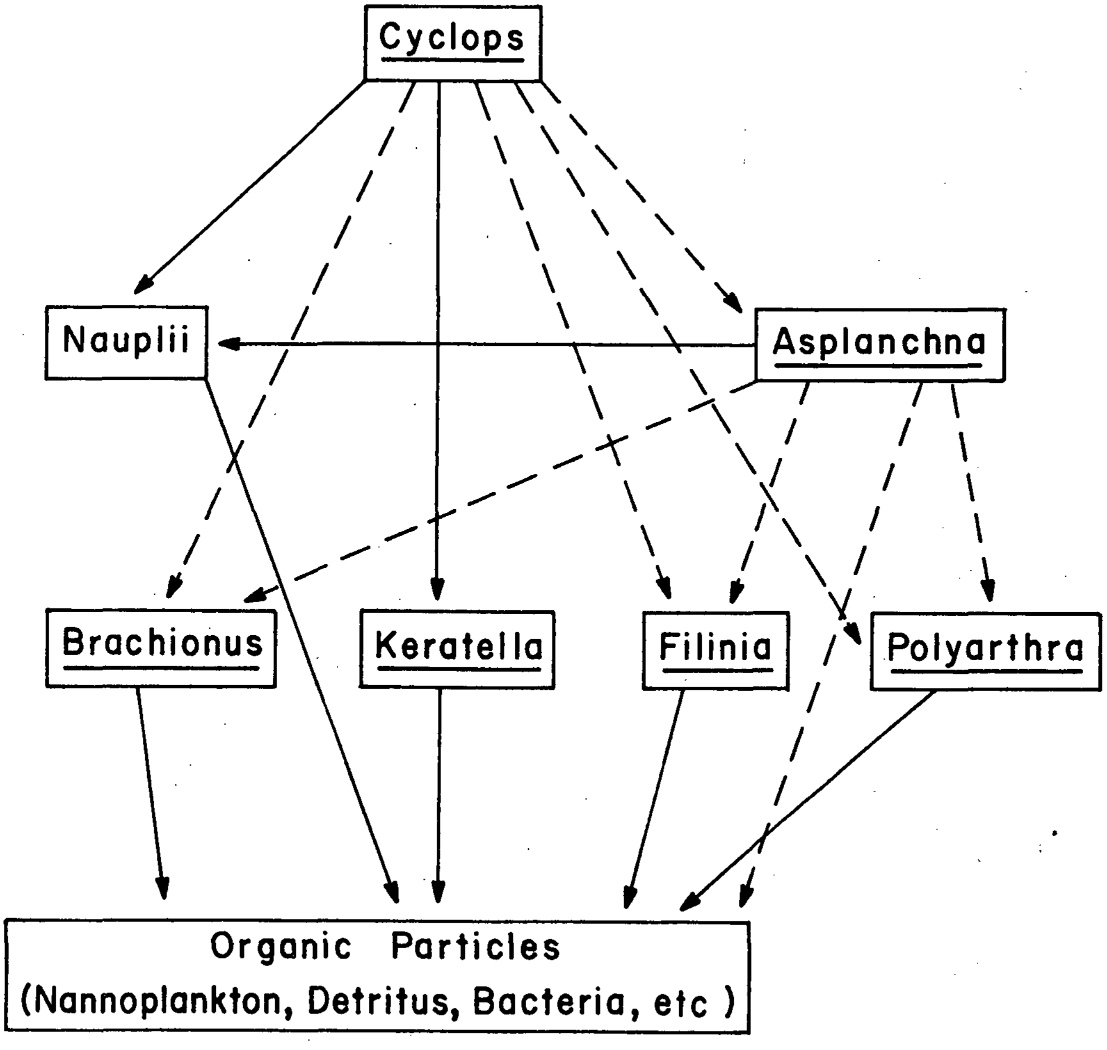

FIGURE 3.3.2 Possible Zooplankton Food Web for Perennial Species on the Broad River Study Area between June 1971 and March 1972.

Plankton standing crop ranged from 0.3 to 22.8 milligrams ash-free dry weight per 100 liters for sample periods in November 1972 and February and May, 1973 (Table 3.3.6). The mean biomass values for November, February, and May were 2.1, 10.2, and 5.5 mg/100 liters, respectively.

Biomass standing crop on the study area was low during the three measurement periods in 1972 and 1973; a direct reflection of the restricted productive capacity of the ecosystem. Standing crop showed the influence of a February bloom when the mean biomass was two to five times greater than in May or November, respectively.

Considerable variability was noted within each sample date making interpretation of results difficult. Some of the variability may be due to the extremely small organic mass present as plankton in 100 liters of water. Because biomass was so low, the reliability of measurement with existing analytical procedures is questionable. Another important source of variability is the organic debris (detritus) in samples not of planktonic origin, e.g., higher plant particles, insect fragments, etc. The reported values should therefore be considered only as an indication of ash-free biomass of plankton standing crop subject to the limitations noted above as well as the selective concentration of organisms with the plankton net.

3.3.5 SUMMARY

3.3.5.1 Phytoplankton

A total of 102 phytoplankton taxa were collected on the Broad River Study Area between June 1971 and May 1973 in surface samples and vertical plankton net tows. The species composition in major taxonomic groups were: Chlorophyta, 37; Chrysophyta, 42; Cyanophyta, 15; Euglenophyta, 5; and Pyrrhophyta, 3.

Diatoms predominated both quantitatively and qualitatively, though all species were low in abundance. The planktonic genera Asterionella, Fragilaria, Melosira, and Tabellaria found in the study area are common in many river systems. Several common benthic algae were found, but only in low numbers. Desmids, common in soft waters, were represented by several species whose density was always low.

The phytoplankton data reported are representative of net phytoplankton and not total phytoplankton as reported by Foley (1972). The methods used in this study are considered adequate to meet the objectives of defining and detecting changes in the predominant species, and providing an overview of population structure.

3.3.5.2 Zooplankton

A total of 35 zooplankton species were collected in the Broad River Study Area between June 1971 and May 1973 in surface samples and vertical plankton net tows. The species composition by major taxonomic groups was as follows: Protozoa, 4; Rotifera, 21; Copepoda, 2; and Cladocera, 8.

Net zooplankton of the Broad River Study Area are dominated by rotifers, a characteristic common to many U.S. river systems. Four of the five most common and widely distributed rotifer genera were collected in the Broad River. Crustaceans, normally dominant in reservoirs, were only of secondary importance in the study area. Crustacean abundance is undoubtedly limited by the high flow rates and low storage ratio of Parr Reservoir as well as the high silt turbidity.

Distribution of zooplankton within the study area reflects the influence of water velocity on population levels. The more lentic areas had higher zooplankton densities. Also, the abundance of zooplankton appeared to be directly related to the abundance of phytoplankton.

Densities of all net zooplankters was much lower than those reported for other U.S. river systems. These low population levels are probably due mainly to the high silt turbidity. Other influencing factors are detrital and bacterial levels, and physical and chemical characteristics of the water. A hypothetical food web was constructed to show possible trophic relationships among zooplankters.

3.3.5.3 Net Plankton Biomass

Although problems were encountered in the analysis of plankton biomass, the low values are an indication of the restricted productive capacity of the ecosystem.

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3.4 VASCULAR HYDROPHYTES

3.4.1 INTRODUCTION

Vascular hydrophytes play an important role in the aquatic ecosystem of the Broad River Study Area since they are utilized by birds, mammals, fish, and numerous invertebrates (Fassett 1966). Therefore, proposed water level fluctuations will have an impact on the plant-animal relationship within the area. The objective of this study was to identify important vascular hydrophytic species to be influenced by the proposed action.

3.4.2 METHODS

A survey of vascular hydrophytes of the Broad River Study Area was conducted by boat in March 1972 and May 1973. Included were the east and west banks of Parr Reservoir, the mouth areas of Frees Creek and Cannons Creek, and along the Broad River above the dam to the Highway 34 bridge (see map in back).

Specimens of emergent and submergent vegetation were collected, pressed, and identified. Emergent hydrophytes were defined as plants attached to the substrate and occurring on exposed or submerged soils, from where the water table is 50 cm (19.7 in) or more beneath the soil surface to where the soil is covered by 150 cm (59.1 in) or more of water. Submerged hydrophytes are plants attached to the substrate and occurring on submerged soils at all water depths to about 10 m (32.8 ft). These plants are characterized by foliage that is completely submerged (Sculthorpe 1967).

3.4.3 FINDINGS

A total of 18 species of vascular hydrophytes were identified growing on the Broad River Study Area (Table 3.4.1). Fifteen species were classified as emergent and three species were submergent hydrophytes.

Cattail (Typha latifolia) was the predominant emergent species

Table 3.4.1 Vascular hydrophytes found during a shoreline survey of the Broad River Study Area.

*Family Scientific Name Common Name	Growth Form	Location
Typhaceae		
Typha sp.		
Cattail	Emergent	Broad River
Najadaceae		
Potamogeton foliosus		
Leafy pondweed	Submergent	Broad River
Potamogeton sp.		
Pondweed	Submergent	Hellers Creek
Alismataceae		
Sagittaria latifolia		Broad River
Arrowhead	Emergent	Hellers Creek
Cyperaceae		
Carex lupulina		Broad River
Hop sedge	Emergent	Cannons Creek
Cyperus sp.		Broad River
Sedge	Emergent	Cannons Creek
Scirpus sp.		
Bulrush	Emergent	Broad River
Araceae		
Peltandra virginica		
Arrow arum	Emergent	Cannons Creek
Pontederiaceae		
Pontederia cordata		
Pickerelweed	Emergent	Cannons Creek
Juncaceae		
Juncus effusus		Broad River
Soft rush	Emergent	Cannons Creek
Juncus pelocarpus		Broad River
Bog rush	Emergent	Cannons Creek
Saururaceae		
Saururus cernuus		
Water-dragon	Emergent	Frees Creek
Salicaceae		Broad River
Salix nigra		Cannons Creek
Marsh willow	Emergent	Frees Creek

Table 3.4.1 (Continued)

*Family Scientific Name Common Name	Growth Form	Location
Polygonaceae		
Polygonum sp.		
Smartweed	Emergent	Broad River
Hypericaceae		
Hypericum sp.		
St. John's Wort	Emergent	Hellers Creek
Haloragaceae		
Myriophyllum sp.		Cannons Creek
Water milfoil	Submergent	Hellers Creek
Umbelliferae		
Hydrocotyle umbellata		Cannons Creek
Water pennywort	Emergent	Frees Creek
Acanthaceae		
Dianthera americana		Cannons Creek
Water willow	Emergent	Frees Creek

*Nomenclature follows Hotchkiss (1967) and Fassett (1966) occurring in dense colonies along the shoreline. Arrowhead Sagittaria latifolia) also was dispersed throughout the area. Marsh willow (Salix nigra) was an important woody hydrophyte growing in shallow water and on moist banks in parts of the study area.

The three submergent species were observed near the dam. The relative abundance of vascular hydrophytes within the study area was generally limited.

3.4.4 DISCUSSION

Most of the species listed are important sources of food for waterfowl and some upland game and song birds. Nutlets (fruits) and tubers are the most utilized portions of the plants. Arrowhead is probably the most favored plant species of waterfowl as a food plant. Marsh willow attracts waterfowl and song birds as a nesting tree. Muskrat and beaver utilize many of these species as a food source (Fassett 1966).

Several species of hydrophytes provide shade and shelter for various fish species. Rush species (Juncus spp.) are spawning grounds for species of fish. Water milfoil (Myriophyllum sp.) and pondweeds (Potamogeton spp.) are extremely important in the aquatic ecosystem since they support an insect population fed upon by fish (Fassett 1966).

Emergent species were confined to shallow water next to shore or the moist shoreline. While emergents can survive water depths greater than 1.5 m (4.9 ft), plant populations are probably limited because of the turbidity of the water. While considerable volumes of soil have been deposited in these rivers from erosion, soils of the Broad River Study Area are low in nutrients (see Section 5.2), and thus, contribute little to the aquatic ecosystem's nutrient supply.

Submergent species were observed growing in protected areas.

Therefore, distribution of these species is probably influenced by stream flow as well as turbidity of the water.

Emergent hydrophytes are capable of surviving a range of water depths. Many are capable of surviving long periods of being totally submerged. These effects usually involve morphological and anatomical changes. This includes changes in the shape and size of leaves and the degree of development of various tissues. Prolonged submergence may result in population shifts to less shallow waters. The effect of periodic water level fluctuations on the emergent species is not well known.

Turbidity limits light penetration in the water which is probably the limiting factor in the growth of submergent vegetation. Some population shifts might occur in response to increased water levels. However, the submergent vegetation should not be significantly altered if physical and chemical conditions of the water are not altered by the proposed facility. Submergent vegetation might become more abundant if water turbidity decreases, allowing greater light penetration.

3.4.5 SUMMARY

Eighteen species of vascular hydrophytes have been observed growing on the Broad River Study Area. Emergent types predominated in shallow waters along the shoreline and moist banks. Cattail was the most common species. Three species of submergent hydrophytes were found growing in areas where water flow was greately reduced.

The planned increased water levels on the study area will inundate many existing emergent types, however, new colonization by emergents will likely occur near the shorelines.

3.4.6 REFERENCES

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3.5 BENTHOS

3.5.1 INTRODUCTION

Benthic macroinvertebrate populations were examined qualitatively and quantitatively at specific sample stations in the Broad River Study Area between June 1971 and May 1973. The purpose of these investigations was to provide basic information on species composition, density, diversity, and biomass of the macrobenthic fauna.

Benthic macroinvertebrates are important biological indicators of conditions within an aquatic system (Kolkwitz and Marsson 1908, 1909; Richardson 1928; Bartsch 1948; Ingram 1957; Hynes 1960). Their analysis is fundamental to the examination of trophic relationships and the understanding of the aquatic system.

3.5.2 METHODS AND MATERIALS

Benthos samples were collected from Transects A through D and F with a 15 cm (6 in) square Ekman dredge. Two (June and September, 1971), three (January and March, 1972), and five (November, 1972, and February and May, 1973) dredge samples were taken at each station using the method outlined by Welch (1948). Several different dredges are available for benthos sampling but the Ekman was selected because recent work by Hudson (1970) and Howmiller (1971) show it is the best sampler available for use in soft, silty substrates characteristic of the study area. Benthos samples from rocky Transect E, below Parr Dam in the swift tailwater current, were collected with a standard Surber sampler having a 30.5 cm (12 in) square frame. Two (June and September, 1971), three (January and March, 1972), and five (November, 1972, and February and May, 1973) samples were taken at each station using the procedure outlined by Welch (1948). Ekman dredge samples were washed with a fine spray of filtered water in a U.S. Standard No. 30 wire mesh sieve. Organisms collected in dredge and Surber samples were placed in jars and preserved in about 10 percent formalin.

Macroinvertebrates were hand picked in the laboratory from gridded petri dishes under a 10X dissecting microscope and enumerated using appropriate magnification. Identification was according to: Berner 1959, Brinkhurst 1971, Burks 1953, Herrington 1962, Johannsen 1970, Mason 1968, Needham and Westfall 1955, Pennak 1953, Ross 1944, Roback 1957, Usinger 1971, and Ward and Whipple 1959. The mean number of organisms in samples from a station was computed and quantitative data were reported in numbers per square meter.

In January and March, 1972, the number of Ekman dredge samples taken at each station was increased from two to three as an effort to improve population estimation, increase the probability of collecting those species present in low numbers, and allow the computation of the standard deviation statistic to examine sampling variability. After instituting triplicate sampling it was obvious that variability between samples at individual stations was great, especially when only a few organisms were found. As a result of an analysis comparing the efficiency of 15 cm (6 in) square Ekman versus the 23 cm (9.1 in) square Ekman, and information provided by Kajak (1963), the number of samples collected with a 15 cm square Ekman was increased to five beginning in November 1972.

Biomass analyses of each of the five samples collected at each station was initiated beginning in November 1972. After enumeration, organisms were dried to a constant weight at 60°C (usually 24 hours), then weighed to the nearest 0.1 mg on an analytical balance, and ashed at 600°C in a muffle furnace. Ash-free dry weight was used as the estimate of biomass and was expressed in mean grams per square meter. Direct biomass determinations were not conducted on chironomids because identification required placing whole specimens on permanent slides. Biomass for chironomids was indirectly estimated with a mathematical model constructed using chironomid data from extra Ekman grab samples. A linear length, ash-free dry weight relationship was computed resulting in the following model:

$$\begin{matrix}\text{Log ash-free} \\ \text{Dry weight (g)}\end{matrix} = -9.45110+1.29935 \text{ log length (mm)}$$

The correlation coefficient (r) of the model was 0.876 which was significant at the 0.001 level. The procedure for use of the model involved counting all chironomids for each 0.25 mm size class and multiplying by the ash-free dry weight for that particular group as determined indirectly from the regression formula. Biomass weights were determined for the total Chironomidae and expressed as mean grams per square meter.

3.5.3 FINDINGS

3.5.3.1 Insects

3.5.3.1.1 Qualitative Analysis

A total of 54 insect species were identified at least to genus, with an additional 11 identified to family and one identified to order for a total of 66 taxa collected on the Broad River Study Area between June 1971 and May 1973 (Table 3.5.1). The species composition by major taxonomic groups was as follows: Coleoptera, 5; Diptera, 31; Ephemeroptera, 7; Hemiptera, 4; Neuroptera, 1; Odonata, 10; Plecoptera, 1; and Trichoptera, 7.

The range in numbers of total insect taxa during each sampling period was as follows: June, 7-21; September, 5-16; January, 0-10; March, 8-17; November, 6-17; and May, 1-14 (Tables 3.5.2 to 3.5.7). The ranges of total taxa in all months sampled were comparable except in January when a decline was evident.

The seasonal range of total insect species from individual transects was as follows: A', 7-11; A, 1-15; B, 10-17; C, 10-16; D, 8-17;

Table 3.5.1 *Species list of benthic macroinvertebrates present (P) at sample periods between June 1971* and May 1973 on the Broad River Study Area.

Taxa	1971		1972			1973
	June	Sept.	Jan.	March	Nov.	May
Insecta						
Coleoptera						
Chrysomelidae						
Donacia sp.	0	0	0	0	P	0
Dytiscidae						
Unidentified*	0	P	0	0	0	0
Elmidae						
Stenelmis sp.	P	P	0	0	0	0
Gyrinidae						
Dineutus sp.	0	0	0	0	0	P
Hydrophilidae						
Berosus sp.	P	0	0	0	0	0
Coleoptera Total	2	2	0	0	1	1
Diptera						
Ceratopogonidae						
Palpomyia sp.	P	P	P	P	P	0
Unidentified	0	0	0	0	P	P
Chironomidae						
Ablabesmia sp.	P	P	P	P	P	P
Brillia sp.	0	P	0	0	0	0
Chironomus sp.	P	P	P	P	P	P
Coelotanypus sp.	P	P	P	P	P	P
Cricotopus sp.	0	P	0	P	P	0
Cryptochironomus sp.	P	P	P	P	P	P
Dicrotendipes sp.	0	0	0	0	P	0
Diplocladius sp.	0	0	0	0	P	0
Glyptotendipes sp.	P	P	0	P	0	P
Harnishia sp.	P	0	0	0	P	P
Heterotrissocladius sp.	0	0	0	P	0	0

Table 3.5.1 (Continued)

	1971		1972			1973
	June	Sept.	Jan.	March	Nov.	May
Hydrobaenus sp. I	0	0	0	0	P	0
Hydrobaenus sp. II	0	0	0	0	P	0
Metriocnemus sp.	0	0	0	0	0	P
Micropsectra sp.	0	0	0	0	P	0
Orthocladius sp.	0	0	0	P	0	0
Paracladopelma sp.	P	0	0	P	0	P
Paralauterborniella sp.	0	0	0	0	P	0
Paratendipes sp.	0	0	0	P	0	0
Pentaneura sp.	P	0	0	0	0	0
Polypedilum sp.	P	P	P	P	P	0
Procladius sp.	P	P	P	P	P	P
Psectrocladius sp.	P	0	0	P	0	P
Pseudochironomus sp.	P	0	0	0	0	P
Smittia sp.	P	0	0	P	0	0
Tanypus sp.	0	P	P	P	0	0
Tanytarsus sp.	P	P	P	P	P	P
Unidentified*	P	P	P	P	P	P
Culicidae						
Chaoborus punctipennis	P	P	P	P	P	P
Diptera Total	17	14	11	19	19	15
Ephemeroptera						
Baetidae						
Ephemerella sp.	0	0	P	0	0	0
Unidentified*	0	0	0	0	0	P
Caenidae						
Tricorythodes sp.	P	P	0	0	0	0
Tricorythodes albilineatus	0	0	0	0	0	P
Ephemeridae						
Hexagenia limbata	P	P	P	P	P	P
Heptageniidae						
Stenonema sp.	P	P	0	P	0	P
Stenonema sp. (*pulchellum* gr.)	0	0	0	0	0	P
Ephemeroptera Total	3	3	2	2	1	5

Table 3.5.1 (Continued)

	1971		1972			1973
	June	Sept.	Jan.	March	Nov.	May
Hemiptera						
Corixidae						
Neocorixa sp.	0	0	0	0	P	0
Unidentified*	P	0	0	0	P	0
Notonectidae						
Notonecta sp.	P	0	0	0	0	0
Veliidae						
Unidentified*	P	0	0	P	0	0
Hemiptera Total	3	0	0	1	2	0
Neuroptera						
Sialidae						
Sialis sp.	P	P	P	P	P	P
Neuroptera Total	1	1	1	1	1	1
Odonata						
Calopterygidae						
Calopteryx sp.	0	P	0	0	0	0
Hetaerina sp.	0	0	P	0	0	0
Coenagrionidae						
Hyponeura sp.	P	P	0	0	0	0
Gomphidae						
Dromogomphus sp.	0	0	0	P	0	0
Gomphus sp.	P	P	P	0	P	0
Unidentified*	0	0	0	P	P	0
Libellulidae						
Perithemis sp.	0	0	0	0	P	0
Somatochlora sp.	0	0	0	0	P	0
Macromiidae						
Macromia sp.	0	0	0	0	P	0
Unidentified*	0	0	0	0	0	P
Odonata Total	2	3	2	2	5	1

Table 3.5.1 (Continued)

	1971		1972			1973
	June	Sept.	Jan.	March	Nov.	May
Plecoptera						
Perlodidae						
Isoperla sp.	0	0	P	0	0	0
Plecoptera Total	0	0	1	0	0	0
Trichoptera						
Hydropsychidae						
Hydropsyche sp.	P	P	P	0	P	0
Hydroptilidae						
Unidentified*	0	0	0	0	P	0
Psychomiidae						
Phylocentropus sp.	0	0	0	0	P	P
Unidentified*	P	0	0	0	0	P
Rhyacophilidae						
Rhyacophila sp.	0	0	0	0	P	0
Unidentified*	0	0	0	0	P	0
Unidentified*	0	0	0	0	0	P
Trichoptera Total	2	1	1	0	5	3
Insecta Total	30	24	18	25	34	26
Crustacea						
Amphipoda						
Tilitridae						
Hyallela azteca	0	0	0	0	P	0
Decapoda						
Palaemonidae						
Palaemonetes sp.	0	0	0	0	P	0
Isopoda						
Asellus sp.	P	0	0	P	0	0
Crustacea Total	1	0	0	1	2	0

Table 3.5.1 (Continued)

	1971		1972			1973
	June	Sept.	Jan.	March	Nov.	May
Archnoidea						
Hydracarina						
Unidentified*	P	P	P	P	P	0
Archnoidea Total	1	1	1	1	1	0
Hirudinea						
Unidentified*	P	0	0	0	P	0
Hirudinea Total	1	0	0	0	1	0
Oligochaeta						
Naididae						
Stylaria fossularis	0	0	0	0	0	P
Unidentified*	0	0	0	0	0	P
Tubificidae						
Branchiura sowerbyii	P	P	P	P	P	P
Unidentified*	0	0	0	0	0	P
Unidentified*	P	P	P	P	P	P
Oligochaeta Total	2	2	2	2	2	5
Nematoda						
Unidentified*	P	P	0	0	P	P
Nematoda Total	1	1	0	0	1	1
Mollusca						
Gastropoda						
Physidae						
Physa sp.	P	P	P	P	P	0
Planorbidae						
Gyraulis sp.	0	0	0	0	P	0
Unidentified*	P	P	0	0	0	0
Lymnaeidae						
Lymnaea sp.	0	0	0	0	P	0
Gastropoda Total	2	2	1	1	3	0

Table 3.5.1 (Continued)

	1971		1972			1973
	June	Sept.	Jan.	March	Nov.	May
Pelecypoda						
Corbiculidae						
Corbicula manilensis	P	P	P	P	P	P
Sphaeriidae						
Pisidium sp.	0	0	0	0	0	P
Sphaerium transversum	0	0	0	0	0	P
Sphaerium sp.	P	P	P	P	P	0
Unidentified*	0	0	0	0	0	P
Unionidae						
Unidentified*	P	0	0	0	P	P
Pelecypoda Total	3	2	2	2	3	5
Mollusca Total	5	4	3	3	6	5
Taxa Total	41	32	24	32	47	37

*Species unknown, may be more than one species but considered here as one.

Table 3.5.2 Total insect species by order and mean number per square meter (in parentheses) on transects in the Broad River Study Area in June 1971.

	A	B	C	D	E
Insecta					
Coleoptera	0 (0)	0 (0)	0 (0)	0 (0)	2 (52)
Diptera	6 (657)	13 (2611)	8 (3427)	12 (267)	12 (399)
Ephemeroptera	1 (11)	1 (14)	1 (308)	2 (208)	3 (1148)
Hemiptera	0 (0)	1 (15)	1 (7)	0 (0)	0 (0)
Neuroptera	0 (0)	1 (50)	1 (7)	0 (0)	0 (7)
Odonata	0 (0)	0 (0)	1 (7)	1 (14)	1 (7)
Trichoptera	0 (0)	1 (22)	1 (7)	0 (0)	2 (43)
Total Taxa Mean No./m^2	7 (668)	17 (2712)	13 (3763)	15 (489)	21 (1656)

Table 3.5.3 Total insect species by order and mean number per square meter (in parentheses) on transects in the Broad River Study Area in September 1971.

	A	B	C	D	E
Insecta					
Coleoptera	0	0	0	1	1
	(0)	(0)	(0)	(5)	(3)
Diptera	9	11	13	7	1
	(785)	(492)	(1811)	(202)	(14)
Ephemeroptera	2	1	1	1	2
	(97)	(25)	(232)	(2008)	(19)
Neuroptera	0	1	1	0	0
	(0)	(12)	(30)	(0)	(0)
Odonata	0	0	1	1	1
	(0)	(0)	(5)	(15)	(6)
Trichoptera	0	0	0	0	1
	(0)	(0)	(0)	(0)	(3)
Total Taxa	11	13	16	10	5
Mean No. /m^2	(882)	(529)	(2078)	(2230)	(45)

Table 3.5.4 Total insect species by order and mean number per square meter (in parentheses) on transects in the Broad River Study Area in January 1972.

	A	B	C	D	E	F
Insecta						
Diptera	3	8	9	6	0	1
	(37)	(829)	(1174)	(54)	(0)	(7)
Ephemeroptera	1	1	1	1	0	1
	(193)	(5)	(148)	(444)	(0)	(22)
Neuroptera	0	1	0	0	0	0
	(0)	(10)	(0)	(0)	(0)	(0)
Odonata	1	0	0	1	0	1
	(15)	(0)	(0)	(5)	(0)	(4)
Plecoptera	0	0	0	0	0	1
	(0)	(0)	(0)	(0)	(0)	(4)
Trichoptera	0	0	0	0	0	1
	(0)	(0)	(0)	(0)	(0)	(7)
Total Taxa	5	10	10	8	0	5
Mean No. /m^2	(245)	(844)	(1322)	(503)	(0)	(44)

Table 3.5.5 Total insect species by order and mean number per square meter (in parentheses) on transects in the Broad River Study Area in March 1972.

	A	B	C	D	E
Insecta					
Diptera	7 (274)	9 (922)	10 (824)	14 (355)	7 (209)
Ephemeroptera	1 (49)	0 (0)	1 (64)	1 (148)	1 (118)
Hemiptera	0 (0)	1 (5)	1 (5)	1 (5)	0 (0)
Neuroptera	0 (0)	1 (10)	0 (0)	0 (0)	0 (0)
Odonata	0 (0)	0 (0)	0 (0)	1 (20)	2 (11)
Total Taxa Mean No./m^2	8 (323)	11 (938)	12 (893)	17 (528)	10 (338)

Table 3.5.6 Total insect species by order and mean number per square meter (in parentheses) on transects in the Broad River Study Area in November 1972.

	A	B	C	D	E	F
Insecta						
Coleoptera	1	0	0	0	0	0
	(30)	(0)	(0)	(0)	(0)	(0)
Diptera	9	12	11	9	6	6
	(3023)	(2929)	(2590)	(682)	(2370)	(1630)
Ephemeroptera	1	0	1	1	0	0
	(740)	(0)	(444)	(1155)	(0)	(0)
Hemiptera	0	0	1	1	0	0
	(0)	(0)	(8)	(156)	(0)	(0)
Neuroptera	0	1	1	1	0	0
	(0)	(52)	(45)	(30)	(0)	(0)
Odonata	4	0	0	1	0	0
	(52)	(0)	(0)	(8)	(0)	(0)
Trichoptera	0	4	0	1	2	0
	(0)	(37)	(0)	(45)	(37)	(0)
Total Taxa	15	17	14	14	8	6
Mean No./m^2	(3845)	(3018)	(3087)	(2076)	(2407)	(1630)

Table 3.5.7 Total insect species by order and mean number per square meter (in parentheses) on transects in the Broad River Study Area in May 1973.

	A	B	C	D	E	F
Insecta						
Coleoptera	0 (0)	0 (0)	0 (0)	1 (11)	0 (0)	0 (0)
Diptera	1 (43)	9 (592)	10 (401)	4 (56)	0 (0)	0 (0)
Ephemeroptera	0 (0)	1 (7)	2 (48)	1 (376)	3 (29)	0 (0)
Neuroptera	0 (0)	1 (4)	1 (11)	0 (0)	1 (4)	0 (0)
Odonata	0 (0)	0 (0)	0 (0)	1 (6)	0 (0)	0 (0)
Trichoptera	0 (0)	3 (32)	1 (11)	1 (6)	0 (0)	0 (0)
Total Taxa	1	14	14	8	4	0
Mean No. /m^2	(43)	(635)	(471)	(455)	(33)	(0)

E, 0-21; and F, 0-16 (Tables 3.5.2 to 3.5.7). The greatest seasonal fluctuations in number of taxa occurred at Transect E, below Parr Dam, while seasonal fluctuations at the other transects were less intense. The number of taxa from Transect A', A, and F was usually less than those from B, C, or D regardless of sample date, while Transect F consistently had fewer taxa than all other transects.

The insect species found during all sample periods that are considered ubiquitous to the Broad River Study Area include: Diptera, (Chironomidae) *Ablabesmia* sp., *Chironomus* sp., *Coelotanypus* sp., *Cryptochironomus* sp., *Procladius* sp., *Tanytarsus* sp.; (Culicidae) *Chaoborus punctipennis*; Ephemeroptera, (Ephemeridae) *Hexagenia limbata*; and Neuroptera, (Sialidae) *Sialis* sp. (Table 3.5.1). Midges were the predominate insect fauna.

3.5.3.1.2 Quantitative Analysis

The orders Diptera and Ephemeroptera were numerically predominant in the Broad River Study Area during all seasons (Tables 3.5.2 to 3.5.7). The Diptera were accounted for primarily by chironomid larvae and phantom midges (*Chaoborus punctipennis*), while the Ephemeroptera consisted primarily of burrowing mayflies (*Hexagenia limbata*).

The density of insects varied by sample period (Tables 3.5.2 to 3.5.7). The density in mean number per square meter ranged as follows by transect: A', 668-882; A, 43-3845; B, 529-3018; C, 471-3763; D, 455-2230; E, 0-2407; and F, 0-1630. The densities on Transects B and C were generally greater than other transects.

Seasonal changes in insect density were evident (Tables 3.5.2 to 3.5.7) with the greatest overall density of insects occurring in June and November. The mean density (number per square meter) ranged as follows by sample period: June, 489-3763; September, 45-2230; January, 0-1322; March, 323-938; November, 1930-3845; and May, 0-635.

Seasonal density changes also occurred within the major taxa, midges (Diptera) and mayflies, mainly Hexagenia limbata (Ephemeroptera) (Tables 3.5.2 to 3.5.7). The density of midges was greatest in June and November, especially at Transects A, B, and C. In general, the midge density was greater than $400/m^2$ at the more lentic-like Transects B and C and usually lower than $400/m^2$ at the more lotic-like Transects D, E, and F. The midges comprised about 80 percent or more of the benthic community at Transects A', A, B, and C except at Transect A during January when they represented only 15 percent. At Transects D, E, and F they accounted for 67 percent or less of the community except at Transects E and F in November when they totaled 98 to 100 percent. Mayfly density was greatest during September. The most abundant populations occurred at Transect D where they ranged from 28 to 90 percent of the community.

A major emergence of Hexagenia limbata was underway in the vicinity of Transect D on 20 June 1971. Midge emergence patterns were not discernable, however, minor emergences were observed during spring, summer, and fall sampling periods.

3.5.3.2 Other Benthic Macroinvertebrates

3.5.3.2.1 Qualitative Analysis

In addition to the insects previously discussed, oligochaetes and molluscs also were important benthic fauna of the Broad River Study Area (Table 3.5.1). The species composition of the oligochaetes was not examined in detail, however, one species, Branchiura sowerbyi, was easily separated on the basis of unique characteristics. The remainder, listed as unidentified, are probably composed of a multiple species complex. The predominant species of molluscs included: Gastropoda, (Physidae) Physa sp.; and Pelecypoda, (Corbiculidae) Corbicula manilensis and (Sphaeriidae) Sphaerium sp. Aquatic mites (Arachnoidea, Hydracarina) and Physa sp. were collected during each sample period except in May 1973, but their densities were low.

3.5.3.2.2 Quantitative Analysis

The density of oligochaetes varied by sample period and transect (Figure 3.5.1). The mean density at Transect A exceeded $400/m^2$ only once in November 1972, while the density at Transect E was even lower and did not exceed $200/m^2$. The mean oligochaete density at Transects B, C, and D was usually greater than $400/m^2$ and was frequently near or in excess of $1000/m^2$. Greatest oligochaete densities were found during January, March, and November although June populations from Transect D did exceed $1000/m^2$. Branchiura sowerbyi comprised a significant proportion of the total oligochaete numbers at Transects B, C, and D regardless of season.

The density of pelecypod molluscs, represented by the exotic Asian clam, Corbicula manilensis, and fingernail clams, Sphaerium spp., was usually low except from Transect D which had densities ranging from about 500 to $2000/m^2$ (Table 3.5.8). The C. manilensis population at Transect D expanded rapidly from June 1971 to November 1972, but a sharp decline was noted in May 1973. During the period of rapid population expansion, the density increased steadily from about $100/m^2$ in June 1971 to over $1900/m^2$ in November 1972. The May 1973 population level of about $350/m^2$ approached the original density found in the June 1971 samples.

3.5.3.3 Biomass

Benthos standing crop was determined from shallow and deep stations of representative Transects B and D in November 1972 and February and May, 1973 (Tables 3.5.9 and 3.5.10). Total ash-free dry weight biomass for the periods

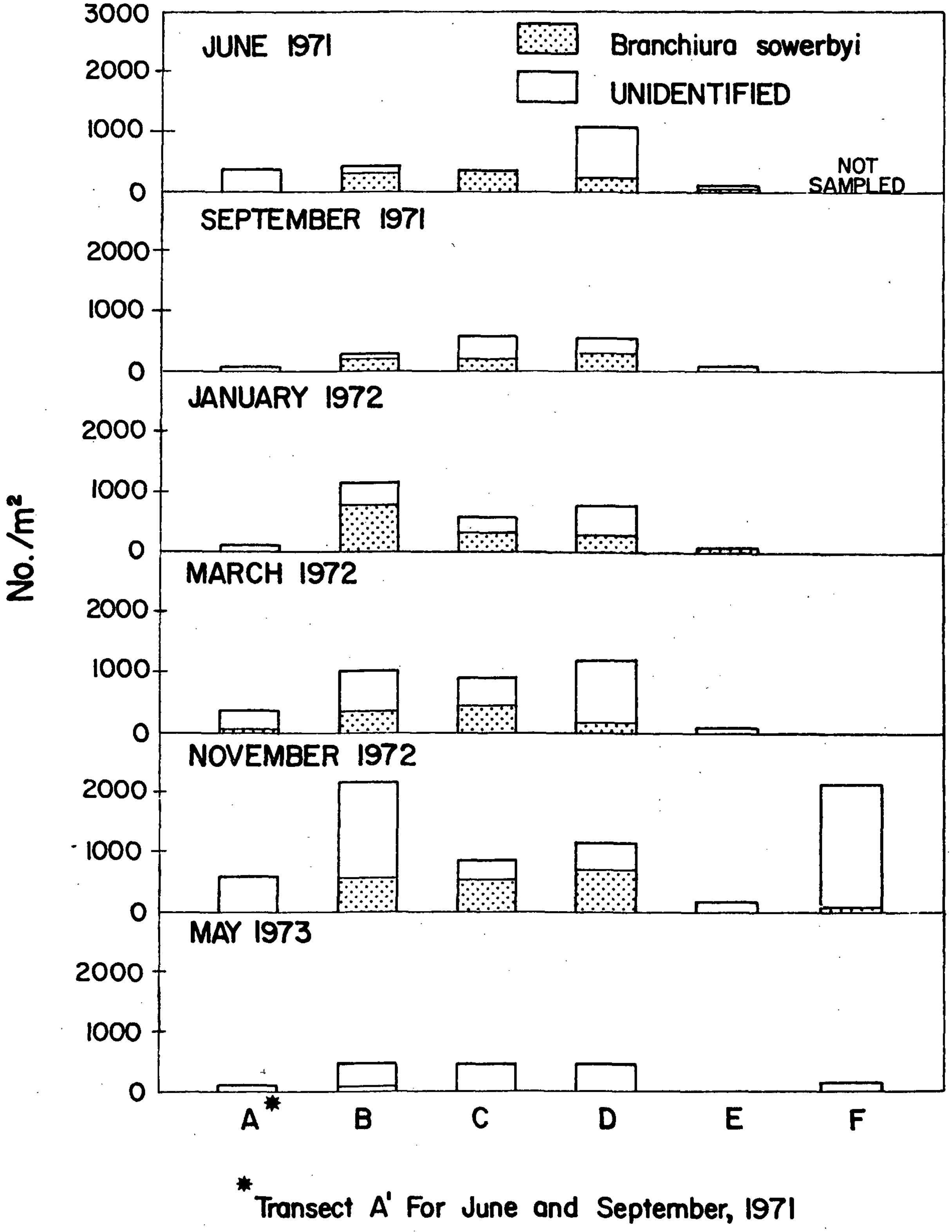

Figure 3.5.1 Mean Number of oligochaetes (Branchiura sowerbyi and unidentified species) per square meter on Transects (A-F) in the Broad River Study Area between June 1971 and May 1973.

Table 3.5.8 Quantitative comparison (number per square meter) of pelecypod families Sphaeriidae and Corbiculidae at fourteen collection points along six transects in the Broad River Study Area between June 1971 and May 1973.

	A*		B			C			D			E		F
	1	2	1	2	3	1	2	3	1	2	3	1	2	1
June 1971														
Sphaeriidae														
Sphaerium sp.	0	0	280	22	0	22	0	86	165	1254	1807	0	157	NS**
Corbiculidae														
Corbicula manilensis	0	0	0	0	0	0	0	0	117	15	264	235	15	NS
September 1971														
Sphaeriidae														
Sphaerium sp.	0	0	30	0	0	0	0	0	49	1260	635	NS	158	NS
Corbiculidae														
Corbicula manilensis	0	0	0	0	0	0	0	0	528	220	328	NS	40	NS
January 1972														
Sphaeriidae														
Sphaerium sp.	0	15	0	0	15	44	15	15	36	118	266	142	NS	0
Corbiculidae														
Corbicula manilensis	0	59	0	0	0	15	0	0	1266	0	74	0	NS	0

Table 3.5.8 (Continued)

	A		B			C			D			E		F
	1	2	1	2	3	1	2	3	1	2	3	1	2	1
March 1972														
Sphaeriidae														
Sphaerium sp.	15	0	15	0	0	59	29	15	0	1628	29	4	NS**	NS
Corbiculidae														
Corbicula manilensis	15	103	0	0	0	0	0	0	2057	1229	148	25	NS	NS
November 1972														
Sphaeriidae														
Sphaerium sp.	15	0	74	NS	15	59	NS	15	0	NS	0	0	NS	0
Corbiculidae														
Corbicula manilensis	15	873	29	NS	0	474	NS	0	1347	NS	2575	1983	NS	0
May 1973														
Sphaeriidae														
Sphaerium sp.	NS	0	0	NS	0	97	NS	0	0	NS	130	0	NS	0
Corbiculidae														
Corbicula manilensis	NS	413	50	NS	0	75	NS	26	344	NS	366	47	NS	0

*Transect A' for June and September, 1971

**Not sampled

Table 3.5.9 Ash-free dry weight biomass in grams per square meter of benthic organisms in quantitative samples at two stations on Transect B in the Broad River Study Area between November 1972 and May 1973.

	B-1 (Shallow)			B-3 (Deep)		
	1972	1973		1972	1973	
	November	February	May	November	February	May
Insecta						
Coleoptera	-	0.536	-	-	-	-
Diptera						
Chironomidae	0.259	0.710	0.071	0.234	1.518	0.237
Others	-	0.671	0.012	0.058	0.955	0.104
Ephemeroptera						
Ephemeridae	-	0.595	0.731	-	-	-
Others	-	-	-	-	-	-
Hemiptera	-	-	-	-	-	-
Neuroptera	0.217	-	0.002	-	0.415	-
Odonata	-	-	-	-	0.212	-
Trichoptera	0.008	0.645	0.060	-	0.006	-
Crustacea	-	-	-	0.003	0.341	-
Arachnoidea	-	0.419	-	-	-	-
Hirudinea	-	-	-	0.031	0.016	-
Oligochaeta						
Tubificidae	0.583	-	0.223	0.207	-	0.753
Others	0.358	0.797	0.193	0.451	2.494	0.023
Nematoda	-	-	0.007	-	0.350	0.104
Mollusca						
Corbiculidae	0.369	-	0.295	-	-	-
Sphaeriidae	0.015	0.610	-	0.001	0.303	-
Others	-	-	-	-	-	-
TOTAL	1.809	4.983	1.594	0.985	6.610	1.221

Table 3.5.10 Ash-free dry weight biomass in grams per square meter of benthic organisms in quantitative samples at two stations on Transect D in the Broad River Study Area between November 1972 and May 1973.

	D-3 (Shallow)			D-1 (Deep)		
	1972	1973		1972	1973	
	November	February	May	November	February	May
Insecta						
Coleoptera	-	-	0.010	-	-	-
Diptera						
Chironomidae	0.151	0.518	0.040	0.212	0.670	0.212
Others	T*	0.291	-	-	0.383	-
Ephemeroptera						
Ephemeridae	2.880	1.759	3.919	0.716	0.863	0.058
Others	-	0.162	-	-	-	-
Hemiptera	0.034	-	-	-	-	-
Neuroptera	0.305	0.123	-	-	-	-
Odonata	0.030	2.489	0.019	-	-	-
Trichoptera	0.130	0.604	0.043	-	-	-
Crustacea	0.063	-	-	-	-	-
Arachnoidea	T	0.750	-	-	-	-
Hirudinea	-	-	-	0.031	-	-
Oligochaeta						
Tubificidae	0.416	-	0.136	0.500	-	1.498
Others	0.053	0.690**	0.136	0.435	1.523**	0.180
Nematoda	T	-	-	-	-	-
Mollusca						
Corbiculidae	32.366	26.307	17.455	162.312	111.488	43.506
Sphaeriidae	-	-	0.082	-	-	-
Others	0.012	-	0.564	-	-	-
Total	36.440	33.693	22.404	164.115	114.927	45.454

*T indicates trace (<0.001g)

**Composite of all oligochaete species on this date only ranged from 1.2 to 6.6 g/m^2 at lentic-like Transect B and from 22.4 to 164.1 g/m^2 at lotic-like Transect D. Biomass from shallow (B-1) and deep (B-3) stations at Transect B were similar during individual sample dates. At Transect D, however, biomass ranged from about two to five times more at the deep station (D-1) than at the shallow station (D-3).

Standing crop was greatest at Transect B in February when 4.9 and 6.6 g/m^2 occurred at the shallow and deep stations, respectively (Table 3.5.9). Ash-free dry weights from Transect B during November and May were similar and ranged from 0.9 to 1.8 g/m^2. Biomass from Transect D declined steadily between November and May (Table 3.5.10). Respective values for November, February, and May were as follows: Shallow - 35.4, 33.7, and 22.4 g/m^2; and Deep - 164.1, 114.9, and 45.5 g/m^2.

● Insects, mainly chironomids, and oligochaetes accounted for about 80 to 95 percent of the ash-free dry weight from Transect B shallow and deep stations. The mayfly, *Hexagenia limbata*, contributed 12 percent to the biomass in February and 46 percent in May at the shallow B station but was unimportant during other periods at either B or D Transects. Other organisms made only small contributions to standing crop and are not discussed.

Molluscs, predominately *Corbicula manilensis*, comprised from 78 to 99 percent of the biomass at Transect D regardless of depth or date. *Hexagenia limbata* contributed from 5 to 18 percent to the total biomass measured at the shallow D station between November and May. Other organisms assumed lesser importance and contributed little to standing crop at Transect D.

3.5.4 DISCUSSION

Cryptochironomus sp., Chaoborus punctipennis, and Sialis sp. are provisionally classified as facultative organisms with wide ranges of tolerance to environmental conditions while Chironomus sp., Coelotanypus sp., and Procladius sp. are pollution tolerant (Mason, et al. 1971). Ablabesmia sp. and Hexagenia limbata are provisionally classified as pollution sensitive by the same authors. Tanytarsus sp. is also pollution sensitive according to Brinkhurst, et al. (1968). The insects found in the study area were predominantly facultative or pollution tolerant, although H. limbata was found in large numbers. The abundance of H. limbata at Transects C and D and certain times at A may be due to existing environmental conditions including substrate type since they are known to prefer soft, silty substrates (Swanson 1967). Both Corbicula manilensis and Sphaerium sp. are facultative organisms tolerant of wide ranges in environmental conditions. On the basis of indicator species and diversity, it appears that the study area is receiving waters moderately organically enriched.

Turbidity, currents, substrate types, and deposition of silt are a few environmental factors probably limiting insect diversity and density. These properties vary with location and tend to explain the differences in species composition and density among transects.

Seasonal differences in number of taxa (species composition) was expected. Insect species have specific emergence patterns with individual species emerging during a particular time of the year. If sampling occurred shortly after emergence of a particular species (or several species), they would be absent from the collection. Life cycles, therefore, help explain seasonal changes in species composition.

Density also changed with season. The lower January, March, and

May densities may be in part a reflection of lowered sieve efficiency since many small insects pass through a 0.59 mm screen opening. Many species over-winter as eggs and hatch during the spring. These species would, therefore, be absent from January samples and perhaps would not be retained by the sieve until they gained sufficient size later in the year.

Standing crop biomass varied considerably between the two transects examined. Factors previously mentioned as probably limiting species diversity and density also influence biomass. The standing crop was always much lower at lentic Transect B than at lotic Transect D regardless of depth. Habitat requirements probably explain the difference since insects (mainly chironomid larvae and mayfly nymphs, Hexagenia limbata) and oligochaetes were dominant at Transect B and molluscs (primarily Corbicula manilensis) and mayfly nymphs (H. limbata) were dominant at Transect D. Considerable variability in standing crop for benthos probably exists on the study area depending on local environmental characteristics.

3.5.5 SUMMARY

3.5.5.1 Insects

A total of 54 insect species were identified at least to genus, with an additional 11 identified to family, and one identified to order for a total of 66 taxa collected on the Broad River Study Area between June 1971 and May 1973.

Total taxa from all transects in June, September, March, November, and May ranged between 1 and 21 while the range in January was between 0 and 10. The January low may be attributed to certain species over-wintering as eggs or small, recently-hatched larvae capable of passing through the sieve screen, and winter mortality.

Diptera and Ephemeroptera species predominated samples during all seasons. The numerically dominant insect species were chironomid larvae, phantom midges (Chaoborus punctipennis), and burrowing mayflies (Hexagenia limbata).

The density of insects from individual transects varied by sample period and ranged from a minimum of $0/m^2$ to a maximum mean of $3763/m^2$. The greatest overall density of insects occurred in June ($489-3763/m^2$) and November ($1630-3845/m^2$).

3.5.5.2 Other Benthic Macroinvertebrates

Oligochaetes and molluscs (pelcypods) were also important components of the benthic fauna of the Broad River Study Area between June 1971 and May 1973. Although the species composition of oligochaetes was not examined in detail, Branchiura sowerbyi, was notably dominant while the remaining species were probably composed of a multiple species complex. The predominant pelecypod molluscs were Corbicula manilensis and Sphaerium sp.

The density of oligochaetes varied by sample period and transect. The mean density at Transects A and E was usually less than $400/m^2$ while the mean density of Transects B, C, and D was usually greater than $400/m^2$ and frequently near or in excess of $1000/m^2$. Branchiura sowerbyi comprised a significant proportion of the total oligochaete populations from Transects B, C, and D, regardless of season.

The density of the Asian clam, Corbicula manilensis and fingernail clams, Sphaerium sp., was usually low except at Transect D where the mean density ranged from about 500 to $2000/m^2$. The Asian clam population at Transect D increased at each sample period from June 1971 to November 1972 but a sharp decline approximating the June 1971 levels was noted in May 1973.

3.5.5.3 Biomass

Benthos standing crop was determined for shallow and deep stations from Transects B and D in November 1972 and February and May, 1973. Total ash-free dry weight for the periods ranged from 1.2 to 6.6 g/m^2 on lentic-like Transect B and from 22.4 to 164.1 g/m^2 on lotic-like Transect D. Biomass was similar at shallow and deep Transect B stations but at Transect D the biomass was about five times greater at the deep station than at the shallow station.

Insects, mainly chironomids, and oligochaetes accounted for about 80 to 95 percent of the Transect B biomass. The mayfly, *Hexagenia limbata*, contributed 12 and 46 percent, respectively, to March and May biomass at the shallow Transect B station but was not a biomass component in the deep Transect B station.

The mollusc, *Corbicula manilensis*, comprised from 78 to 99 percent of the biomass on Transect D. *Hexagenia limbata* contributed 5 and 18 percent to the ash-free dry weight biomass in November and May, respectively.

3.5.6 LITTORAL ZONE BENTHOS (QUALITATIVE)

3.5.6.1 Introduction

The purpose of qualitative benthic studies is primarily to catalogue the presence of species in Parr Reservoir and its tributaries. Often an indication of relative abundance of species can also be obtained from the collection. These qualitative studies are needed to confirm the presence of existing species which can be used to determine possible effects of the facility.

The littoral organisms in Parr Reservoir are important in food web relationships serving as potential prey for fish and other organisms. Since the water level fluctuations affect the littoral zone, the littoral zone organisms will be the most immediately and fundamentally impacted organisms in the reservoir.

The scope of this study is limited to the collection and taxonomic determination of the invertebrates, small fish, and incidental amphibians and reptiles living along selected parts of the shore of Parr Reservoir and its tributaries.

3.5.6.2 Methods and Materials

All specimens were collected by using aquatic D-frame nets and an apron net. Sediments were scooped up, washed, and the organisms picked out and immediately preserved in 85 percent ethanol. The specimens were taken to the lab for sorting and taxonomic identification, then were labeled, placed in vials, and stored in cabinets at the Cincinnati office of Dames & Moore. Taxonomy references include Arnett 1968; Borror and Delong 1971; Burks 1953; Kittrell 1969; Mackenthun and Ingram 1967; Needham and Needham 1962; Needham and Westfall 1955; Pennak 1953; Reid 1967; Ross 1944; Ward and Whipple 1959.

The littoral zone was sampled in the same areas as the benthic transects (Section 3.5) except as noted. At Transect A, both sides of the river were sampled.

At Transect B, Frees Creek, the southern shoreline was sampled. The littoral zone was fairly steep. In some places the vertical drop was almost 2 m (6.6 ft), indicating that a fairly swift current is present along the shore.

The littoral sampling in Cannons Creek, Transect C, was conducted along the shore about 300 m (985 ft) east of the benthic transect. This area included 80 m (263 ft) of shoreline on both sides of County Highway 28 bridge. By contrast with the littoral zone of Frees Creek, the gradient from the shore outward was very gentle. The greatest vertical drop at the shoreline was approximately 25 cm (10 in). There was a great deal of rooted aquatic vegetation in spots, as contrasted to none in Frees Creek. There was a small area, 15 by 10 m (4.9 by 3.3 ft), of very coarse sand.

Littoral sampling near Transect D took place on the east side of the large unnamed island immediately north of the transect proper. The substrate consisted of soft mud.

Littoral sampling near Transect E was confined to the east shore of the Broad River. It was necessary to begin sampling approximately 200 m (650 ft) downstream of the hydro plant tailrace because of the swiftness of the current. Sampling was along the shore for about 100 m (328 ft) and extending offshore for about 6 m (20 ft). The physical parameters below Parr Dam are completely different from those above the dam. The swift flowing shallow water and the rocky substrate all combine to create conditions suitable for a completely different fauna than that of the impounded Parr Reservoir.

The littoral sampling near Transect F was in close proximity to the transect area proper. The west bank and the riffles in the middle of the Broad River were sampled as well as riffle areas at the confluence of the Enoree and Broad Rivers.

The sampling area G, labeled Transect G, is on upper Frees Creek. It is approximately 30 m (98 ft) north of the State Highway 99 bridge over the creek. The creek at this point is about 3 to 4 m wide (9.6 to 12.8 ft), not usually over 50 cm (20 in) deep, and very clear. It is also a few degrees (3°-5°C) colder than the impounded portion of the creek.

The coefficient of similarity was calculated by the alogorithm, $S=2j/(a+b)$, where "a" is the number of species occurring in Area A, "b" is the number of species occurring in Area B, and "j" is the number of joint species in Areas A and B (Sorenson 1948, cited in Southwood 1966).

The coefficient of similarity is a numeric representation designed to evaluate similarities between the species composition of two ecological communities. Its values range from zero to one; zero indicating no common species and one representing two communities with all species identical. Thus, the coefficient of similarity accounts for differences in the number of species and species composition between communities.

3.5.6.3 FINDINGS

The cumulative number of species collected from the study area has increased greatly with each sampling period. Approximately 30 species were collected from four of the seven transects during the June 1971 survey. Nearly 70 different species were added from all seven transects during the September 1971 survey. Approximately 40 species previously unrecorded in the area were added during each of the January and March 1972 surveys.

The qualitative results from the 1971-1972 quarterly sampling are presented in Table 3.5.11. The four sampling periods yielded 2,190 individuals representing 186 different species. The insects dominated the species list, as expected, with lesser quantities of crustaceans, mollusks, annelids, and vertebrates.

Table 3.5.11 Results from qualitative sampling of littoral and terrestrial invertebrates in the Broad River Study Area, June 1971, September 1971, January 1972, and March 1972.

Phylum	Arthropoda										
Class	Order	Family			Transect						
Subclass	Suborder	Subfamily	Genus and Species	Author	A	B	C	D*	E	F	G
Hexapoda	Ephemeroptera	Heptageniidae	*Heptagenia marginalis*	Banks	0	0	0	0	X	0	0
Pterygota			*Stenonema ares*	Burks	X	0	0	0	X	0	X
			Stenonema sp. 1	Traver	0	0	0	0	X	0	X
			Stenonema sp. 2		0	0	0	0	X	0	0
			Stenonema sp. 3		0	0	0	0	X	0	0
			Stenonema sp. 4		0	0	0	0	X	0	0
			Stenonema sp. 5		0	0	0	0	X	0	0
			Stenonema sp. 6		0	0	0	0	X	0	0
			Genus sp.		0	0	0	0	0	X	0
		Baetidae									
		Baetinae	*Neocleon alamance*	Traver	0	0	0	0	0	0	X
			Pseudocleon sp.		0	0	0	0	X	0	0
		Siphlonuridae									
		Isonychiinae	*Isonychia* sp.	Eaton	0	0	0	0	X	0	X
		Siphlonurinae	*Ameletus* sp.	Eaton	X	0	0	0	0	0	0
		Tricorythidae	*Tricorythodes* sp.	McDunnough	0	0	0	0	X	0	0
		Neoephemeridae	*Neoephemera purpurea*	(Traver)	0	0	0	X	0	0	0
		Leptophlebiidae	*Leptophlebia* sp.	Westwood	0	0	0	0	0	0	X
			Genus sp.		0	X	0	0	0	0	0
		Ephemeridae	*Hexagenia limbata*	Serville	X	X	X	X	0	0	0
		Ephemerellidae	*Ephemerella frisoni*	McDunnough	0	0	0	0	0	0	X
			Ephemerella sp.	Walsh	0	0	0	0	0	0	X
			Ephemerella rotunda	Morgan	0	0	0	0	X	0	0
			Ephemerella temporalis	McDunnough	0	0	0	0	X	0	0
	Trichoptera	Hydropsychidae	*Hydropsyche* sp.	Pictet	0	0	0	0	X	0	X
			Cheumatopsyche sp.	Wallenger	0	0	0	0	X	0	X
			Macronemum carolina	Banks	0	0	0	0	X	0	0
			Macronemum sp.	Burmeister	0	X	0	0	X	0	0

* - Mid River Island Station, Not Sampled in March 1972; ** - Tentative Identification; X - Present.

Table 3.5.11 (Continued)

Phylum	Arthropoda										
Class	Order	Family			Transect						
Subclass	Suborder	Subfamily	Genus and Species	Author	A	B	C	D*	E	F	G
Hexapoda	Trichoptera	Psychomyiidae	*Psychomyia nomade***		0	0	0	0	X	0	0
Pterygota			*Phylocentropus placidus*	(Banks)	0	0	0	X	0	0	0
		Hydroptilidae	*Dibusa angata*	Ross	0	0	0	0	X	0	0
		Hydropsychidae	*Potamyia flava*	(Hagen)	0	0	0	0	X	0	0
		Leptoceridae	*Leptocella* sp.	Banks	0	0	X	0	0	0	0
			Genus sp.		0	0	X	0	0	0	0
			Athripsodes silutus	(Hagen)	0	0	0	0	X	0	0
		Philopotamidae	*Chimmarra* sp.	Stephens	0	0	0	0	0	0	X
		Family	Genus sp.		0	0	0	X	0	0	0
	Neuroptera	Cordalidae	*Corydalus* sp.	Latreille	0	0	0	0	X	0	0
			Niaronia sp.	Banks	0	0	0	0	0	0	X
		Sialidae	*Sialis* sp.	Latreille	X	0	0	0	0	0	X
	Plecoptera	Perlidae	*Acroneuria* sp.	Pictet	0	0	0	0	X	0	X
			Perlesta placida	(Hagen)	0	0	0	0	X	0	X
		Pteronarcidae	*Pteronarcys pteronarcys dorsata*	Say	0	0	0	0	X	0	0
		Nemouridae									
		Leuctrinae	*Paraleuctra sara***	Claassen	0	0	0	0	X	0	0
		Capniinae	*Nemocapnia* sp.	Banks	X	0	0	0	0	0	0
		Nemourinae	*Nemoura* sp.	Pictet	0	0	0	0	0	0	X
		Perlodidae	*Isoperla* sp.	Banks	0	0	0	0	0	0	X
	Lepidoptera	Family	Genus sp.		0	0	0	0	0	0	X
	Hemiptera	Gerridae	Genus sp.		0	X	0	0	X	0	X
			Metrobates sp.		0	X	0	0	0	0	0
		Corixidae	Genus sp.		X	0	0	X	0	0	0
			Trichocorixa sp.	Kirkaldy	X	0	0	X	0	0	0
		Schizopteridae	Genus sp.		0	0	X	0	0	0	0
		Coreida	Genus sp.		X	0	0	0	0	0	0
		Nepidae	*Ranatra* sp.	Fabricus	0	0	X	0	0	0	0

* - Mid River Island Station, Not Sampled in March 1972; ** - Tentative Identification; X - Present.

Table 3.5.11 (Continued)

Phylum	Arthropoda										
Class	Order	Family			Transect						
Subclass	Suborder	Subfamily	Genus and Species	Author	A	B	C	D*	E	F	G
Hexapoda	Hemiptera	Veliidae	*Microvelia*	Westwood	0	0	0	0	0	0	X
Pterygota	Homoptera	Cercopidae	Genus sp.		0	0	X	0	0	0	0
	Ondonata	Gomphidae	*Progomphus zephyrus*	Needham	0	0	0	0	0	0	X
	Anisoptera		*Progomphus* sp.		0	0	0	0	0	X	0
			Ophiogomphus mainensis	Packard	0	0	0	0	0	0	X
			Dromogomphus spoliatus	Hagen	0	X	X	0	0	0	0
			Dromogomphus spinosus	Selys	0	0	0	0	X	0	0
			Dromogomphus armatus	Selys	0	X	X	0	0	0	0
			Erpetogomphus sp.	Selys	0	0	0	0	X	0	0
			Erpetogomphus lampropeltis	Kennedy	0	0	X	X	X	0	0
			Gomphus s. lat.		0	0	0	X	0	0	0
			Genus sp.		0	0	0	0	0	0	X
		Libellulidae									
		Libellulinae	*Perithemis seminale*	Calvert	0	0	X	0	0	0	0
			Perithemis tenera	Say	0	X	0	0	0	0	0
			Ladona sp.	Needham	X	X	X	X	0	0	0
			Miathyria sp.	Kirby	X	0	0	0	0	0	0
			Miathyria marcella		0	0	X	0	0	0	0
			Plathemis lydia	Drury	X	0	0	0	0	0	0
			Paltothemis lineatipes	Karsch	0	0	0	X	0	0	0
			Libellula sp.	L.	0	0	X	0	0	0	0
			Sympetrum sp.	Newman	0	0	X	0	0	0	0
			Tramea carolina		0	0	X	0	0	0	0
			Dythemis velox	Hagen	0	X	0	0	0	0	0
			Genus sp. 1		0	X	X	0	0	0	0
			Genus sp. 2		0	X	0	0	0	0	0
		Corduliinae	*Cordulia* sp.	Leach	0	X	0	0	0	0	0
			Tetragoneuria spinosa	Hagen	0	X	0	0	0	0	0

* - Mid River Island Station, Not Sampled in March 1972; ** - Tentative Identification; X - Present.

Table 3.5.11 (Continued)

Phylum	Arthropoda										
Class	Order	Family			Transect						
Subclass	Suborder	Subfamily	Genus and Species	Author	A	B	C	D*	E	F	G
Hexapoda	Ondonata	Libellulidae									
Pterygota	Anisoptera	Corduliinae	*Tetragoneuria* sp.	Hagen	0	X	0	0	0	0	0
			Tetrogoneuria petechialis	Muttkowski	0	0	X	0	0	0	0
		Macrominae	*Didymops transversa*	Say	0	0	X	0	X	0	0
			Macromia illinoiensis	Walsh	0	0	0	0	X	0	0
			Macromia alleghaniensis	Williamson	0	0	X	X	0	0	0
			Macromia caderita		0	0	X	0	0	0	0
			Macromia sp.		0	0	X	0	0	0	0
		Aesnidae	*Boyeria vinosa*	Say	0	0	0	0	0	0	X
		Cordulegastridae	*Cordulegaster erroneus*	Hagen	0	0	0	0	0	0	X
	Zygoptera	Agrionidae	*Argia* sp.	Rumbar	0	X	X	0	X	0	0
			Telebasis sp.	Selys	0	X	0	0	0	0	0
			Enallagma sp. 1	Charpentier	0	X	X	0	0	0	0
			Enallagma sp. 2	Charpentier	0	0	X	0	0	0	0
			Enallagma sp. 3	Charpentier	0	0	X	0	0	0	0
			Chromagrion sp.	Needham	0	0	0	0	X	0	0
			Nehalennia sp.	Selys	0	X	X	0	0	0	0
			Neoneura sp.		0	0	X	0	0	0	0
			Genus sp. 1		0	X	X	0	0	0	0
			Genus sp. 2		0	0	X	0	0	0	0
			Genus sp. 3		0	X	X	0	0	0	0
		Calopterygidae	*Calopteryx* sp.	Leach	0	0	0	0	0	0	X
			Hetaerina sp.		0	0	0	0	0	X	0
		Family	Genus sp.		0	0	0	0	X	0	0
	Diptera	Simuliidae	Genus sp.		0	0	0	0	0	0	X
		Empididae	Genus sp.		0	0	0	0	0	0	X
		Chironomidae	Genus sp.		X	X	X	X	X	0	X
		Tipulidae	*Tipula abdominalis*	Say	0	0	0	0	0	0	X
			Tipula sp.	L.	0	0	0	0	0	0	X

* - Mid River Island Station, Not Sampled in March 1972; ** - Tentative Identification; X - Present.

Table 3.5.11 (Continued)

Phylum	Arthropoda										
Class	Order	Family			Transect						
Subclass	Suborder	Subfamily	Genus and Species	Author	A	B	C	D*	E	F	G
Hexapoda	Diptera	Tipulidae	*Erioptera* sp.	Meigen	0	0	X	0	0	0	0
Pterygota		Tabanidae	*Tabanus* sp.		0	0	0	0	0	X	0
		Culicidae	*Aedes* sp.		X	0	0	0	0	0	0
			Chaoborus punctipennis		0	0	0	X	0	0	0
			Culex sp.		0	0	0	X	0	0	0
		Anthomyiidae	Genus sp.		0	0	0	0	0	X	0
		Family	Genus sp.		0	0	0	0	0	0	X
		Family	Genus sp.		0	0	0	X	0	0	X
	Psocoptera	Psocidae	Genus sp.		X	0	0	0	0	0	X
	Coleoptera	Gyrinidae	*Gyretes* sp.		0	0	X	0	0	0	0
			Dineutus sp.	MacLeay	0	X	0	0	0	0	X
		Haliplidae	*Peltodytes* sp.	Regimbart	X	X	X	0	0	0	0
		Carabidae	*Pseudomorphinae* sp.		0	0	0	0	0	0	X
		Amphizoidae	*Amphizoa* sp.	LaConte	0	X	0	0	0	0	X
		Chelonariidae	*Chelonarium* sp.	Fab.	0	X	0	0	0	0	0
		Psephenidae	*Psephenus* sp.	Haldeman	0	0	0	0	0	0	X
		Dytiscidae	*Oreodytes* sp.	Seidlitz	0	0	X	0	0	0	0
		Elmidae	Genus sp.		0	0	X	0	0	0	0
		Hydrophilidae	*Berosus* sp.		0	0	0	X	0	0	0
			Genus sp.		0	0	0	0	0	0	X
	Orthoptera	Gryllidae									
		Nemobiinae	Genus sp.		0	0	0	X	0	0	0
		Eneopterinae	Genus sp.		X	0	0	0	0	0	0
		Trigonidiinae	Genus sp.		0	0	0	X	0	0	0
		Gryllacrididae	Genus sp.		0	0	0	0	0	0	X
		Tettagoniidae									
		Decticinae	Genus sp.		X	0	0	0	0	0	0

* - Mid River Island Station, Not Sampled in March 1972; ** - Tentative Identification; X - Present.

Table 3.5.11 (Continued)

Phylum	Arthropoda										
Class	Order	Family			Transect						
Subclass	Suborder	Subfamily	Genus and Species	Author	A	B	C	D*	E	F	G
Hexapoda											
Apterygota	Collumbola	Entomobryidae	*Isotomurus palustris*	(Muller)	0	0	X	0	0	0	0
		Sminthuridae	Genus sp.		0	0	X	0	0	0	0
Crustacea											
Malacostraca	Decapoda	Palaemonidae	*Palaemonetes paludosus*	(Gibbes)	X	X	X	0	0	0	0
			Palaemonetes kadiakensis	Rathbun	0	0	X	0	0	0	0
		Astacidae									
		Cambarinae	*Cambarus bartoni*	(Fab.)	0	0	0	0	0	0	X
			Genus sp.		0	0	0	0	0	0	X
			Genus sp.		0	0	X	0	0	0	X
	Amphipoda	Talitridae	*Hyallela azteca*	Saussure	0	X	X	X	X	0	X
		Gammaridae	*Synurella* sp.		0	0	0	0	0	0	X
	Isopoda	Asellidae	*Asellus millitaris*	Hay	0	0	X	0	0	0	0
			Asellus sp.	St.Hillaire	X	0	X	X	0	0	X
Arachnida	Araneida	Family	Genus sp. 1		X	0	0	0	0	0	X
			Genus sp. 2		0	0	0	0	0	0	X
			Genus sp. 3		0	0	0	0	0	0	X
		Family	Genus sp.		0	0	0	X	0	0	0
	Labidognatha										
		Anyphaenidae	Genus sp.		0	0	0	0	0	0	X
		Clubionidae	Genus sp.		0	0	0	0	0	0	X
	Acarina	Hydracarina	Genus sp.		0	0	X	0	0	0	0
Diplopoda											
Chilognatha	Spirobolida		*Narceus americanus*	Beauvois	0	0	0	0	0	0	X
	Polydesmida		Genus sp.		0	X	0	0	0	0	0

* - Mid River Island Station, Not Sampled in March 1972; ** - Tentative Identification; X - Present.

Table 3.5.11 (Continued)

Phylum	Mollusca										
Class	Order	Family			Transect						
Subclass	Suborder	Subfamily	Genus and Species	Author	A	B	C	D*	E	F	G
Gastropoda											
Prosobranchia	Mesogastropoda	Viviparidae	*Campeloma* sp.	Rafinesque	0	0	X	X	0	0	0
			Viviparus sp.	Montfort	0	0	X	0	0	0	0
		Pleuroceridae	*Goniobasis* sp.		0	0	0	0	0	X	0
	Basommatophora	Physidae	*Physa sayi*		X	X	X	X	0	0	0
		Lymnaeidae	*Lymnaea Bulimnaea* sp.	Haldeman	X	0	0	0	0	0	0
		Planorbidae	*Menetus* sp.	H.&A. Adams	0	0	X	0	0	0	0
			Gyraulus sp.	Charpentier	0	0	X	0	0	0	0
			Helisoma sp.	Swainson	0	0	X	0	0	0	0
			Planorbula sp.	Haldeman	0	0	0	0	X	0	0
		Family	Genus sp.		0	0	X	0	0	0	0
Pelecypoda	Heterodonata	Corbiculidae	*Corbicula manilensis*	Phillipi	0	0	X	X	X	0	0
		Sphaeriidae	*Eupora* sp.	Bourguignat	0	0	X	0	0	0	0
		Sphaeriinae	*Musculium* sp.	Link	X	X	X	X	X	0	0
	Eulamellibranchia	Unionidae									
		Lampsilinae	*Ligumia* sp.	Swainson	0	0	0	0	X	0	0
		Anodontinae	*Anodonta* sp.		0	0	X	X	0	0	0
Phylum	Annelida										
Hirudinae		Glossiphoniidae	*Glossiphonia heteroclita*	(L.)	X	X	X	X	0	0	0
			Helobdella sp.		0	0	X	0	0	0	0
		Family	Genus sp.		0	X	X	0	0	0	0
		Planariidae	*Placobdella* sp.		0	0	X	0	0	0	0
Oligochaeta		Lumbriculidae	*Lumbriculus* sp.		X	0	0	0	0	0	0
		Tubificidae	*Branchiura sowerbyi*	Bedd	0	X	0	0	0	0	0
		Family	Genus sp.		X	X	X	X	X	X	X

* - Mid River Island Station, Not Sampled in March 1972; ** - Tentative Identification; X - Present.

Table 3.5.11 (Continued)

Phylum	Chordata										
Class	Order	Family			Transect						
Subclass	Suborder	Subfamily	Genus and Species	Author	A	B	C	D*	E	F	G
Amphibiata		Family	Genus sp.		0	0	0	0	0	0	X
Lepospondyli	Salientia	Bufonidae	*Bufo woodhousei*	Hinckley	0	0	0	0	0	0	X
	Caudata	Plethodontidae	*Desmognathus* sp.		0	0	0	0	0	0	X
			Eurycea bislineata	(Green)	0	0	0	0	0	0	X
Osteichthyes	Perciformes	Centrarchidae	*Lepomis macrochirus*	Rafinesque	0	0	X	0	0	0	0
			Lepomis sp. 1		0	0	X	0	0	0	0
			Lepomis sp. 2		0	0	X	0	0	0	0
	Cypriniformes	Cyprinidae	*Notropis boops*	(Gilbert)	0	0	0	0	X	0	0
			Notropis anagenus	(Forbes)	0	0	0	0	0	0	X
Number of Species per Sampling Area					25	35	64	27	43	6	57

* - Mid River Island Station, Not Sampled in March 1972; ** - Tentative Identification; X - Present.

The number of species collected by transect during the four collections is presented in Table 3.5.12. It should be remembered that these studies were not quantitative, however, these data can indicate species diversity at a particular transect.

Table 3.5.13 lists the coefficients of similarity for Transects A through G as related to habitat type. None of the areas appear to be very similar, the maximum value, 0.2933, is less than 30 percent of the value for identical habitats. In most cases, each group appears to have values that are quite closely related. Notable exceptions include Transect F when it is compared to E and A and Transect A compared to D.

3.5.6.4 Discussion

It was anticipated that in four samples most of the number of different benthic species in Parr Reservoir would have been collected. However, this has not proven to be the case. There are four factors which have contributed to the number of different species found to date. The first is seasonal change. Since each sample in this report was taken during a different season, and since every species has its own intrinsic periodicity relative to the calendar year, identification of different species was expected for each season. Seasonality effects will tend to disappear with subsequent samples.

The second factor contributing to the number of different species is the variety of habitats being sampled. Having collected the major littoral zone habitats around the reservoir, further contributions of different species from this source should not be significant.

The third source of different species is the species pool of the region, i.e., all the habitats which may occasionally contribute species to the habitats regularly being sampled (Golley, et al. 1965). New species accumulate from the regional species pool at a slow rate. Theoretically we could discover

Table 3.5.12 Number of species collected in qualitative sampling, Broad River Study Area, 1971-72.

	Transect						
	A*	B	C	D	E	F	G
Summer June 1971	NS**	6	26	5	1	NS	NS
Fall Sept. 1971	18	10	17	9	20	5	30
Winter Jan. 1972	4	7	25	21	19	NS	17
Spring March 1972	5	15	28	NS	17	2	25

* Transect A' during June and September, 1971.
** Not sampled.

Table 3.5.13 Functional habitat groupings and average annual coefficients of similarity* based on littoral zone fauna.

Habitats	Compared Transects	Coefficient of Similarity
Impounded Areas	C-D	0.2933
	B-C	0.2616
	B-D	0.2260
Unimpounded Areas	F-G	0.1799
	E-G	0.1723
	E-F	0.0526
Main River Channel vs Impounded Areas		
	A-D	0.2400
	A-B	0.1818
	A-C	0.1337
Impounded vs Unimpounded Areas	A-F	0.2857
	D-G	0.1302
	B-E	0.1240
	C-G	0.1028
	C-E	0.0968
	A-E	0.0887
	A-G	0.0809
	D-E	0.0730
	B-G	0.0500
	C-F	0.0333
	D-F	0.0000
	B-F	0.0000

* Transect A' not utilized.

new species present from this regional pool for many years.

The fourth factor contributing to different species is taxonomic revision of the specimens already collected.

The composite list of species shows several very prominent differences between the various transects. For example, most of the Plecoptera are found in Transect G or E. These transects are characterized by swiftly flowing waters whereas Transects A, B, C, and D are more lentic in nature. Many of the Ephemeroptera are also characterized by living in swift water, whereas Hexagenia limbata is found only in the more lentic stations with mud substrates. Among the odonates there seems to be, except for Boyeria vinosa, a general aversion to the upper part of Frees Creek. This could be partially due to the predatory nature of this species. Hunting success would appear to be greater in slower moving water than those with high velocities. It is significant that Boyeria vinosa was found exclusively in protected areas consisting of sticks and detritus caught in the branches of bushes growing beside the creek. These little backwaters provide the more lentic habitat necessary for the species.

The sandy substrate in Cannons Creek is different from the usual soft mud common in the study area. As could be expected, the sandy substrate produced a quite different littoral fauna than the soft mud. Almost all the snails were found in this sandy area.

Organisms found in the littoral zone differ from those found in deeper waters. These differences can be noted by comparing the species list for both studies. For example, the grass shrimp, Palaemonetes paludosus, has been found in considerable numbers in the littoral zone, but has not been recorded in the quantitative benthic samples. These shrimp are large enough to contribute significantly to the carnivorous fish, while smaller organisms are important food sources for small forage fish as well as juvenile game species.

The dissimilarity between habitats, as noted by the coefficients of similarity, was expected since these areas were selected by noting differences so as to include all possible ecosystems within the study area.

The impounded areas were the most consistently similar of any group. Their low was 0.2260 (B-D) and their high was 0.2933 (C-D).

The unimpounded areas, characterized by swift flowing water, are clearly of two groups, with E and F very dissimilar 0.0526, and E-G (0.1723) and F-G (0.1799) relatively similar.

The September quarterly report indicated that Transect F was peculiar in having such a poor faunal composition for such a well oxygenated riffle area. Since both Transect E and F are riffle areas in the same river, they would be expected to be quite similar faunistically. The March 1972 samplings of these two areas did show some improvement over the September 1971 sample, from 0.0000 to 0.1052. Transects E and F may have a strong seasonal differences which could account for their lack of similarity. Further sampling would be necessary to substantiate seasonal differences.

The river channel proper (Transect A in January and March, 1972) shows an intermediate position of similarity between the previous groups. This is expected since the river is quite swift at Transect A, however, it is beginning to show the effects of impoundment.

As expected, least similar habitats are the impounded areas when compared to the swift flowing streams.

The prediction which can be made is that upper Frees Creek and any other currently unimpounded areas will, after impoundment, become more similar in faunal composition to the currently impounded areas. There will still be ecological differences between the drowned watersheds even as there are differences today between Transects B and C after many years of being impounded.

3.5.6.5 Summary

In four seasons of qualitative sampling of littoral organisms, 2,190 specimens representing 186 species were collected. Many species were found which were not included in the quantitative benthic samples taken by use of the Ekman dredge. Since these species contribute significantly to the food web of the ecosystem, their identity and abundance are important. These littoral organisms are of special significance in the Broad River Study Area since this zone will undergo water-level fluctuations.

Species were related to stream flow velocity, depth, substrate, and vegetation. Each factor or combination of factors defines the habitat in which a particular species can survive.

Similar habitats account for similar species composition between transects. Unimpounded areas, after impoundment, can be expected to show changes in faunal composition, becoming more similar to impounded forms.

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3.6 FISH

3.6.1 INTRODUCTION

Fishes are often the most obvious components of the aquatic community. To understand the position of the fishes in the aquatic ecosystem it is necessary to know what species occur in the area and certain aspects of the biology of the fishes involved. The objectives of the fisheries investigations included ascertaining the following aspects of the biology of fishes of the Broad River Study Area: species composition; distribution; relative abundance; length-weight relationships; standing crop estimates; age and growth; sex ratios; gonad condition; condition factors; food habits; and parasitism.

The information contained in this report will be helpful in attempts to minimize possible adverse effects of the proposed project and in forming the basis of a fishery management program.

3.6.2 METHODS AND MATERIALS

3.6.2.1 Collection

Fishes were collected with electrofishing equipment and modified hoop nets. Electrofishing equipment used during initial surveys consisted of two boat-mounted electrodes connected to a 2000 watt, McCulloch single-phase AC alternator. After November 1972, a Smith-Root Type VI electrofisher was used. This unit allows adjustment of voltage and amperage for maximum efficiency under various water conditions.

The shoreline areas surrounding each transect were fished for two hours during each sampling period prior to November 1972. The Smith-Root electrofisher proved much more efficient and collecting time was reduced to one hour per transect. Stunned fishes were retrived by dipnet and held for processing in water-filled tubs. Prior to initiation of food-habit studies, fishes were returned alive to the reservoir. Investigation of food habits necessitated sacrificing some specimens.

To reduce bias attributable to any single collecting technique, netting operations were conducted in the immediate vicinity of all transects except F. Swift currents prohibited use of nets and only electrofishing was utilized at this transect. Netting gear consisted of a three-ring hoop net constructed of 12.7 mm (0.5 in) square mesh netting and fitted with square throat hoops. A single lead 15 m (50 ft) in length of 12.7 mm (0.5 in) square mesh netting was attached to the throat hoops. A sample consisted of two nets set perpendicular to the shoreline on opposite shores for 24 hours each. At the end of the period, the nets were retrieved and all fish were held in water-filled containters for analysis.

Fishes which could not be identified in the field were preserved and identified in the laboratory or referred to a specialist.

Fishes were identified, counted, and locality and date of collection were recorded. Species composition, distribution, and relative abundance were determined from this data.

3.6.2.2 Age and Growth

Scales were removed from important species in the field and placed in envelopes which were labeled to identify the species, length, weight, place of collection, and other pertinent data. The scales were removed from the left side of the fish, between the lateral line and dorsal fin. The left pectoral spines of catfishes were removed.

In the laboratory scales were cleaned and impressions of five scales from each fish in the sample were made on cellulose acetate slides with the use of a roller press. The impressions were projected on a plane surface with a Bausch and Lomb microprojector. Annuli were counted and distances between them measured in millimeters and recorded.

Back calculation of length at successive annuli was performed using the method of Lee (1920) which assumes a linear body-scale relationship and a positive length at scale formation. The formula is expressed as:

$$l_n - C = S_n(l - C/S)$$

where l_n is the length of fish when annulus 'n' was formed; l is the length of fish at time scale sample was obtained; S_n = radius of scale annulus 'n' (at length = "l_n"); S is the total scale radius; and C is a constant, representing the Y-intercept of the regression equation or length at which scales were first formed.

Because this type of determination of accurate age-growth relationships requires establishment of the length of fishes at the time of scale formation, statistical methods were utilized as an estimation procedure. Linear regression using least squares was performed by regressing fish length on scale radius. From the equation describing the regression line, the Y intercept was estimated. In addition, the product-moment-correlation coefficient was calculated to test the linear nature of the data.

3.6.2.3 Length-Weight Relationships

All fishes collected in March and June, 1971, were measured to the nearest tenth of an inch and weighed to the nearest hundredth of a pound. These values were converted to centimeters and grams. Subsequent data were taken directly in metric measurements.

The relationship of length to weight for each species at each transect was analyzed. Empirical plots of individual specimens were made on double logarithmic graph paper. Regression lines were fitted to the scatter plots by least squares and the equation describing the line determined and presented in the general form:

$$W = aL^b$$

where W is the estimated weight in grams; a is the Y intercept of the regression line; L is the total-length in mm; and b is the regression coefficient (or slope of the regression line). In addition to the above, the product-moment correlation coefficient was calculated.

3.6.2.4 Condition Factor

Condition factors (K) were calculated for individual fish and the mean condition factor for each species in each centimeter group was determined. The formula $K_{(TL)} = 1000\ W/L^3$ was used for all condition factor determinations. (W = weight in grams, L = total length in centimeters.)

3.6.2.5 Sex Ratios and Gonad Condition

Specimens from which stomachs and gonads were removed were sexed in the field and recorded. Gonads were classified according to the method proposed by Nikolsky (1963), and presented in Table 3.6.1.

3.6.2.6 Standing Crop Estimate

Annual rotenone cove samples in Cannons Creek and Frees Creek were initiated 11-13 November 1972, to establish standing crop data and to refine the relative abundance information from other sampling methods. The Frees Creek and Cannons Creek areas of the reservoir were selected as sites for estimation of biomass of fishes because:

1. These two impounded creeks were ecologically representative of the majority of the lake-like habitat in Parr Reservoir;
2. This sampling method was applicable to both areas;
3. Data from the first year revealed that these embayments supported relatively large numbers of important species; and
4. These areas would likely be affected by the proposed facility.

Table 3.6.1 The classification of maturity stages (gonadal condition) in fishes (from Nikolsky 1963).

	Stage	Gonadal Condition
1	Immature	- Young individuals which have not yet engaged in reproduction; gonads of very small size.
2	Resting stage	- Sexual products have not yet begun to develop; gonads of very small size; eggs not distinguishable to the naked eye.
3	Maturation	- Eggs distinguishable to the naked eye; a very rapid increase in weight of the gonad is in progress; testes change from transparent to a pale rose color.
4	Maturity	- Sexual products ripe; gonads have achieved their maximum weight; but the sexual products are still not extruded when light pressure is applied.
5	Reproduction	- Sexual products are extruded in response to very light pressure on the belly; weight of the gonads decreased rapidly from the start of spawning to its completion.
6	Spent condition	- The sexual products have been discharged; genital aperature inflamed; gonads have the appearance of deflated sacs, the ovaries usually containing a few left-over eggs, and the testes some residual sperm.

To achieve appreciable meaning from the sampling procedure, one must assume that the sampling areas for biomass estimation are representative of the majority of habitat in the embayments sampled. The rotenone cove sampling sites were selected by evaluating the available habitat types in the Frees and Cannons Creek areas; including depth, cover, bottom type, and other general observations. An effort was made to select an area representative of the entire sample area.

A 0.41 ha (1.0 acre) area was blocked off with 12.7 mm (0.5 in) square mesh nets, (200 ft X 20 ft), constructed according to Lambou (1959). A net was secured to the shoreline and vertically dropped by boat to its maximum length and secured with a pole forced into the lake bottom. A second net was set in a like manner perpendicular to the first net and parallel to the shoreline. This net was secured to a dead tree at this corner. A third net was secured to the tree and dropped in like manner and secured to the shoreline.

The nets were checked for firm contact with the bottom by two divers equipped with SCUBA gear.

A system of mark and recapture using the Petersen estimate formula (Ricker 1971) was employed to determine the percentage of fish collected within the net and to refine estimates of the numbers of individual species. Fishes were collected outside the net with electrofishing gear. The total-length was measured and individuals were marked for later recognition by clipping the lower lobe of the caudal fin. The marked fish were released within the enclosed area and allowed to remain overnight. The area was checked the following morning for dead fish, but none were found. It was assumed that all fish (marked and unmarked) were equally susceptible to the toxicant.

A solution containing 2.5 percent rotenone plus 2.5 percent sulfoxide (ProNox fish) was applied to the blocked area from a boat and thoroughly mixed. Three boats with a minimum crew of two persons per boat were used to collect distressed fish. Random boat movements were maintained and all fish encountered were retrieved by dipnet. No special capture effort was given to any size, species, or marked fish. The fish were sorted to species and all marked specimens were removed. Unmarked fish were weighed, measured, and sexed in the field.

3.6.2.7 Food Habits and Parasites

Food habits of selected species of fish from the reservoir and river were examined. Attempts were made to collect as many specimens of each species as possible from each transect although abundance of species in the collections varied widely. Viscera were taken from a representative number of each general size group of fishes in the field for food habit analysis. The viscera were taken by cutting the esophagus as near the isthmus as possible and removing the entire viscera. All specimens were placed in individual plastic containers or cheesecloth, labeled, and preserved with 10 percent formalin.

The following quantities were calculated:

1. $\bar{Y}$%TV, mean percentage of total volume comprised by a taxon;
2. % frequency, the frequency of occurrence of the item in the stomach of a grouping expressed as a percentage;
3. $\bar{Y}$TN, mean total number of an item.

In the laboratory, the liver and other organs adjacent to the stomach were examined for evidence of parasitism. Next, the stomach was cut away from the rest of the viscera and weighed to the nearest 0.1 g. A longitudinal cut was then made from the pylorus to the esophageal sphincter and the stomach contents were washed into a labeled jar and preserved in 5 percent formalin or 70 percent alcohol. The empty stomach was then weighed. This procedure was altered for the Catostomidae and Cyprinidae. In these families, the entire digestive tract was emptied and examined since a stomach region per se was not identifiable. In addition, parasites of the Catostomidae and Cyprinidae most often occurred in the intestine.

Analysis of stomach and gut contents was made by examining the contents in a gridded petri dish using a dissecting microscope. Organisms were identified, counted, and assigned an estimated volume. Unidentifiable organic and inorganic material was also volumetrically estimated. The data were compiled by species, transect, and sampling period.

Analysis of food habits of gizzard shad were conducted somewhat differently than those for other species. A total of 27 gizzard shad stomachs were analyzed to determine food items ingested by this species. The shad were divided into size classes by 50 mm (1.97 in) total length increments from 0 to 300 mm (11.82 in) total length, and by 300 mm increments above 300 mm total length. When possible, three fish of each size class from each transect were examined. One previously examined gizzard shad from Transect B in November, 1972, was not included in this analysis.

The stomach contents of the shad were diluted to a specified volume (usually 50 ml) with distilled water. The sample was then thoroughly mixed, and a one ml subsample was placed in a Sedgwick-Rafter counting chamber. The entire chamber was scanned at 100X, organisms were identified to genus, and the number of each organism recorded. In addition, a cell count on the number of centric and pennate diatoms was made by examining several longitudinal strips the width of the Whipple square at 200X. All counts were then converted to total number present in the stomach. A proportional count of the diatom species present was made from prepared diatom slides.

3.6.3 FINDINGS AND DISCUSSION

3.6.3.1 Species Composition and Relative Abundance

Species composition and relative abundance provide basic information about species diversity of the fish fauna and their numerical status in the fish community.

Since the study area is primarily reservoir habitat, collecting efforts were concentrated in that habitat.

Bluegill (Lepomis macrochirus) were the most abundant fish when data from all stations were combined in Table 3.6.2. Bluegill (34.58%), gizzard shad, Dorosoma cepedianum (18.82%), white crappie, Pomoxis annularis, (12.70%), redear sunfish, Lepomis microlophus (8.42%), and largemouth bass, Micropterus salmoides, (3.85%) comprised 78.87 percent of the fishes collected. These figures reflect the intentional bias in sampling reservoir habitat more intensively than flowing river habitat. At Transect F, flat bullhead, Ictalurus platycephalus (45.24%) numerically dominated collections.

Species composition, distribution by transect, and relative abundance were determined for all fishes collected. They are arranged phylogenetically and discussed by species in an annotated list. Arrangement and use of common names are from Bailey (1970).

The following is an annotated list of species of fishes collected at the Broad River Study Area, March 1971 through May 1973:

Lepisosteidae - Gar family

Lepisosteus osseus - Longnose gar. The longnose gar was extremely abundant at Transect E, however, it was collected at all transects. Many gar, species unknown, were observed during routine activities on the study area. The longnose gar ranked ninth in overall abundance and is not considered a sport fish in the study area.

Table 3.6.2 Species composition and relative abundance of all fishes collected from the Broad River Study Area from March 1971 through May 1973.

Common Name	Scientific Name	No.	%
Bluegill	Lepomis macrochirus	1454	34.58
Gizzard shad	Dorosoma cepedianum	794	18.82
White crappie	Pomoxis annularis	534	12.70
Redear sunfish	Lepomis microlophus	354	8.42
Largemouth bass	Micropterus salmoides	162	3.85
River carpsucker	Carpiodes carpio	102	2.43
Carp	Cyprinus carpio	86	2.05
Flat bullhead	Ictalurus platycephalus	78	1.86
Longnose gar	Lepisosteus osseus	74	1.76
Black crappie	Pomoxis nigromaculatus	65	1.55
Redhorse*	Moxostoma spp.	55	1.31
Channel catfish	Ictalurus punctatus	53	1.26
White catfish	Ictalurus catus	52	1.24
Pumpkinseed	Lepomis gibbosus	50	1.19
Warmouth	L. gulosus	42	1.00
Golden shiner	Notemigonus crysoleucas	42	1.00
Shorthead redhorse	Moxostoma macrolepidotum	35	0.83
Silver redhorse	M. anisurum	21	0.50
Silvery minnow	Hybognathus nuchalis	18	0.43
Redbreast sunfish	Lepomis auritus	16	0.38
Quillback	Carpiodes cyprinus	14	0.33
White sucker	Catostomus commersoni	13	0.31
Yellow bullhead	Ictalurus natalis	10	0.24
American eel	Anguilla rostrata	10	0.24
Green sunfish	Lepomis cyanellus	10	0.24
Spotted sucker	Minytrema melanops	9	0.21
White bass	Morone chrysops	9	0.21
Satinfin shiner	Notropis analostanus	8	0.19
Unidentified shiner	Notropis spp.	6	0.14
Brown bullhead	Ictalurus nebulosus	5	0.12
Hybrid sunfish	Lepomis sp.	5	0.12
Longear sunfish	L. megalotis	5	0.12
Creek chubsucker	Erimyzon oblongus	2	0.05
Black bullhead	Ictalurus melas	2	0.05
Spotted gar	Lepisosteus oculatus	1	0.02
Tadpole madtom	Noturus gyrinus	1	0.02
Speckled madtom	N. leptocanthus	1	0.02
Chub**	Hybopsis sp.	1	0.02
Pallid shiner	Notropis amnis	1	0.02
Yellow perch	Perca flavescens	1	0.02
Swamp darter	Etheostoma fusiforme	1	0.02
Total No.		4204	
Total Species		40 minimum	

*There was difficulty positively identifying species of Moxostoma during initial surveys.

** Pending verification.

Lepisosteus oculatus - Spotted gar. A single specimen of spotted gar was collected. It is likely that this species is more common than collections would indicate since many gar of unknown species were observed. They are not considered a sport fish.

Anguillidae - Freshwater eel family

Anguilla rostrata - American eel. The American eel was collected only at Transect E, below Parr Dam. This species was much more abundant than indicated by numbers collected. Numerous specimens were sighted that were not collected. Eels are catadramous and the construction of Parr Dam undoubtedly hindered movements of eels upstream. This species ranked twenty-third in overall abundance.

Clupeidae - Herring family

Dorosoma cepedianum - Gizzard shad. Gizzard shad were the second most abundant fish overall. This species was collected at all transects. Gizzard shad are probably one of the most important forage species of the study area.

Cyprinidae - Minnow family

Cyprinus carpio - Carp. Carp were collected at all transects except F and carp ranked seventh in overall abundance in the study area. All carp collected were of a large size. There is a limited fishery for carp, especially during the spring.

Hybopsis sp. - Chub. A single specimen collected at Transect E was identified only to genus. The scarcity of specimens indicates this species is probably unimportant in the fishery of the study area. No further comments will be made concerning this specimen pending positive identification.

Hybognathus nuchalis - Silvery minnow. The silvery minnow was collected at Transects B, C, D, and E. This species ranked eighteenth in overall abundance. The relatively low numbers and small size of specimens collected indicate that this species contributes little to the fishery of the study area, though it should be considered as part of the forage base.

Notemigonus crysoleucas - Golden shiner. This species ranked fifteenth in overall abundance in the study area. This species contributes to the forage base in the study area. Golden shiners were collected at all transects except F, though they were collected more commonly in the reservoir than the river.

Notropis amnis - Pallid shiner. A single specimen collected at Transect D was identified as the pallid shiner. This is outside the reported range of this species and the identification will be confirmed before further comments are made.

Notropis analostanus - Satinfin shiner. This species was collected only at Transect D in the study area. The satinfin shiner is a large river form and probably can be expected to thrive only in a river-type habitat.

Notropis sp. - Shiner. Four specimens of unidentified shiners have been collected in the study area. It is probable that several species of shiners occur in the study area that have not been collected. However, it is likely that these populations are small and contribute little to the forage base.

Carpiodes carpio - River carpsucker. The river carpsucker was collected at all stations in the study area. It was collected in large numbers at Transect E. This species ranked sixth in overall abundance in the study area. Spring spawning migrations of catostomids are very common and probably concentrate the fish at the base of the dam in the spring. The river carpsucker has no sport value in the study area.

Carpiodes cyprinum - Quillback. The quillback ranked twentieth in overall abundance in the study area. It was collected at all transects except

A. Though this species occurs in the reservoir, it was collected most commonly at Transect E. This species is not considered a sport fish in the study area.

Catostomus commersoni - White sucker. Thirteen white suckers were collected at Transect E in the study area. The white sucker is not considered a normal resident of the study area nor a part of the sport fishery.

Erimyzon oblongus - Creek chubsucker. The creek chubsucker ranked thirty-first in overall abundance in the study area. Two specimens were collected at Transect E. It is not considered an important part of the forage base or sport fishery of the study area.

Minytrema melanops - Spotted sucker. The spotted sucker ranked twenty-fifth in overall abundance. Nine specimens were collected at Transect E, and it was not collected at other stations. This species is considered an occasional resident of the study area and is not utilized as a sport fish.

Moxostoma anisurum - Silver redhorse. The silver redhorse ranked seventeenth in overall abundance. They were collected at Transects C, D, E, and F. There was difficulty in the positive identification of the redhorse species during initial surveys. The silver redhorse is common in the river and contributes significantly to the fauna of that ecosystem. The concentration at Transect E was probably due to the dam blocking upstream migrations. Although redhorse are not considered sport fish in the study area, they are in other areas.

Moxostoma macrolepidotum - Shorthead redhorse. The shorthead redhorse was collected at Transects D, E, and F. This species ranked sixteenth in overall abundance in the study area. The shorthead redhorse was collected primarily from the river though it was occasionally collected in the reservoir. The shorthead was the most commonly collected redhorse and some specimens identified only as redhorse during initial surveys were undoubtedly shortheads.

The redhorse are an important segment of the river fishery due to their abundance and large size.

Ictaluridae - Freshwater catfish family

Ictalurus catus - White catfish. The white catfish ranked eleventh in overall abundance. It was collected at Transects B, C, D, and E. This species occurs in sufficient numbers to be considered a significant segment of the sport fishery of the study area. Numerous fishermen seek "catfish" and it is doubtful that they discriminate between white and channel catfish.

Ictalurus melas - Black bullhead. Two specimens identified as black bullhead were collected from the study area. This species is rare in the study area and probably contributes minimally to the sport fishery.

Ictalurus natalis - Yellow bullhead. The yellow bullhead ranked twenty-second in overall abundance in the study area. It was collected at Transects A, B, and E. The yellow bullhead is a sport fish in the study area but due to the small number collected it appears to be of only minimal importance.

Ictalurus nebulosus - Brown bullhead. The brown bullhead ranked twenty-eighth in overall abundance and was collected at Transects A, B, and D. The brown bullhead is considered a sport fish in the study area, but due to its apparently low population density, it probably contributes little to the sport fishery.

Ictalurus platycephalus - Flat bullhead. The flat bullhead ranked eighth in overall abundance. This species was collected from all transects, but was more abundant in the river. Many specimens of a desirable sport size were collected and this species is considered a major segment of the sport fishery, especially in the river.

Ictalurus punctatus - Channel catfish. The channel catfish ranked twelfth in overall abundance. It was collected at all transects, but was most commonly collected at Transect E. Although it is not highly abundant numerically, fishermen interviewed indicated it was one of the most desired sport fish in the study area. Several specimens of desirable sport size were collected.

Noturus gyrinus - Tadpole madtom. One tadpole madtom was collected at Transect E. Madtoms do not attain a sufficient size to be considered an important segment of the sport fishery. The low numbers collected indicate this species contributes minimally to the forage base.

Noturus leptacanthus - Speckled madtom. One speckled madtom was collected at Transect E. Speckled madtoms do not attain a suitable size to be an important sport fish and low abundance reduces the probability of its contributing significantly to the forage base.

Poeciliidae - Live bearer family

Gambusia affinis - Mosquito fish. The mosquito fish was not collected during the normal fish sampling program. It was observed and collected with an aquatic insect net in the reservoir at Transects B and C. This species typically occurs near the shoreline in shallow water. The mosquito fish probably contribute to the forage base of the reservoir.

Percichthyidae - Temperate bass family

Morone chrysops - White bass. This species ranked twenty-sixth in overall abundance in the study area. White bass were collected at Transects B, C, and E. Eight of the ten specimens collected were captured at Transect E. It is assumed that normal spring upstream movements concentrate these fishes at the base of Parr Dam. This species was rarely collected in the reservoir. The white bass may seasonally form a significant segment of the sport fishery, but it is probably not utilized by most fishermen in the study area.

Centrarchidae - Sunfish family

Lepomis auritus - Redbreast sunfish. The redbreast sunfish ranked nineteenth in overall abundance. This species was collected at Transects C, E, and F. The redbreast sunfish made up a significant portion of the fish population at F. This species is considered a sport fish in the river but probably contributes relatively little to the sport fishery of the reservoir.

Lepomis cyanellus - Green sunfish. The green sunfish ranked twenty-fourth in overall abundance. It was collected at Transects C, D, E, and F. It was not abundant at any of the transects. Low numbers and low fishermen appeal appear to limit the importance of the sport fishery value of this species.

Lepomis gibbosus - Pumpkinseed. The pumpkinseed ranked thirteenth in overall abundance of the fishes collected in the study area. This species was collected at Transects B, C, and D. No specimens were collected from river transects. The pumpkinseed probably contributes to the forage base in the reservoir, but it is not considered an important sport fish.

Lepomis gulosus - Warmouth. The warmouth ranked fourteenth in overall abundance. This species was collected at all reservoir transects (A, B, C, D) but was not collected in the river. This species probably contributes to the forage base, but does not appear to be actively sought as a sport fish. It constituted only one percent of the total number of fishes collected.

Lepomis macrochirus - Bluegill. The bluegill was numerically the most abundant species collected. It was collected at all transects and was especially abundant in the reservoir. In the reservoir the bluegill is believed to be a major segment of the forage base and one of the primary sport fishes.

Lepomis megalotis - Longear sunfish. The longear sunfish ranked thirty-second in relative abundance. It was collected at Transects C and E. This species does not appear to be actively sought as a sport fish although some larger individuals could be taken.

Lepomis microlophus - Redear sunfish. The redear sunfish ranked fourth in overall abundance. It was collected at all transects though it was relatively rare in the river. This species is considered an important component of the sport fishery. Many individuals of catchable size were collected. The redear is actively sought and highly esteemed by local fishermen.

Micropterus salmoides - Largemouth bass. The largemouth bass ranked fifth in overall abundance. It was collected at all transects except F. The relatively high numbers and large size of bass collected indicate that the largemouth is one of the major predators in the reservoir. It is actively sought by fishermen and is considered a major component of the sport fishery.

Pomoxis annularis - White crappie. The white crappie ranked third in overall abundance in the study area. This species was collected at all transects, but was much more abundant in the reservoir. The white crappie is actively sought as a sport fish and undoubtedly also contributes to the forage base. The white crappie is considered an important segment of the sport fishery.

Pomoxis nigromaculatus - Black crappie. The black crappie ranked tenth in overall abundance. This species was collected at all transects except E. The black crappie is less abundant than the white, but generally follows the same pattern of distribution being much more prevalent in the reservoir than the river. The black crappie is considered an important segment of the sport fishery and undoubtedly contributes to the forage base.

Percidae - Perch family

Etheostoma fusiforme - Swamp darter. A single specimen of the swamp darter was collected at Transect C. This species usually inhabits slow-flowing, weedy areas. The small size and low density of swamp darters indicate that this species is not an important component of the fishery of the area.

Perca flavescens - Yellow perch. A single specimen was collected at Transect D. Since this species was encountered only one time during the survey, it is not considered an important segment of the sport fishery.

3.6.3.2 Age and Growth

The results from the age and growth study for important species indicate that, in general, fish in the Broad River Study Area are slower growing than fish from comparable areas (Table 3.6.3).

Mean lengths attained each year by bluegill in Broad River are slightly greater than values given for Lake Wappapello, Missouri (Patriarche 1953) for age classes I-IV, but fall below values given for Clearwater Reservoir, Missouri (Lane 1954).

The white crappie mean total lengths at age I exceeded values obtained for Lake Marion, South Carolina, but for every year after were less (Stevens 1959a). Growth rates for white crappies in Broad River were slower than those reported for Lake Moultrie, South Carolina (Stevens 1959a).

Mean back calculated total lengths for year classes of gizzard shad were less than those of comparable areas (Eschmeyer, et al. 1944; Turner 1953; Parsons and Lowry 1953).

Redear sunfish in the Broad River exhibited better values for mean total length at all ages than values given for Oklahoma (Jenkins et al. 1955). The lengths for each year class did, however, fall within the range given for Reelfoot Lake, Tennessee (Schoffman 1939).

Mean lengths for year classes of largemouth bass were less for comparable areas for all age classes (Stroud 1948; Patriarche 1953).

3.6.3.3 Length-Weight Relationship

Length-weight relationships of important species were calculated and equations describing the regression are presented in Table 3.6.4. The

Table 3.6.3 Mean back calculated total lengths and average growth increments of selected fishes from all Parr Reservoir transects (B, C, D), March 1971 - May 1973.

		Total Length (mm) at Annulus						
Year Class	n*	1	2	3	4	5	6	7
				Bluegill				
1971	69	54						
1970	103	55	91					
1969	83	52	86	115				
1968	53	56	87	115	141			
1967	12	65	97	130	155			
1966	8	29	69	106	134	154	172	
Mean Length		52	86	117	143	154	172	
Mean Increment		52	34	32	26	11	18	
				White Crappie				
1971	39	74						
1970	56	71	129					
1969	43	58	126	166				
1968	23	74	128	174	210			
1967	6	52	97	137	198	235		
1966	7	47	102	150	204	237	271	
Mean Length		63	116	157	204	236	271	
Mean Increment		63	56	44	50	35	34	
				Gizzard Shad				
1971	89	112						
1970	43	120	176					
1969	30	94	160	203				
1968	23	106	177	201	276			
1967	14	125	173	198	232	286		
1966	4	130	218	240	275	318	348	
1965	1	150	195	260	290	330	360	397
Mean Length		120	183	220	268	311	354	397
Mean Increment		120	62	36	44	46	30	37

*Number of fishes examined.

Table 3.6.3 (Continued)

	Total Length (mm) at Annulus							
Year Class	n*	1	2	3	4	5	6	7
				Redear				
1971	14	53						
1970	20	62	109					
1969	15	57	112	148				
1968	18	54	119	146	177			
1967	6	61	119	162	185	194		
1966	2	84	109	148	173	195	209	
1965	6	54	77	120	150	188	208	222
1964	4	54	80	124	167	196	221	241
Mean Length		60	106	141	170	193	214	332
Mean Increment		60	43	39	30	24	20	17
				Largemouth Bass				
1971	10	95						
1970	10	118	141					
1969	10	97	181	270				
1968	5	161	215	275				
1967	5	116	175	233	285	354		
1966	6	99	186	257	300	353	399	
1965	1	55	107	141	180	212	241	255
1964	1	40	80	148	235	323	375	405
Mean Length		98	155	221	250	289	338	330
Mean Increment		98	57	63	55	60	42	22

*Number of fishes examined.

Table 3.6.4 Regression equations of length-weight relationships for fishes collected from the Broad River Study Area, November 1972.

Species	Transect	Equation
Bluegill	B	$W=3.136 \times 10^{-6} L^{3.336}$
	C	$W=1.705 \times 10^{-5} L^{2.950}$
	C	$W=9.899 \times 10^{-4} L^{2.168}$
	D	$W=4.719 \times 10^{-7} L^{3.719}$
	E	$W=1.135 \times 10^{-7} L^{3.960}$
Gizzard Shad	B	$W=2.984 \times 10^{-6} L^{3.211}$
	C	$W=7.674 \times 10^{-5} L^{2.584}$
	D	$W=1.315 \times 10^{-5} L^{2.946}$
	E	$W=8.128 \times 10^{-6} L^{3.063}$
	F	$W=1.774 \times 10^{-4} L^{2.462}$
White Crappie	B	$W=4.602 \times 10^{-6} L^{3.173}$
	C	$W=4.459 \times 10^{-6} L^{3.180}$
Redear	B	$W=6.232 \times 10^{-6} L^{3.203}$
	C	$W=2.088 \times 10^{-5} L^{2.936}$
	D	$W=1.053 \times 10^{-5} L^{3.558}$
Largemouth Bass	B	$W=4.352 \times 10^{-6} L^{3.188}$
	C	$W=1.286 \times 10^{-5} L^{2.958}$
	D	$W=2.508 \times 10^{-6} L^{3.305}$
	E	$W=2.138 \times 10^{-9} L^{4.474}$
Carp	E	$W=2.193 \times 10^{-4} L^{2.563}$
Longnose Gar	B	$W=4.331 \times 10^{-7} L^{3.240}$

Table 3.6.4 (Continued)

Species	Transect	Equation
Black Crappie	C	$W=1.320x10^{-7} L^{3.907}$
	E	$W=3.042x10^{-6} L^{3.279}$
Silver Redhorse	E	$W=7.127x10^{-7} L^{3.472}$
Shorthead Redhorse	E	$W=3.496x10-6 L^{3.198}$
Channel Catfish	E	$W=7.294x10^{-8} L^{3.822}$
White Catfish	B	$W=1.615x10^{-6} L^{3.348}$
	C	$W=5.052x10^{-6} L^{3.131}$
Pumpkinseed	B	$W=2.430x10^{-6} L^{3.410}$
	C	$W=3.048x10^{-4} L^{2.393}$
Warmouth	B	$W=8.060x10^{-6} L^{3.165}$
	C	$W=1.977x10^{-5} L^{2.974}$
Quillback Carpsucker	E	$W=7.779x10^{-5} L^{2.685}$
Golden Shiner	B	$W=7.126x10^{-6} L^{3.033}$

weight of a fish generally varies with the cube of its length. Values obtained fall generally within the reported range. There is a great deal of individual variation in length-weight relationships and the small sample size precludes drawing definite conclusions concerning observed differences.

3.6.3.4 Condition Factors

Condition factors may vary with the size of fish collected, sex, season, feeding activity, and numerous other factors. To reduce the bias, a large sample size collected over a long period of time is necessary. The sample size was so small for most species that condition factors must be viewed with caution with respect to the number of individuals collected with some variation expected. In general, the condition of Parr Reservoir fishes is average to slightly below average with respect to condition of fishes in other reservoirs of the nation.

Mean condition factors for all specimens collected from the Broad River Study Area are presented in Table 3.6.5.

Most bluegills collected were in the 7 to 15 cm (2.8 to 5.9 in) size group. Specimens from Transect D were generally larger than those from other transects. Condition factors did not appear to vary among transects.

Size groups of redear sunfish collected were distributed evenly throughout the range, however, an unusually high number of large, 23 to 26 cm (9.0 to 10.2 in), specimens were collected at Transect D. Larger fish tended to have higher condition factors.

Largemouth bass were collected primarily from reservoir transects. They were generally evenly distributed throughout the size ranges encountered. Specimens from Transect E were larger and had higher condition factors.

Carp were generally evenly distributed throughout the size ranges collected. Condition factors did not vary greatly among transects.

Table 3.6.5 Mean condition factors for all important species collected from the Broad River Study Area, March 1971 - May 1973.

Species	Total Number	Condition Factor
Bluegill	733	1.8
Gizzard shad	429	0.9
White crappie	95	1.3
Redear sunfish	211	1.8
Largemouth bass	87	1.3
River carpsucker	57	1.2
Carp	44	1.4
Flat bullhead	41	1.2
Longnose gar	29	0.2
Black crappie	52	1.2
Redhorse	4	1.1
Channel catfish	20	0.8
White catfish	25	1.1
Pumpkinseed	16	1.8
Warmouth	24	1.9
Golden shiner	13	1.0
Shorthead redhorse	36	1.2
Silver redhorse	21	1.2
Silvery minnow	17	1.1
Redbreast sunfish	16	1.9
Quillback	2	1.3
Yellow bullhead	3	0.7
American eel	5	0.2
White bass	2	1.5
Unidentified shiners	2	1.0
Brown bullhead	2	1.4
Hybrid sunfish	1	1.5
Longear sunfish	2	2.1
Creek chubsucker	2	1.1
Black bullhead	2	1.5
Spotted gar	1	0.2
Tadpole madtom	1	0.6
Yellow perch	1	1.1
Swamp darter	1	0.6

Longnose gar were generally evenly distributed by size groups collected. Condition factors did not vary between size groups or transects.

At Transect B most black crappie collected were in the 7 to 12 cm (2.8 to 4.7 in) size range. Condition factors did not vary greatly among transects, or by size group.

The sample size (5) of channel catfish was too small to draw conclusions.

Condition factors of white catfish did not vary greatly between transects. However, the small sample size makes conclusions difficult.

Larger pumpkinseed sunfish tended to have higher condition factors. Condition factors did not vary greatly between transects. Sample size prevents drawing conclusions concerning size group frequency distributions.

One specimen of warmouth from Transect D had an unusually high condition factor, however this is probably attributable to individual variation.

Due to the small sample size,it is impossible to draw conclusions concerning condition factor and frequency distribution by size groups for the silvery minnow, and yellow bullhead in the study area.

No significant variation was observed in the condition factors of the brown bullhead examined.

Two specimens of black bullhead were collected. Although the condition factors were considerably different at the two transects, the small sample size precludes drawing conclusions concerning the difference.

Larger specimens of white crappie were collected at Transects C and D and condition factors were slightly higher at those two transects. However, they were not significantly different.

There appeared to be no significant differences of condition factors among gizzard shad with transects or size groups.

3.6.3.5 Sex Ratios

The sex ratio data on the fish collected in November 1972 and February and May, 1973, were combined to obtain a better estimation of the sex ratios (Table 3.6.6). Even after the data were combined, several species of fish had insufficient numbers for an accurate evaluation of ratios. The various species of sunfish (bluegill, redear, warmouth, pumpkinseed, redbreast sunfish, and a hybrid) generally had more females present in the population than males. The average ratio for these sunfishes was 1:1.6 (males:females). In the other species of Centrarchidae (white crappie, black crappie, and largemouth bass), males and females were collected in nearly equal numbers. Although the number of rough fish (carp and redhorse) sexed was too small for a definitive statement on sex ratios, males were generally collected twice as frequently as females. The major forage fish (gizzard shad) in the study area exhibited nearly equal proportion of males and females in the population. The species of Ictaluridae (catfish and bullheads) were collected in very small numbers and no statement can be made on the sex ratios of these fish.

3.6.3.6 Gonad Condition

The average gonadal conditions of mature fishes collected in February 1973 are given in Table 3.6.7. The mean maturity stage for all sunfishes (Centrarchidae) was between the resting stage and maturation. According to Nikolski (1963), this indicates sexual products were either undeveloped or slightly developed. Therefore, spawning of these species had not occurred at the time of sampling.

Gizzard shad, golden shiner, river carpsucker, and carp were found to be between maturation and maturity. These species were approaching

Table 3.6.6 Sex ratios of fishes collected from the Broad River Study Area, November 1972 and February and May, 1973.

Species	Male	Female	Ratio
Bluegill	181	278	1:1.5
Redear sunfish	61	98	1:1.6
Warmouth	14	21	1:1.5
Pumpkinseed	6	12	1:2.0
Redbreast sunfish	4	5	1:1.3
Hybrid sunfish	1	1	1:1.0
White crappie	52	38	1:0.7
Black crappie	29	22	1:0.8
Largemouth bass	40	42	1:1.1
Gizzard shad	161	133	1:0.8
Carp	27	13	1:0.5
Shorthead redhorse	13	20	1:1.5
Silver redhorse	10	8	1:0.8
Redhorse	3	1	1:0.3
River carpsucker	42	12	1:0.3
Golden shiner	2	1	1:0.5
Creek chubsucker	1	0	1:0
Brown bullhead	0	1	0:1.0
Black bullhead	0	2	0:2.0
Flat bullhead	10	13	1:1.3
Channel catfish	2	11	1:5.5
White catfish	3	7	1:2.3

Table 3.6.7 Mean gonadal condition of mature female fishes collected in the Broad River Study Area, February and May, 1973.

	February		May	
Species	n*	Average Condition	n	Average Condition
Bluegill	123	2.0	89	4.3
Redear sunfish	42	2.2	27	4.2
Pumpkinseed	4	2.3	-	-
Warmouth	2	2.0	7	4.1
Redbreast sunfish	-	-	5	4.6
Hybrid	1	2.0	-	-
White crappie	11	2.6	3	4.6
Black crappie	-	-	2	2.0
Largemouth bass	15	2.5	8	3.1
Gizzard shad	46	3.1	23	4.0
Golden shiner	1	3.0	-	-
Carp	6	3.5	5	4.2
Silver redhorse	6	4.0	3	6.0
Shorthead redhorse	5	4.4	6	6.0
River carpsucker	4	3.5	7	4.1
Quillback	-	-	1	6.0
White catfish	2	3.0	1	6.0
Channel catfish	1	2.0	4	3.0
Brown bullhead	1	3.0	-	-
Black bullhead	-	-	2	5.0
Flat bullhead	5	3.4	8	5.4

*Number of fishes examined.

their spawning period at the time sampled.

The redhorse, which had the most advanced stage of maturity ranging from maturity through reproduction, were sampled just prior to their spawning period.

Channel catfish and white catfish had a gonadal condition indicating the resting stage. These species are known to spawn later than the period sampled (Stevens 1959b).

Brown and flat bullheads had a more advanced stage than other catfish. Their average stage ranged from maturation to maturity. Their spawning would probably occur earlier than the channel and white catfish.

The mean stage of gonadal maturity of fishes collected in May, 1973, is given in Table 3.6.7. The mean gonadal condition of most Centrarchidae was found to be the stage of maturity or approaching the stage of reproduction.

Gizzard shad, river carpsucker, and carp were between the stage of maturity and reproduction. These species were nearing their spawning period.

The redhorse sampled during this period were found to have a mean stage of spent condition. The redhorse, therefore, spawned between the February and May samples in 1973.

One mature female white catfish was collected and determined to have spawned prior to this sampling period. Four mature female channel catfish were found to have a stage of maturation. This indicates that this species would not spawn for some time.

The black and flat bullheads collected were determined to be in reproduction at the time of sampling.

This discussion of the mean gonadal condition of mature female fishes collected in February and May, 1973, suggests some preliminary insights of the spawning periods of selected fishes of the Broad River Study Area. All trends evidenced correspond with expected spawning periods for the region being investigated.

3.6.3.7 Standing Crop

Rotenone samples, for biomass estimates, were conducted in the Cannons Creek and Frees Creek areas of Parr Reservoir. Transect C, Cannons Creek, was sampled November 9 to 11, 1972 (Table 3.6.8). At this station, a total of 5,841 fish, representing 14 species, were collected or observed. The weight of the fishes collected totaled 13.565 kg (29.8 lb). The recapture factors (marked/recaptured ratio) derived from the Petersen estimating procedure ranged from zero to 1.0. It is believed that reliable estimates of the percentage of fish were obtained from the rotenoned area.

The total biomass estimate from Cannons Creek area was 204.521 kg/ha (182.0 lb/acre). A total estimate of 50,076 fishes/ha (20,274/acre) was calculated for this area. The gizzard shad was the most abundant species with an estimated 32,700 fish/ha (13,239/acre) having a biomass of 51.562 kg/ha (45.9 lb/acre). The bluegill was second in abundance at 15,906 fish/ha (6,440/acre) but represented greatest biomass at 91.307 kg/ha (81.3 lb/acre). The contribution of individual species to the total biomass estimate are presented in Table 3.6.8.

Transect B (Frees Creek) was sampled November 11 to 13, 1972 (Table 3.6.9). A total of 728 fishes weighing 9,388 g (20.6 lb) and representing 19 species were collected. Estimated total standing crop was 60.843 kg/ha (54.1 lb/acre).

Standing crop in the Cannons Creek sample was over three times higher than found in the Frees Creek sample.

The Petersen estimate recapture factor (marked/recapture ratio) varied for the 19 species. It ranged from zero, which were species that had no marks placed in the rotenoned area, to 1.0, which indicated that all marked

Table 3.6.8 Standing crop estimates of the fishes from a shoreline rotenone sample of the Cannons Creek area of Parr Reservoir, South Carolina, November 9-10, 1972.

Species	Number Collected	Grams Collected	Recapture Factor	Number/Hectare	Kg/Hectare
Longnose gar	**	-	-	-	-
Gizzard shad	5563	8772	0.41	32700	51.562
Quillback	**	-	-	-	-
Golden shiner	1	66	1.0	2	0.159
White catfish	8	683	-	19[††]	1.646[††]
Tadpole madtoms	17	45	-	41[††]	0.108[††]
Largemouth bass	11	2496	0.17	156	35.384
Warmouth	27	354	0.17*	383[†]	5.018[†]
Bluegill	66	388	0.01*	15906[†]	93.508[†]
Pumpkinseed	3	74	0.50	14	0.357
Redear	6	169	0.03	482	13.576
Green sunfish	10	50	-	24[††]	0.121[††]
Black crappie	9	403	0.36	60	2.698
Young-of-the-year sunfish	110	50	-	265[††]	0.121[††]
Swamp darters	10	9	-	24	0.263
Totals	5841	13565	-	50076	204.521

* No recaptures were obtained, so factor based on assumption of one recapture.
**Species observed outside sampled area, assumed to occur 1/.5 hectare.
† Indicates minimum estimate assume one recapture.
††Minimum estimate because no recapture data available.

Table 3.6.9 Standing crop estimates of the fishes from a shoreline rotenone sample of the Frees Creek area of Parr Reservoir, South Carolina, November 11-13, 1972.

Species	Number Collected	Grams Collected	Recapture Factor	Number/Hectare	Kg/Hectare
Longnose gar	1	1910	-	2	4.720
Gizzard shad	283	1378	0.75	932	4.539
River carpsucker	**	-	-	-	-
Carp	**	-	-	-	-
Golden shiner	42	443	1.00	104	1.094
Silvery minnow	202	1265	1.00	499	3.126
Unidentified shiner	2	14	-	5[††]	0.035[††]
White catfish	9	756	1.00	22	1.868
Yellow bullhead	2	41	-	5[††]	0.101[††]
Tadpole madtom	16	32	-	40[††]	0.079[††]
Mosquitofish	4	1	-	10[††]	0.002[††]
Largemouth bass	1	6	0.47	5	0.032
Warmouth	13	276	0.40	82	1.705
Bluegill	59	753	0.08	1917	24.482
Pumpkinseed	1	27	0.33	7	0.202
Redear	35	1213	0.21	413	14.272
White crappie	22	688	1.00	54	1.700
Black crappie	30	581	0.50	148	2.871
Swamp darter	6	4	-	10[††]	0.015[††]
Totals	728	9388	-	4255	60.843

**Species observed outside sampled area, assumed to occur 1/0.5 hectare.

[††] Minimum estimate because no recapture data available.

fish of that species were recovered. It was felt that adequate estimates of the percentage of each species were obtained in the sample.

Table 3.6.9 illustrates the full breakdown of species composition and abundance. It is of interest to note that the gizzard shad at Transect B were present in much lower numbers than at Transect C. This phenomenon was noted not only in the rotenone samples but in other collecting procedures as well. The reason for this phenomenon is unclear at this time.

Of the species collected in this area, the bluegill comprised the greatest biomass with 24.482 kg/ha (21.8 lb/acre). They were also present in the largest numbers with 1917 individuals estimated per hectare.

Redear were second in biomass with 14.272 kg/ha (12.7 lb/acre). As noted previously, the standing crop of fishes in the Frees Creek area was significantly lower than in Cannons Creek (Transect C).

The standing crop as measured from Cannons Creek, closely approximates the mean standing crop of 207 kg/ha (183 lb/acre), reported by Jenkins (1967) for nine South Carolina reservoirs, although the mean of 132 kg/ha (117.5 lb/acre) from both Parr Reservoir samples is lower than both the South Carolina mean and the mean of 228 kg/ha (202.9 lb/acre) reported by Jenkins for South Carolina reservoir having moderately high sediment loads and low storage ratios. In addition, clupeid standing crop comprises more than half of the total standing crop of other South Carolina reservoirs. Gizzard shad make up less than one-fourth of the total standing crop of Parr Reservoir.

One of the greatest problems encountered in the sampling procedure was the low water temperature (15.0°C) at the time of sampling which caused the rotenone to affect the fish very slowly, thus precluding a rapid pickup. Further, the low water temperature likely allowed some fish to remain alive within the rotenoned area.

One of the limitations of the sampling procedure is, that fish are often not available for marking to perform the Petersen estimate. Related to this, investigators often recover none of the fish of a given species placed within the sampled area. To account for these sources of error, one assumes that the estimates for the species exhibiting these discrepancies are minimal. Therefore, the final estimates are recorded as n+ indicating an unknown error of positive nature. However, in the case of the two samples from Parr Reservoir, it is felt that these errors are small.

3.6.3.8 Food Habits

Food habits analyses were conducted on selected fishes collected from the Broad River Study Area from November 1972 through May 1973. These data were reported by collection period, transect, species, and size group.

Bluegill

A total of 147 bluegill stomachs were analyzed for food habits. There appeared to be differences in food habits between size classes, seasons, and transects.

A transition in food habits with increase in size was noted. Fish less than 50 mm (1.9 in) total length fed primarily on zooplankton with some chironomid larvae also being taken. Fish in the 51 to 100 mm (2 to 3.9 in) total length group fed approximately equally on zooplankton and chironomids. Aquatic insects were the major component in stomachs of specimens of the 101 to 150 mm (4 to 5.9 in) total length size group. Fish over 150 mm total length fed primarily on chironomid larvae. Zooplankton showed a definite decrease in importance as food items in fish over 100 mm total length. When fish eggs were detected as food items they usually comprise approximately 50 percent numerically and volumetrically of the food taken by fish over 100 mm total length.

Seasonal variation was also detected in bluegill feeding habits. In May 1973 all food items were ingested in higher numbers than at other seasons. May was the only month in which fish eggs were taken as food items, and during this sampling period fish eggs and chironomid larvae comprised 80 percent of the food items numerically and 90 percent of the total volume. Although pelecypods were never major constituents of the diet, they were more abundant in the stomachs of fish collected in November and February than in fish collected in May.

There appeared to be some variation in bluegill food habits between transects. Bluegill collected at Transect D had larger quantities of all food items except fish eggs in their stomachs. Bluegill from Transect D fed largely on chironomids. When present, fish eggs were the major food item found in fish stomachs collected at Transect B. Fish collected at Transects B, C, and D (reservoir) generally contained five to ten times as many food items as bluegill collected at Transects E and F (river).

According to Calhoun (1966) studies of bluegill diets in a wide variety of habitats in the eastern and central United States indicated that zooplankton and aquatic insects are usually dominant food.

Gizzard Shad

Twenty-eight stomachs of gizzard shad were analyzed for food habits. Twenty-seven of the specimens collected in May 1973 and a single stomach collected in November 1972 were analyzed.

Gizzard shad fed on a variety of organisms. Diatoms (Bacillariophyceae) were by far the most numerically abundant food item. Other prevalent items included species of Cyanophyta, Chrysophyta, Chlorophyta, and Rotifera. Rotifers and filamentous green algae (<u>Cladophora</u> spp. and <u>Spirogyra</u> spp.) generally comprised the majority of the biomass when present. There appeared to be some variation of feeding habits with size. Smaller fish (50 to 110 mm [2 to 4.3 in] total length) fed primarily on the phytoplanktonic Dinobryon sp. Stomachs of specimens between 200 and 300 mm (7.8 to 11.8 in) total length contained greater numbers of zooplankton and types of phytoplankton other than Dinobryon sp. which decreased in relative abundance. Stomachs from fish greater than 300 mm total length showed a decrease in the relative abundance of phytoplankton and an increase in the abundance of filamentous green algae. The bulk of the biomass in larger fish was composed of filamentous green algae and zooplankton.

Several studies have shown that gizzard shad feed primarily on zooplankton during the first few weeks of development, after which phytoplankton becomes the major constituent of the diet (Kutkuhn 1957; Miller 1960; Cramer and Marzoff 1970). This shift in diet generally occurs when fish are between 25 and 30 mm (0.9 to 1.2 in) total length (Bodola 1966). Cramer and Marzolf (1970) showed that shad less than 20 mm (0.8 in) total length were able to feed selectively on certain species of zooplankton. After the fish had developed beyond the larval and post-larval stages greater than 60 mm (2.3 in) total length, they apparently fed randomly, utilizing the gill rakers as a filtering mechanism (Tiffany 1921; Bodola 1966). Jester and Jensen (1972) stated that the diet of gizzard shad was controlled primarily by the availability of food items. Jester and Jensen found that phytoplankton were numerically more abundant in the gut contents of shad, but zooplankton comprised the major portion of the biomass.

White Crappie

A total of 54 stomachs from white crappie were examined. There appeared to be a transition in food habits with size. Smaller fish fed primarily on zooplankton, intermediate size fish tended to feed on insects and larger fish were more piscivorous.

Seasonal changes in food habits were also evident. During November 1972, the larger, 201 mm (7.9 in), white crappie fed almost entirely on fishes, primarily gizzard shad. In February 1973, insects were evident in the diet, and by May 1973, the mean percent total volume of insects surpassed that of the fishes as food items. In November 1972, the intermediate sized, 101 to 200 mm (3.9 to 7.8 in), white crappie fed on zooplankton, insects, and gizzard shad in approximately equal volumes. In February, insects and fishes comprised the major protion of the diet; and by May, insects were the primary food.

Of the white crappie less than 100 mm (3.9 in) total length, those collected in November contained only zooplankton. In February, zooplankton and insects contributed approximately equal volumes of the observed food components. No specimens of the smaller size class were collected in May 1973.

These observations agree well with food habits reported by other workers (Harlan and Speaker 1956; Huish 1957; Sigler 1959). No differences in food habits were detected at different transects.

Redear Sunfish

A total of 88 redear stomachs were examined. There was no apparent difference in food habits between transects or between size groups, however, there appears to be a seasonal difference in redear food habits. Pelecypods, primarily the exotic asiatic clam, Corbicula manilensis, comprised from 70 to 99 percent of the total volume of the stomach contents of redear collected in May and November. C. manilensis was also found to be abundant in benthic samples. Unidentified organic matter was the next most prevalent item during May and November. In February, ephemeropterans and other insects, especially odonates, replaced pelecypods as the major food item. Ephemeropterans were particularly evident in the diet of specimens collected at Transect D in

February.

According to Calhoun (1966), newly hatched redear feed on green algae and microcrustacea, and older fish feed primarily on plankton, insects, snails, and occasional small fish. In Lake George, Florida, the November and December diet of redear was mainly small snails (Huish 1958).

Largemouth Bass

A total of 63 largemouth bass stomachs were examined from the study area. There appears to be no seasonal differences in food habits of largemouth bass. A difference in major food items was detected between fish collected in the reservoir (Transects B, C, and D) and those collected from the river (Transect E). A transition of feeding habits with size of fish also was detected. Bass in the 101 to 150 mm (3.9 to 5.9 in) total length size class from the reservoir appeared to be feeding on aquatic insects (Ephemeroptera, Trichoptera, Hemiptera). Fish of 151 to 300 mm (5.9 to 11.8 in) fed primarily on fishes, but the species of fish utilized could not be identified. Largemouth bass longer than 300 mm total length fed primarily on fishes (black crappie, gizzard shad, and bluegill), but decapods and frogs were occasionally utilized as food items. All largemouth bass collected at Transect E were longer than 300 mm (11.8 in) total length and contained decapods as the primary food item.

Largemouth bass feed on a wide variety of food items (Calhoun 1966); however, adults eat mainly fishes (Harlan and Speaker 1956; Sigler 1959).

River Carpsucker

Of the river carpsucker stomachs examined, a total of 23 contained food items. The majority of the food material was unidentified organic matter. Dipterous larvae, primarily larval chironomids, comprised the majority of the remainder of the food material. The volume of chironomids in the stomachs varied from trace amounts to 30 percent. There appeared to be no difference among size groups, transects, or seasons.

Carp

Carp were collected only at Transects B and E. Eight carp stomachs were analyzed for food items. All fish examined were between 450 and 800 mm (17.7 to 31.5 in) total length. Unidentified organic matter was the most frequently detected food item, accounting for 85 to 100 percent of the total volume of the stomach contents for all fish examined. Cyclopoid copepods and chironomid larvae were numerically the most important food items encountered. Numerous references indicate carp feed primarily on bottom fauna such as chironomids, zooplankton, phytoplankton, and plant remains (Ewers and Boesel 1935; Rose and Moen 1951; Moen 1954; Sigler 1959; Rehder 1959; Scidmore and Woods 1960; Nelson 1962).

Flat Bullhead

Thirty-four stomachs were examined to determine the feeding habits of flat bullhead. Flat bullheads fed on a variety of organisms. There apparently was some difference in the feeding habits associated with size. Fifty percent of the larger specimens contained Notropis sp.

Plant material was abundant in 71 percent of the specimens collected at Transect F. Insects were present in the stomachs of 32 percent from the same location. Those specimens from Transects D and E contained primarily insects.

Twenty-one percent of the specimens examined contained other invertebrates (leeches, arachnids, and nematodes).

Black Crappie

A total of 22 stomachs from black crappie were analysed for food habits. There appeared to be some seasonal variation in black crappie feeding habits. Fish remains were the major food items detected in stomachs collected in November 1972. During the February and May, 1973 samples, the black crappie appeared to be primarily insectivorous. During this period they fed on a wide variety of benthic forms with Ephemeroptera, Trichoptera, Chaoborus sp., and larval chironomids being the most frequently encountered food items.

There appeared to be some variation in feeding habits by transects during the May 1973 survey. Chaoborus sp. accounted for over 95 percent of the total volume at Transect B while at Transect C it formed approximately 20 percent. At Transect D, no stomachs contained Chaoborus sp. and Hexagenia sp. was the major food item.

Moxostoma spp.

There was difficulty during initial surveys identifying redhorse suckers. Consequenty at least two species are grouped under this heading. A total of 25 digestive tracts were examined. Insects dominated the food items observed. Chironomids, ephemopterans, and hydropsychids comprised the bulk of the ingested matter, and 75 percent of those specimens examined contained chironomids. There were no obvious differences between size groups or transects.

Channel Catfish

A total of 15 channel catfish stomachs were analyzed, 12 of which were collected in November 1972. Unidentified organic matter was the major food item detected in stomachs. Insects were low in mean total number and mean percent total volume in November 1972. However, in February 1973, insects comprised 80 percent of the stomach contents by volume (one stomach analyzed). One large specimen (801 to 850 mm [17.7 to 19.7 in] total length size group) contained 30 percent unidentified fish remains by volume. Fish were not detected as food items in stomachs of smaller individuals.

Published reports indicate channel catfish fed on aquatic insects (Ewers and Boessel 1935; Bailey and Harrison 1948) and bottom arthropods

(Darnell 1958) when small, but beyond 100 mm (3.9 in) total length were usually omnivorous (Bailey and Harrison 1948; Cross 1951; Darnell 1958; McDonald and Dotson 1960; Hoopes 1960; Davis 1960) or piscivorous (Dendy 1946; Russel 1964).

White Catfish

Food habits of white catfish are based on the analysis of nine stomachs which contained food items. Due to the small sample size and the variety of food items, no trends or differences could be detected. The mayfly, Hexagenia limbata, dominated the food items by volume in the stomachs of two white catfish collected in November 1972; however, both stomachs contained only single specimens of H. limbata. One stomach collected at the same time from a specimen captured at Transect D contained Ephmeroptera and other insects in trace amounts. Insects were also detected in the stomach of the single specimen collected at Transect B in February 1973. Several specimens collected in February 1973 contained only unidentified organic matter.

Published reports indicate white catfish feed on a variety of food items, including pondweeds, aquatic insects and fishes (Stevens 1959b; Miller 1966).

Pumpkinseed

A total of 13 stomachs were analyzed to determine the food habits of the pumpkinseed. Pumpkinseed fed primarily on aquatic insects (Chironomidae and Ephemeroptera), especially during February. Pelecypods and unidentified organic matter were also consumed. No differences in food habits were detected between size classes, transects, or seasons.

Trautman (1957) stated that pumpkinseed fed chiefly on aquatic insects, small mollusks, and crustacea, and that large individuals may also feed on small fishes.

Warmouth

Fourteen warmouth stomachs were analyzed to determine food habits. Thirteen of the specimens examined were less than 150 mm (5.9 in) total length. Specimens examined fed on aquatic insects, decapods, and amphipods. Stomach contents of the single specimen greater than 150 mm total length contained 90 percent by volume unidentified fish remains. There were no obvious differences in feeding habits between transects or seasons.

Other studies indicated that post-larval individuals fed on Protozoa and bacteria, with insects, zooplankton, snails, and small crustaceans becoming increasingly important as the fish grew; with fishes comprising a large part of the diet of those over 130 mm (5.1 in) total length (Lenis and English 1949; Harlan and Speaker 1956; Larimore 1957).

Golden shiner

A single specimen of golden shiner in the 101 to 150 mm (4 to 5.9 in) size group was collected at Transect C in May 1973. The stomach contained three chydorid cladocerans, and 80 percent algae and 20 percent unidentified organic matter by volume. According to Radcliff (1931) and Flemer and Woolcott (1966) young shiners feed principally on Entomostraca and phytoplankton, while adults feed largely on algae.

Shorthead Redhorse

A total of 16 digestive tracts of specimens positively identified as <u>Moxostoma macrolepidotum</u> were analyzed to determine food habits. No significant variation between size groups, transects, or seasons was detected. Insects, particulary chironomid larvae, appeared to be the primary food item encountered. Chironomids were present in all but two of the specimens in which ingested material was identifiable.

Small redhorse reportedly feed on Cladocera and chironomids

(Nurnberger 1930) and larger individuals feed on benthic insects (Meyer 1962; Reed 1962).

Silver Redhorse

Food habits of silver redhorse were based on examination of contents of the digestive tract of 15 specimens. Most specimens contained unidentifiable organic matter. Twenty percent of examined specimens contained molluscs, primarily *Corbicula manilensis*; and approximately 20 percent had ingested benthic insects, primarily chironomid larvae.

No obvious differences between size groups or seasons was detected. The greatest variety of food items was observed in specimens collected from Transect E.

Meyer (1962) found that chironomids, mayflies, and caddisflies were the principal foods of silver redhorse in the Des Moines River, Iowa.

Redbreast Sunfish

A total of nine redbreast were examined for food habits. Eight of the specimens were less than 200 mm (7.8 in) total length. Redbreast fed primarily on insects (Chironomidae and Odonata). Unidentified organic matter was also an important food item. The stomach of the single specimen larger than 200 mm total length contained a flat bullhead. No redbreast were collected during the November sampling, or from Transects A, B, C, or D on other sampling dates.

Yellow Bullhead

Food habits of a single specimen of yellow bullhead collected at Transect E in May 1973 were analyzed. The stomach contained unidentified organic matter.

According to Harlan and Speaker (1956) principal foods of the yellow bullhead included insects, crustaceans, mollusks, and small fishes.

Eddy and Surber (1947) stated that plant materials often form a large part of the diet.

Green Sunfish

Stomach contents of a single specimen of green sunfish captured at Transect E in November 1972 were analyzed. The stomach contained 90 percent unidentified organic matter by volume, one trichopteran, and one dipteran.

Sigler and Miller (1963) stated that adult green sunfish prefer larger animal foods such as fish, dragonfly larvae, freshwater shrimp, and aquatic snails.

White Bass

Two specimens of white bass were collected at Transect E in May 1973. Unidentified fish remains comprised 90 to 100 percent by volume of the food items detected. White bass feed on insects and fishes (Lamb 1951; Toole 1952; Bonn 1953).

Brown Bullhead

Stomach contents of two brown bullheads were analyzed for food habits. Stomachs from Transects B and D contained primarily unidentified organic matter. Both stomachs contained Chironomidae, trichopterans, *Hexagenia* sp., and unidentified insect remains.

Longear Sunfish

Stomach contents of a single specimen of longear sunfish in the 51 to 100 mm (2 to 3.9 in) length size group were analyzed. The stomach contained 100 bryozoan statoblasts comprising 50 percent of the contents by volume. Unidentified organic matter comprised 40 percent of the contents by volume. Seven dipteran larvae were also present in the stomach.

Black Bullhead

Two black bullhead stomachs were analyzed for food habits. Both specimens were collected in May 1973. One specimen was collected at Transect B and the other at E. Both stomachs contained unidentified organic matter.

According to Harlan and Speaker (1956) black bullhead are omnivorous; their diet includes insects, crustaceans, worms, mollusks, fish eggs, fish, and plant matter.

3.6.3.9 Parasites

No external parasites were noted at the time of collection. Internal parasites, mainly of the digestive tract, were noted and recorded during the course of stomach analysis. A table summarizing host-parasite relationships was compiled for each sampling period (Tables 3.6.10 to 3.6.12). The data are presented on a quarterly basis in order to show more clearly the differences which occurred during the sampling periods.

The two most important parasites in terms of number of species were Posthodiplostomum minimum and Nematode "a". P. minimum centrarchi, a metacercarial trematode, was noted in the liver and mesentaries of Centrarchidae in sampling periods November 1972 to May 1973; young centrarchids were often found to have large numbers of these metacercariae in the liver. The infecting agents of this parasite are the cercariae escaping from the first intermediate host (Physa sp.), entering the second intermediate host (Centrarchidae) through the skin, and migrating to the hepatic region where encystment occurs. The definitive host of Posthodiplostomum minimum centrarchi in the study area is probably the great blue heron.

The greatest variety of parasites is found in the Nematoda; up to eight possible species were noted in the November 1972 sample. The nematodes were, in general, morphologically similar with the exception of Nematode "a"

Table 3.6.10 Parasites of fishes collected from five transects in the Broad River Study Area, November 1972.

	Posthodiplostomum minimum centrarchi	P. minimum	Nematoda Species								Camallanus	Camallanus type
			a	b	c	d	e	f	g	h		
Centrarchidae												
Bluegill	X (44)		X									X
Redear	X		X									
Pumpkinseed	X											
Warmouth			X									
Black crappie	X		X									
Largemouth bass			X									
Ictalauridae												
White catfish		X	X									
Channel catfish		X							X			
Flat bullhead		X		X								
Catostomidae												
Shorthead redhorse					X	X	X	X		X		
River carpsucker											X	

Table 3.6.11 Parasites of fishes collected from five transects in the Broad River Study Area, February - March, 1973.

	Posthodiplostomum minimum centrarchi	Trematoda Species			Nematoda Species				*Camallanus*	Cestoda
		a	b	c	a	b	c	d		
Centrarchidae										
Bluegill	X		X	X	X					
Redear	X	X	X		X					
Pumpkinseed	X				X					
Warmouth	X				X					
White crappie	X				X					
Black crappie					X					
Largemouth bass	X		X		X					
Redbreast	X									
Ictalauridae										
White catfish		X			X					
Channel catfish		X								
Flat bullhead							X			
Castostomidae										
Silver redhorse									X	X
Shorthead redhorse								X		
River carpsucker									X	

Table 3.6.12 Parasites of fishes collected from five transects in the Broad River Study Area, May 1973.

	Posthodiplostomum minimum centrarchi	Trematoda	Nematoda Species								Camallanus	Cestoda	Proteocephalus
			a	b	c	d	e	f	g	h		a	b
Centrarchidae													
Bluegill	X	X	X			X	X					X	
Redear	X	X	X	X									
Warmouth	X		X								X		
White crappie	X		X										
Black crappie			X	X	X								
Largemouth bass	X												X
Ictauridae													
Flat bullhead								X	X				
Catostomidae													
River carpsucker										X			
Cyprinidae													
Carp												X	

and Camallanus sp. Consequently, the letter designation given these parasites do not necessarily correspond to each other among the different samples. The majority of these roundworms, and the other parasites as well, are undescribed species (Dr. Wilmer Rogers, pers. comm.)[1].

Nematode "a" was originally reported as Spinitectus sp. to which it bears a strong resemblance. It is undescribed however, and occurs mainly in the Centrarchidae although white catfish were found to harbor this parasite also. A possible intermediate stage of the nematode has been found in the thorax of the mayfly nymph Hexagenia limbata. Percent infections of Nematode "a" and Posthodiplostomum minimum centrarchi in relation to the Centrarchidae and fish population as a whole are shown in Figure 3.6.1.

The most abundant parasite occurring in a single species was a nematode found in flat bullheads in November 1972 and May 1973 designated Nematode "b" and Nematode "f", respectively. This worm occurred in the pylorus of flat bullheads from Transect F and was found in very large numbers. Estimates of the number of worms per host vary from several hundred to several thousand.

Camallanus sp., a large (25 mm [1.0 in]) distinctive nematode, occurred in the Catostomidae, usually in river carpsuckers from swift water (Transects E and F). A larval form of this worm was found in one warmouth from Transect D in May 1973 and an incomplete specimen in one bluegill from Transect B in November 1972. Only a few were found in any one fish. Infection by Camallanus sp. occurs when the intermediate copepod host is ingested and development to the adult stage takes place in the final host's intestine.

Adult trematodes were found in February, March, and May, 1973 (Tables 3.6.11 and 3.6.12). In the former sampling period, three species of

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[1] Dr. Wilmer Rogers, Alabama Cooperative Fishery Unit, Auburn, Ala.

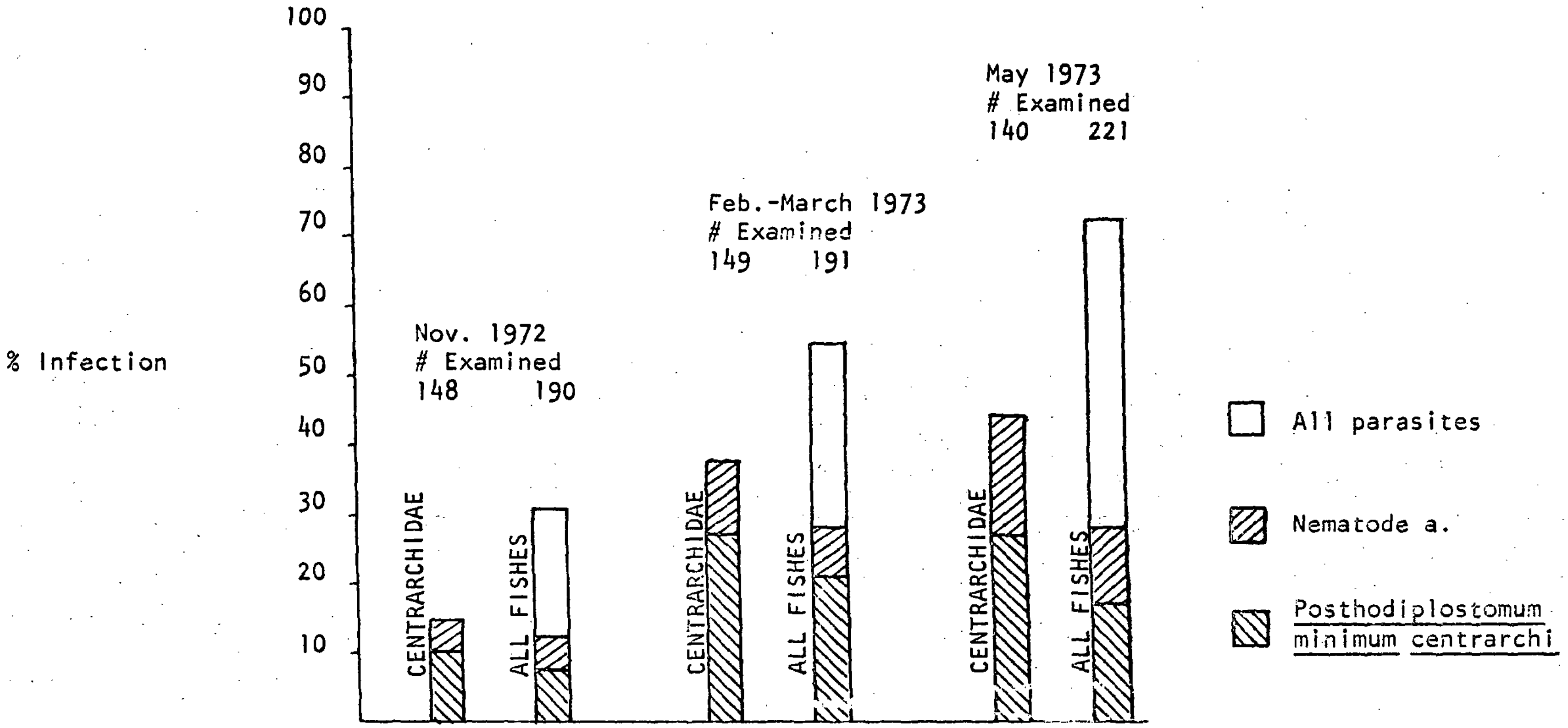

Figure 3.6.1 Percent infection of Centrarchidae and all fishes by selected parasites and all parasites in the Broad River Study Area, 1972-1973.

flukes were recorded from three Centrarchidae and two Ictaluridae. These trematodes are undescribed, but appear to belong in the Cryptogonimidae. In the May 1973 sample, one unidentified species belonging in Allocreadiidae occurred in bluegill and redear only. The fluke appears to be similar to Crepidostomum sp. but may be undescribed. Life cycles of the Cryptogonimidae and Allocreadiidae are not well known and varied modes of infection are possible. No heavy infections by trematodes were noted.

Cestodes were also first recorded in 1973. An undescribed cestode (Caryophyllaeidae) was recovered from three silver redhorse from Transects E and F. Another species of the same family, bearing a resemblance to Spartoides sp., occurred in two carp from Transect E; 43 were found in one intestine. These are small unsegmented tapeworms less than one cm in length, and varied modes of infection are possible. The unidentified Cestode "a" (May 1973) was found in one bluegill. It was not possible to identify this incomplete segmented worm. Four Proteocephalus sp. were recovered from one largemouth bass from Transect C. The adult develops in the final host after ingestion of a smaller fish containing the plerocercoid. Procercoid development takes place in the hemocoel of crustaceans.

It is likely that parasites recorded from the Broad River Study Area have little deleterious effect on their hosts. However, a few exceptions may be discussed further:

(1) Pyloric nematode of flat bullheads (Nematode "b", November 1972; Nematode "f", May 1973).

Generally speaking, the effects of parasitism are related to the abundance of the parasite in the host; this is especially true of nematodes. The fact that this nematode was found in extremely high concentrations may be significant. In most cases, the pylorus was completely blocked by masses of this worm and other masses were found in adjacent regions of the stomach. Conceivably, digestion could be severely impaired by such masses of worms. Wasting or death of the host could be the result of this reduced assimilation efficiency. However, the particular hosts examined appeared healthy.

(2) Posthodiplostomum minimum centrarchi

This parasite can be detrimental during two of its life history stages. The infective miracidia can cause small hemorrages as they penetrate beneath the host's scales and migrate to the hepatic region. In addition, the miracidial entrance wounds may serve as sites for secondary bacterial or fungal infections. The metacercariae encysted in the liver could cause reduced hepatic function and death of the host (Hunter 1942). Mesenteric adhesions resulting from metacercariae of Posthodiplostomum minimum centrarchi have been reported from sunfishes by Bangham (1938) and Fischtal (1953). Hugghins (1972) has attributed the emaciated appearance of black crappie in Lake Frasier, South Dakota to the effects of this parasite.

Fishes of the Broad River Study Area showed no obvious effects from infection by this parasite; mitigating factors in the environment may be acting to reduce the effects of this trematode.

(3) Proteocephalus sp.

The adult form of this tapeworm is less harmful than the larval plerocercoid. The plerocercoid migrates in the visceral cavity and has been shown to cause gonadal fibrosis resulting in sterility (Hoffman 1967). Adhesions have also been reported (Hugghins 1972).

Plerocercoids were not found in any fish examined at the time of gut removal, and the adult was found in only one largemouth bass. It is probable that the incidence of Proteocephalus sp. is low in the bass population. However, should an epizootic of this parasite occur, the potential for a massive decrease in largemouth bass reproduction would be very great.

Other parasites recorded were, with the exception of Nematode "a" and Posthodiplostomum minimum centrarchi, either sporadic in occurrence or occurred in low numbers in the hosts. Parasitism in the population as a whole has more than doubled from November 1972 to May 1973 (Figure 3.6.1), but the fishes examined appeared healthy. No detrimental effects of parasitic infections can be found in the total population or selected groups, including the relatively heavily parasitized Centrarchidae.

3.6.4 SUMMARY

Quarterly surveys of fishes were conducted at the Broad River Study Area from March 1971 through May 1973. Forty species of fishes representing ten families have been identified from the study area.

A total of 4,204 specimens were collected. Bluegill, gizzard shad, white crappie, redear sunfish, and largemouth bass comprised 78.9 percent of the fishes collected. The area sampled is dominated by sport fishes though river carpsucker, carp, flat bullhead, and longnose gar are abundant, especially in the river.

Age and growth of selected species were examined. Growth of bluegill in the study area was comparable to that reported from other areas. Growth rates of white crappie, gizzard shad, and redear sunfish were less than those reported for other areas of South Carolina.

Length-weight relationship regressions and condition factors were calculated and results agree reasonably well with published data. As more specimens are collected, this baseline data will be used for comparison.

Sex ratios were determined for important species. In the family Centrarchidae,males were collected more often than females. Males were much more abundant among the carp and suckers collected. The observed results may be due to sampling during phases of upstream migrations. One sex often precedes the other during such migrations.

Gonad condition of mature fishes of important species was determined in May 1973. Most species had spawned by May 1973. Specimens of the following species; gizzard shad, carp, redhorse, river carpsucker, and flat bullhead had developing gonads or were ripe at this time.

Standing crop was estimated at two areas in the Broad River Study Area. The total biomass estimate from Cannons Creek area was 204 kg/ha (182.0 lb/acre) and the Frees Creek area estimate was 60 kg/ha (54.1 lb/acre). Low water temperature may have prevented a total kill in the sampled area.

Food habits of all fishes examined generally agreed with published studies. The variety of food items observed indicates that most organisms occurring in the aquatic habitat are being utilized.

Fishes were examined for external parasites as they were collected and internal parasites were noted as food habit studies were conducted. A variety of parasites were recorded but apparently had little observable effect on the hosts.

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3.7 PRODUCTIVITY

3.7.1 INTRODUCTION

The metabolism of aquatic plant and animal communities results in measurable changes in the chemical composition of water such as oxygen concentrations, carbon dioxide content, pH, alkalinity, etc. In habitats including polluted water, small ponds, and some streams the diurnal changes may be quite large. In these systems, such changes in the chemical environment are used to estimate primary productivity. However, in unproductive streams and in many productive large rivers, the magnitude of the diurnal changes is so small that reliable estimates are difficult to obtain. When applicable, the diurnal change method involving oxygen and carbon dioxide is advantageous because the communities are in a natural state and not in enclosures (e.g., light - dark bottle and carbon - 14 methods). Observations utilizing diurnal changes can be continued for lengthy periods whereas the enclosure type studies are limited in duration because of the accumulation of metabolites and bottle effects. On the other hand, diurnal change methods are grossly affected by input and output of substances being measured. The more commonly used diurnal curve method at a single station assumes that stream homogeneity exists above the zone of measurement and the incoming water has the same diurnal history as the water proceding it (Odum 1956). Diffusion should be taken into account since it is the main process which fluctuates diurnally, and diffusion rates very considerably, especially in large rivers.

Many attempts have been made to determine primary productivity rates of communities in running waters with very limited success. A variety of methods have been proposed but unfortunately all are subjected to questionable assumptions and numerous limitations. Algal biomass, pigment assays, carbon - 14 uptake, light and dark bottle method, and diurnal changes in oxygen and carbon dioxide have been used to estimate stream productivity. Analysis of diurnal curves of dissolved oxygen has been frequently used (Odum 1956, 1957; Hoskin 1959; McConnell and Sigler 1959; Edwards and Owens 1962; Duffer and Dorris 1966). This method has been used successfully in environments such as productive springs, polluted waters, and in some streams and rivers. In large productive rivers or relatively low productive streams the magnitude of the diurnal change is quite low and experimental error alone may produce erratic results. Diffusion rates vary considerably and in rivers may vary from 0.6-5.0 g $O_2/m^2/hr$ (Odum 1956) and since diffusion is the main process which fluctuates diurnally, it should be taken into account. However, if the area under the rate of change curve is measured, approximate gross production is obtained without diffusion, and accrual corrections are small if deviations from saturation are small relative to the total production.

3.7.2 METHODS AND MATERIALS

Primary productivity estimates were determined by the diurnal single curve method of Odum (1956) at Transect D in the Broad River and in Frees Creek, a tributary to the Broad River. Samples were collected at 2 to 3 hour intervals throughout the 24 hour period and analyzed immediately after collection at a field laboratory. Dissolved oxygen was determined by the azide modification of the Winkler method and analyses were performed in duplicate. Oxygen values were corrected to the average daily temperature. Carbon dioxide was calculated from pH, methyl purple alkalinity, and temperature by means of an alkalinity nomogram (American Public Health Association, et al. 1971).

A hypothetical diurnal curve is both oversaturated and undersaturated with oxygen relative to the atmosphere and there is usually a balance between productivity and respiration. The method proposed by Odum (1956) is based on the following processes that affect the oxygen and carbon dioxide concentrations in flowing waters:

(1) There is a release of oxygen into the water from photosynthetic processes during the day;

(2) There is an uptake of oxygen from the water by respiration of aquatic organisms;

(3) There is an exchange of oxygen with the air based on a saturation gradient;

(4) There may be an influx of oxygen with accrual of ground water and surface drainage.

These processes are expressed quantitatively in terms of g $0_2/m^2/$ hr as:

$$Q = P - R + D_{in} + A \qquad (1)$$

Where:

Q = rate of change of dissolved oxygen

P = rate of gross primary productivity per area

R = rate of respiration per area

D_{in} = rate of oxygen uptake by diffusion per area

A = rate of drainage accrual

Drainage accrual is usually negligible relative to the other influences and is often disregarded. The rate of diffusion into the water is dependent on the saturation deficit and should be taken into account. The gas transfer coefficient (K) is determined from the measurements of dissolved oxygen recorded shortly after sunset and just before sunrise.

At sunset:

$$qe = \frac{KSe}{Z} - r \quad (2)$$

where qe = evening rate of change in oxygen
Se = saturation deficit
Z = depth in meters
r = respiration

At sunrise:

$$qm = \frac{KSm}{Z} - r \quad (3)$$

where qm = morning rate of change in oxygen
Sm = saturation deficit
Z = depth in meters
r = respiration

Subtraction of the equations results in the following relationship:

$$K = Z \frac{(qm - qe)}{Sm - Se} \quad (4)$$

Subsequent values of oxygen concentrations throughout the study period are corrected for diffusion effects by subtracting diffusion rates.

The area under the diurnal rate of change curve is determined by the summation of the change in oxygen concentration per hr (ΔO_2 in g/m^3/hr) for the 24-hour period. The gross production in g O_2/m^2/day is determined by the following equation:

Gross Primary Production PG = (Z) (Area under diurnal curve expressed as g O_2/m^3/hr)

Where PG = gross primary production
Z = depth in meters
Area = area under diurnal curve q

The rate of change of oxygen per unit time is calculated according to the relationships in equation (1). Carbon dioxide productivity estimates based on the diurnal carbon dioxide curve are calculated in the same manner.

It should be emphasized that the diurnal single curve method is no substitute for a two station method but may be useful in obtaining order of magnitude (Odum 1956).

3.7.3 FINDINGS AND DISCUSSION

Primary productivity estimates were determined seasonally by the single station diurnal curve method at Transect D in the Broad River and in Frees Creek, a tributary to the Broad River. Physicochemical data for the study periods are found in Tables 3.7.1 to 3.7.3. The diurnal oxygen curves are shown in Figures 3.7.1 to 3.7.4.

Primary productivity curves (Figures 3.7.5 - 3.7.8) resembled curves from other studies on 24 February 1973 at Transect D and in Frees Creek on 15 November 1973. However, the data at Transect D was extremely variable and no discernable pattern was evident on 15 November 1973 and

Table 3.7.1 Physicochemical data (average values in water column) at Transect D in Broad River and Frees Creek, 15 November 1972.

Time	Temp.	pH	Alkalinity	Free CO_2 mg/l	ΔCO_2/hr	* O_2 mg/l	ΔO_2 g/m^3/hr	O_2 % Saturation
TRANSECT D								
0830	14.5	6.95	28.00	4.84	-	8.92	+0.24	86.4
1245	14.5	6.97	28.00	4.84	0.00	8.72	-0.05	84.5
1720	14.5	6.85	26.00	6.60	+0.38	8.62	-0.02	83.5
2145	14.9	6.74	22.50	6.62	+0.01	8.69	+0.02	84.2
0200	14.1	6.63	20.75	7.04	+0.10	8.56	-0.03	82.9
0600	13.9	6.60	19.50	5.72	-0.33	8.32	-0.06	80.6
FREES CREEK								
1130	14.0	7.00	29.00	4.40	-	8.93	+0.05	86.5
1600	15.5	7.00	29.00	4.84	+0.07	9.45	+0.12	91.6
2030	15.0	6.62	32.00	12.32	+1.66	8.70	-0.17	84.3
2330	14.0	6.71	30.50	9.24	-1.03	9.09	+0.13	88.1
0330	13.9	6.72	30.00	9.24	0.00	8.65	-0.11	83.8
0745	13.8	6.62	30.50	12.32	+0.73	8.76	+0/03	84.9

* Corrected to average daily temperature of 14.4 C.

Table 3.7.2 Physicochemical data (average values in water column) at Transect D in Broad River, 24 February 1973.

Time	Temp.	Conductivity µmho/cm	pH	Alkalinity	Free CO_2 mg/l	ΔCO_2/hr	* O_2 mg/l	$\Delta O_2/g/m^3/hr$	O_2 % Saturation
0	10.0	100	7.20	20.00	3.4	-	11.13	-	99.4
0310	10.0	-	7.10	10.25	3.8	+0.06	11.10	-0.01	99.1
0600	8.9	100	7.05	19.00	4.5	+0.25	10.86	-0.09	97.0
0800	10.0	105	7.15	18.50	3.4	-0.55	11.05	+0.10	98.7
1030	12.0	-	7.20	18.00	2.9	-0.20	11.77	+0.29	105.1
1215	12.0	-	7.28	19.25	2.5	-0.23	11.87	+0.06	106.0
1400	13.0	-	7.35	19.25	2.1	-0.23	12.05	+0.10	107.6
1600	12.8	-	7.20	19.00	2.8	+0.35	11.95	-0.05	106.7
1800	11.0	-	7.28	18.50	2.4	-0.20	11.50	-0.23	102.7
2100	8.8	-	7.35	18.50	2.1	-0.10	10.95	-0.18	97.8
2400	8.3	-	7.28	18.50	2.6	-0.17	10.88	-0.02	97.2

* Corrected to average daily temperature of 10.5 C.

Table 3.7.3 Physicochemical data (averaged values in water column) at Transect D in Broad River, 16 May 1973.

Time	Temp.	*mg/l O_2	ΔO_2	$\Delta O_2 g/m^3/hr$	% Saturation	Free CO_2	ΔCO_2	CO_2/hr
0	20.0	9.38	-	-	102.0	2.4	-	-
0200	20.0	9.43	+0.05	+0.03	102.5	1.9	-0.55	-0.28
0400	20.0	9.40	-0.03	-0.01	102.2	1.5	-0.40	-0.20
0630	20.0	9.25	-0.15	-0.06	100.5	1.6	+0.15	+0.06
0930	20.0	9.40	+0.15	+0.05	102.2	1.0	-0.60	-0.20
1130	20.0	9.33	-0.08	-0.04	101.4	1.0	0.00	0.00
1500	20.0	9.60	+0.28	+0.08	104.3	0.9	-0.10	-0.03
1600	20.0	9.35	-0.25	-0.25	101.6	1.0	+0.10	-0.10
1845	20.3	9.60	+0.25	-0.09	104.9	1.8	+0.80	+0.29
2210	19.3	9.90	+0.30	+0.09	107.1	2.4	+0.60	+0.18

*Corrected to average daily temperature of 20.0 C.

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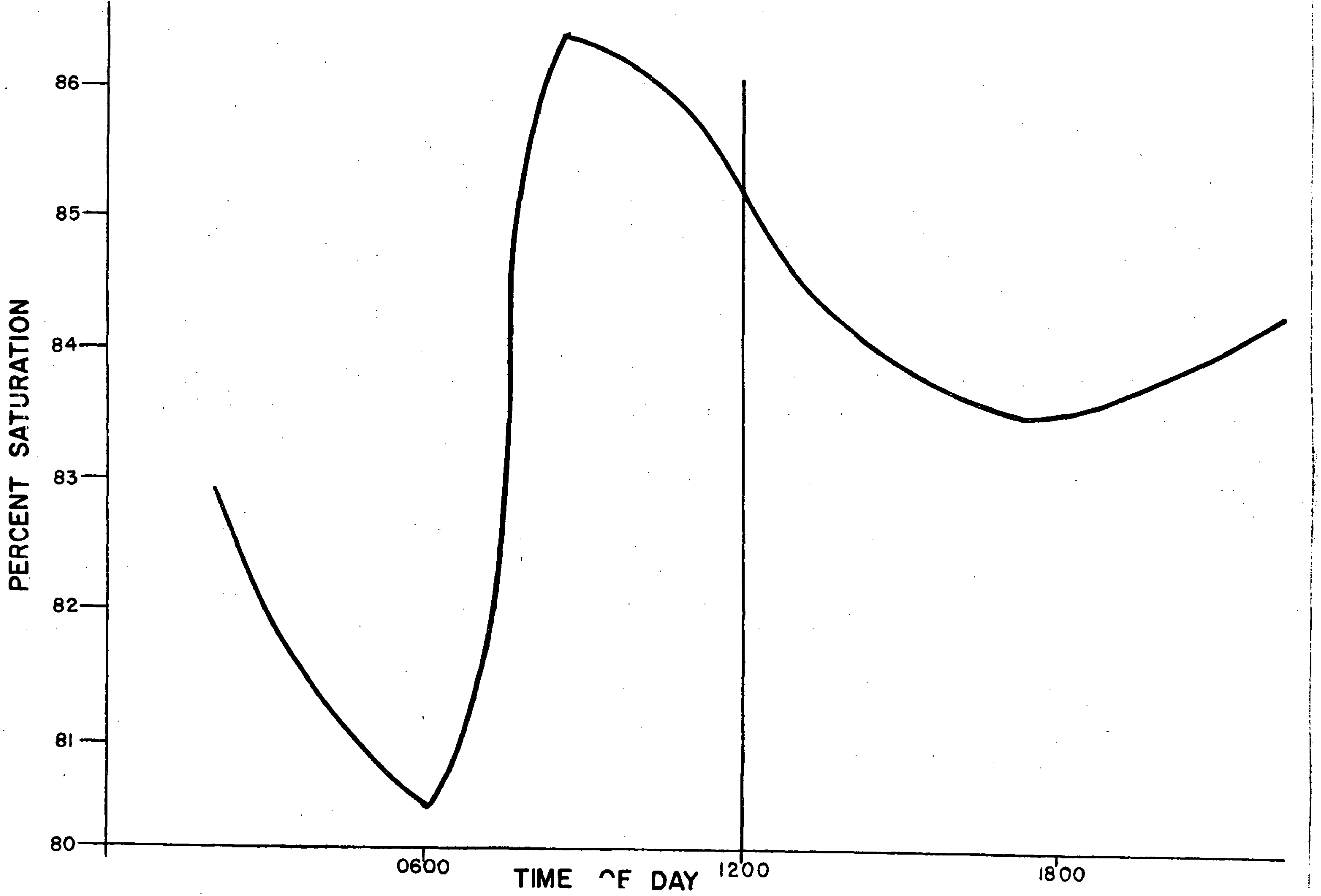

FIGURE 2.1 PERCENT SATURATION OF DI[illegible]LVED OXYGEN IN BR[illegible] RIVER, NOVEM[illegible] 1972.

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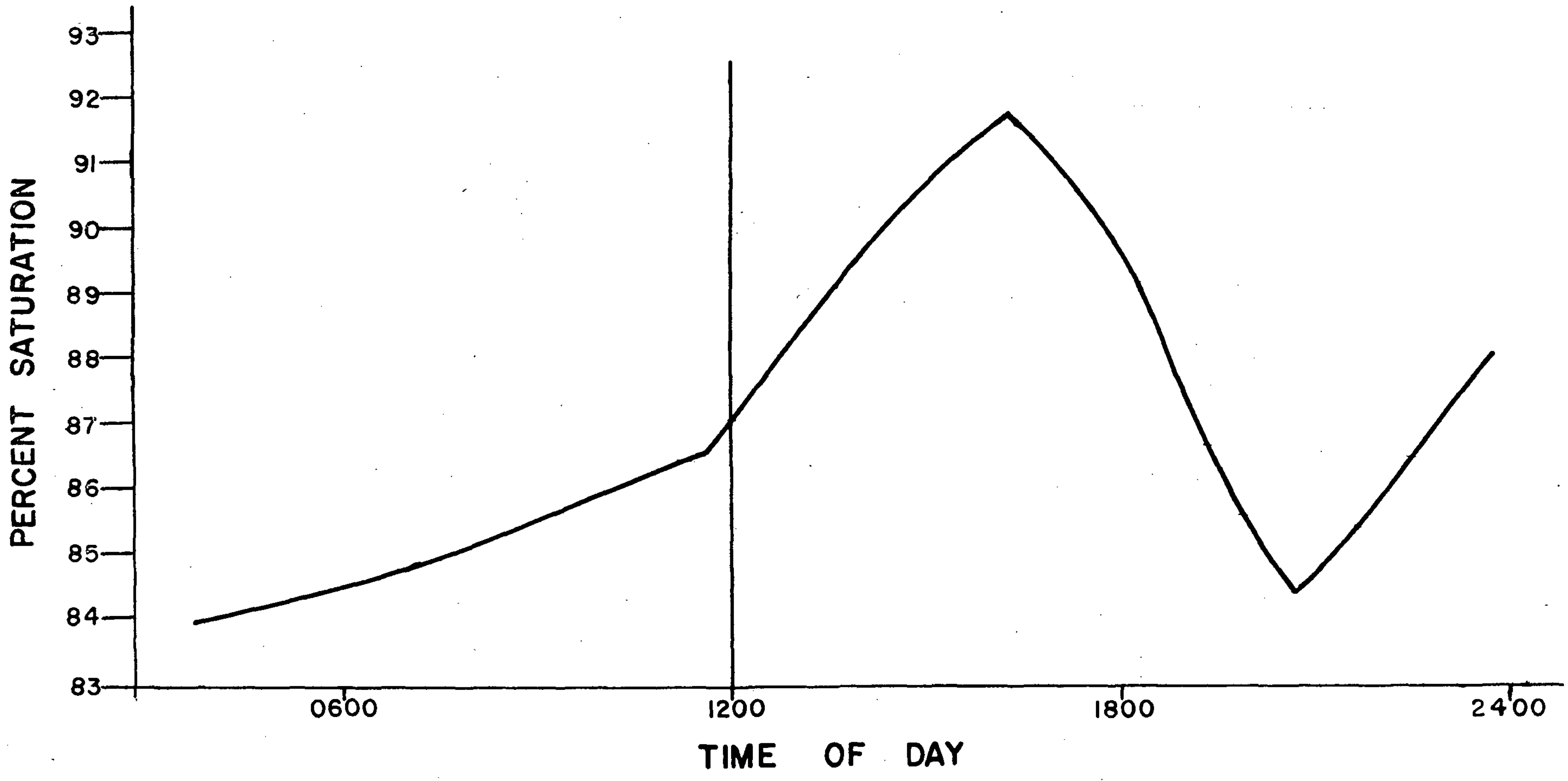

FIGURE 372 PERCENT SATURATION OF DISSOLVED OXYGEN IN FREES CREEK, 15 NOVEMBER 1972.

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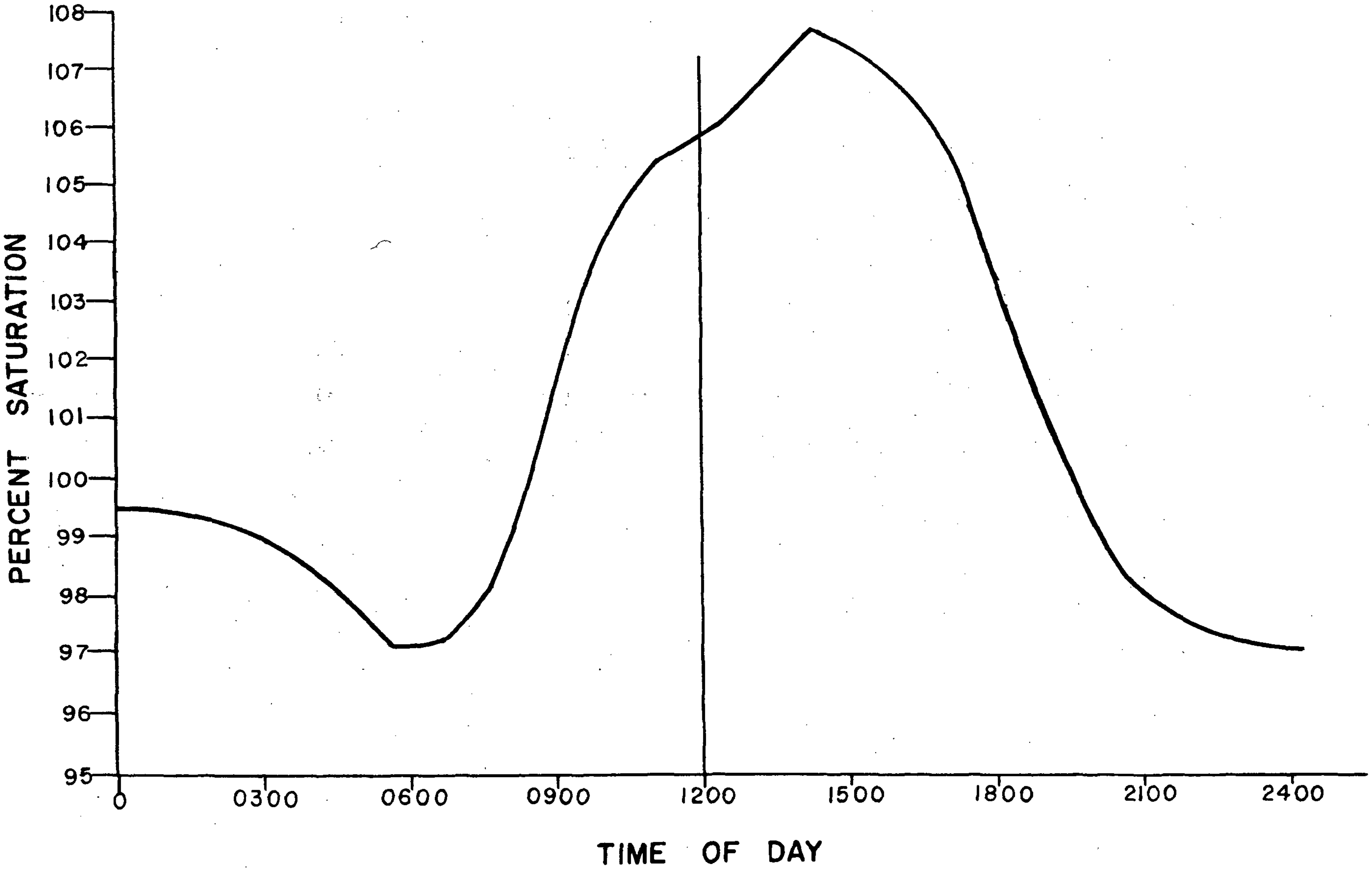

FIGURE 3 PERCE SATURATION OF DI LVED OXYGEN AT T SECT D BROAD ER, 24 FEBRU Y 1973.

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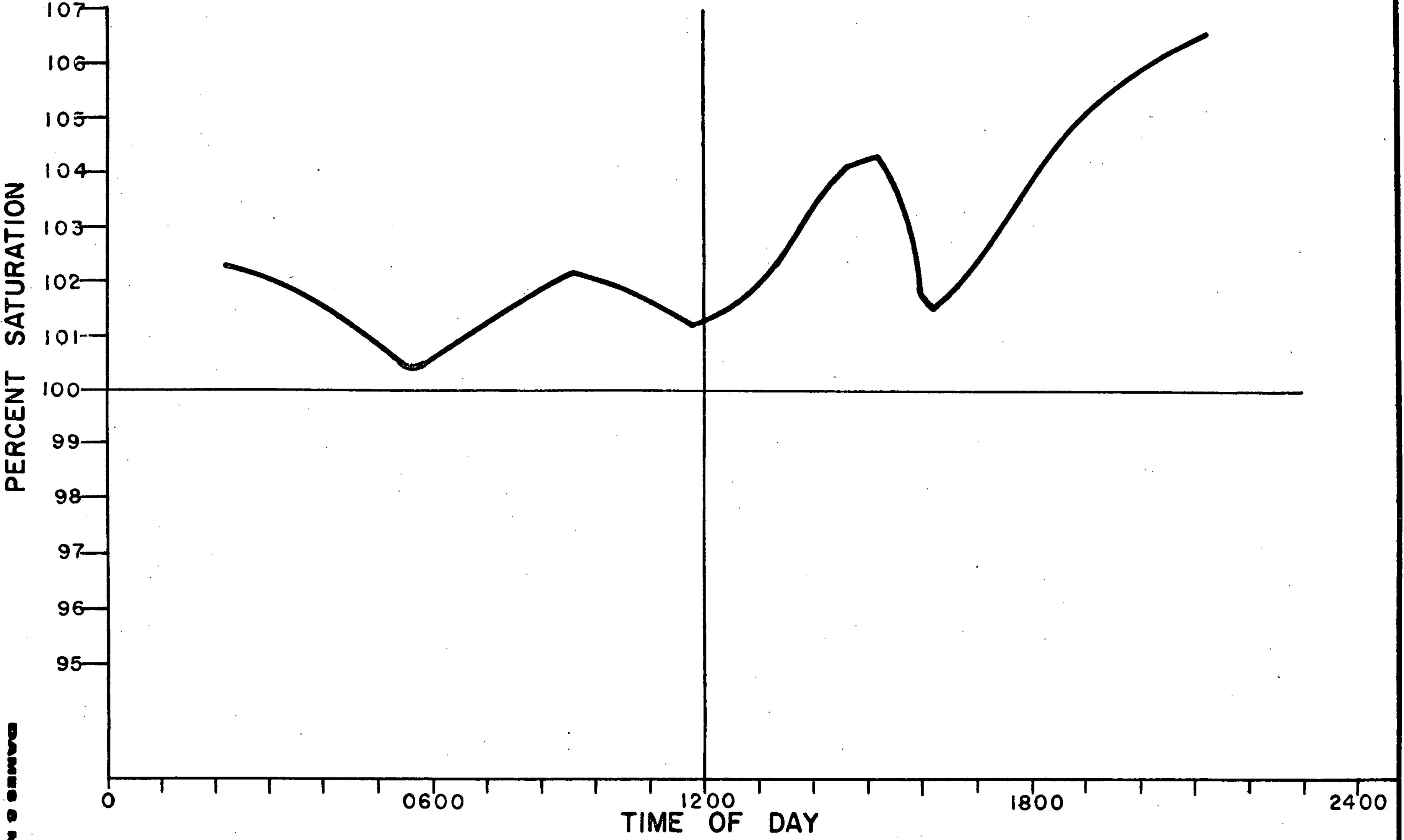

FIGURE 3.7.4 PERCENT SATURATION OF DISSOLVED OXYGEN AT TRANSECT D IN BROAD RIVER, 16 MAY 1973

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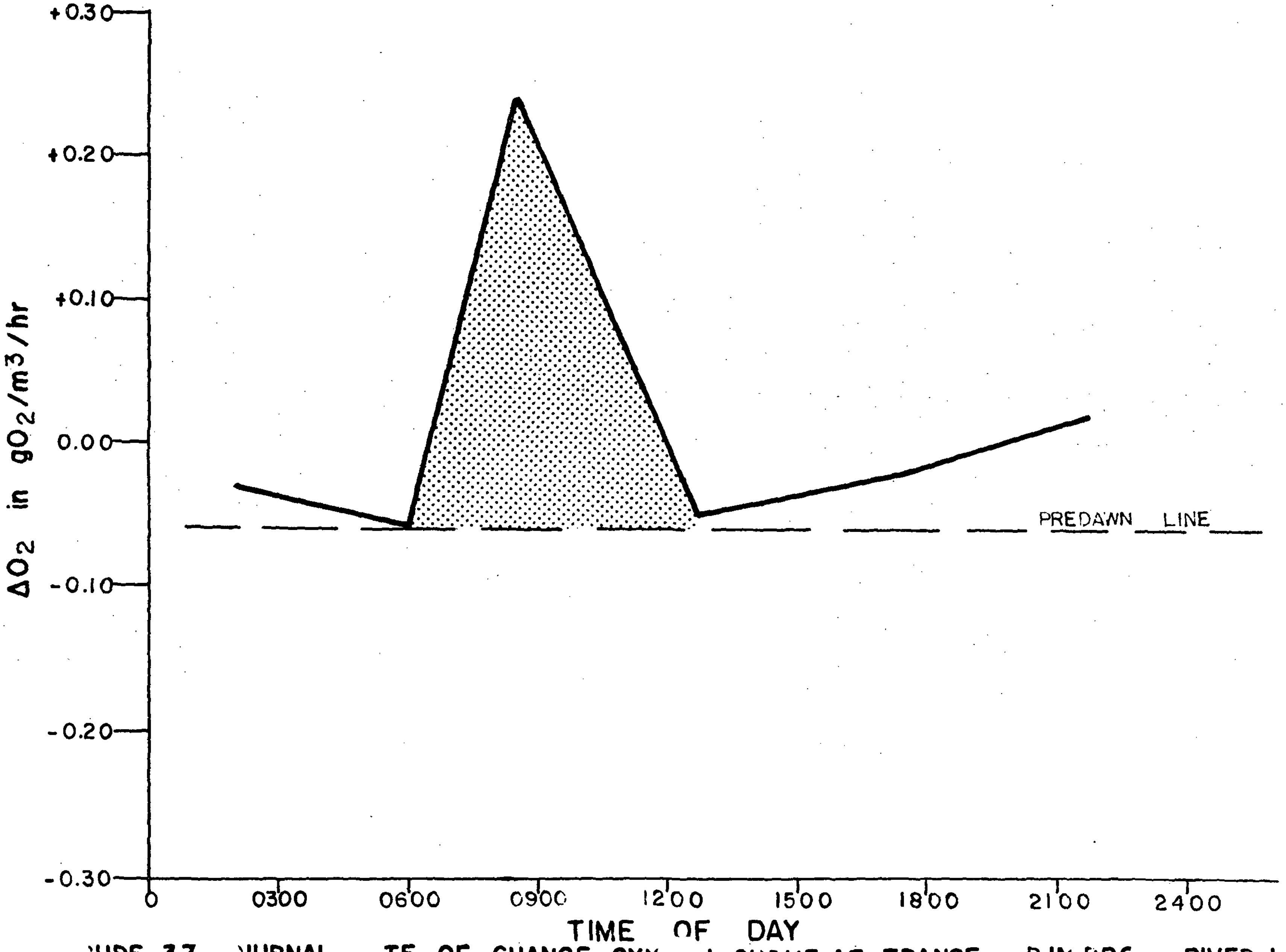

URE 3.7 IURNAL TE OF CHANGE OXY CURVE AT TRANSE D IN BRC RIVER, I
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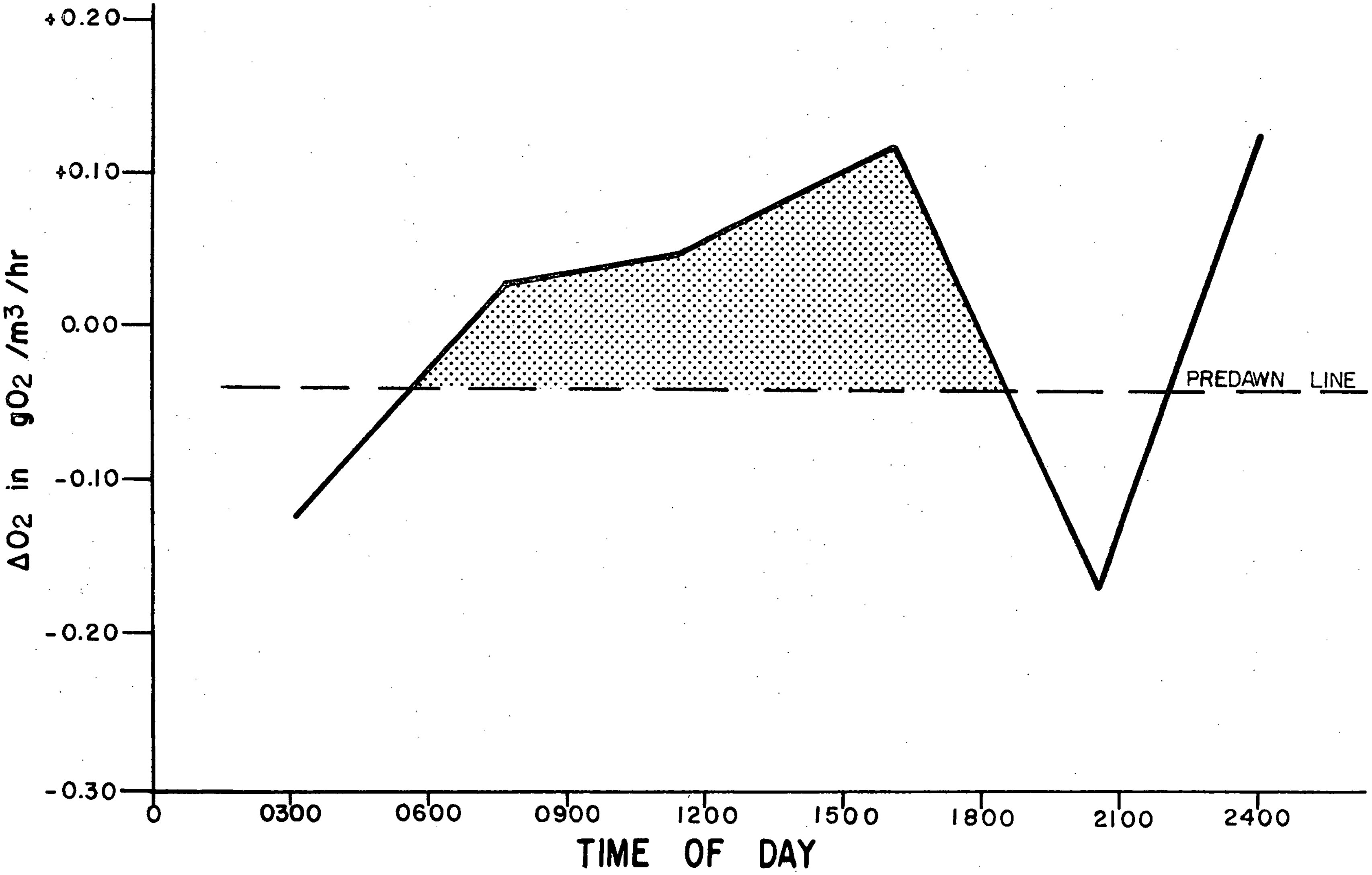

FIGURE 3.7.6 DIURNAL RATE OF CHANGE OXYGEN CURVE IN FREES CREEK, 15 NOVEMBER 1972.

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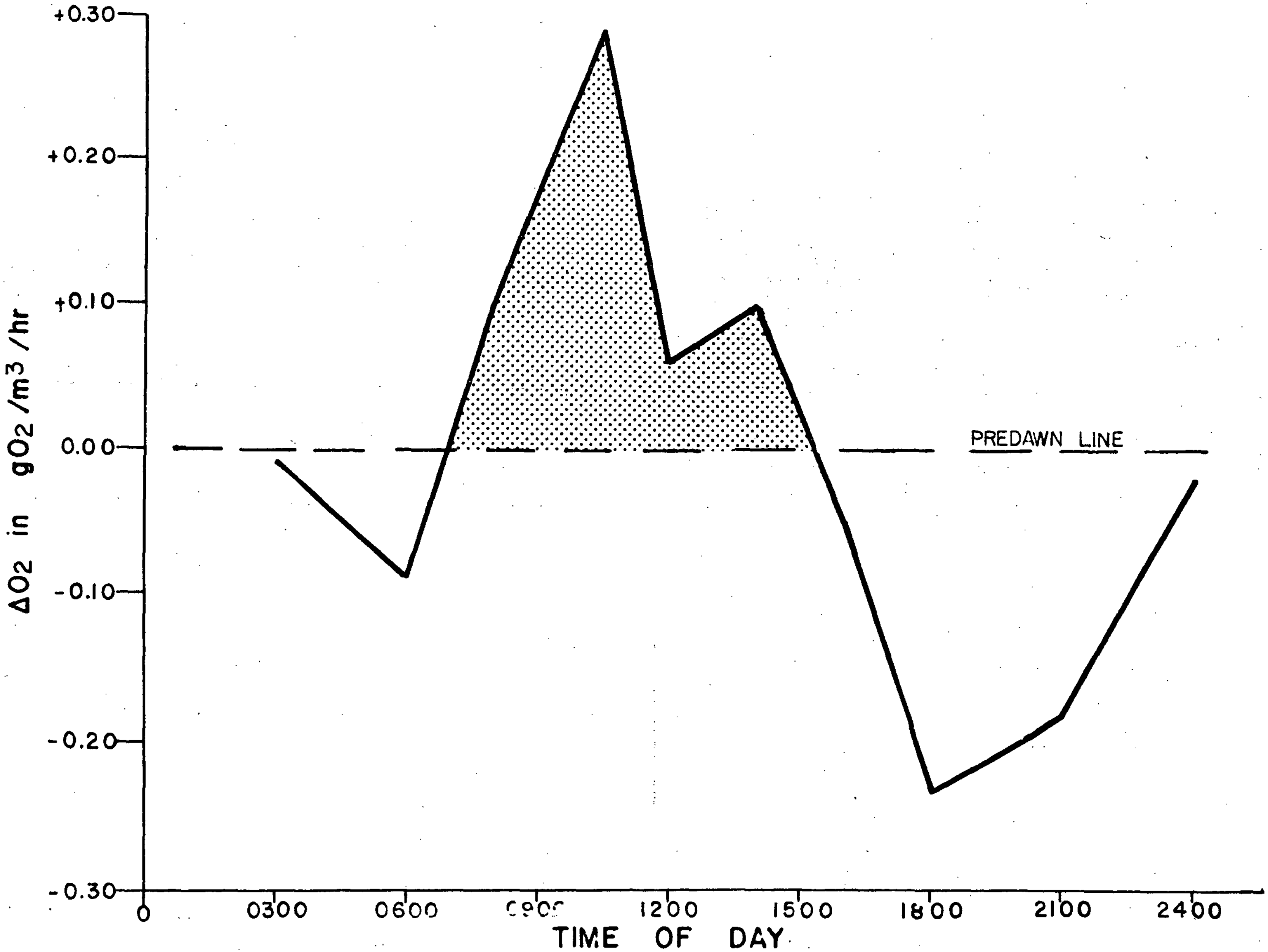

FIGURE 7 DIURN RATE (CHANGE OXYGEN C E AT TRANSECT D IN OAD RI ,24 FE ARY 1973

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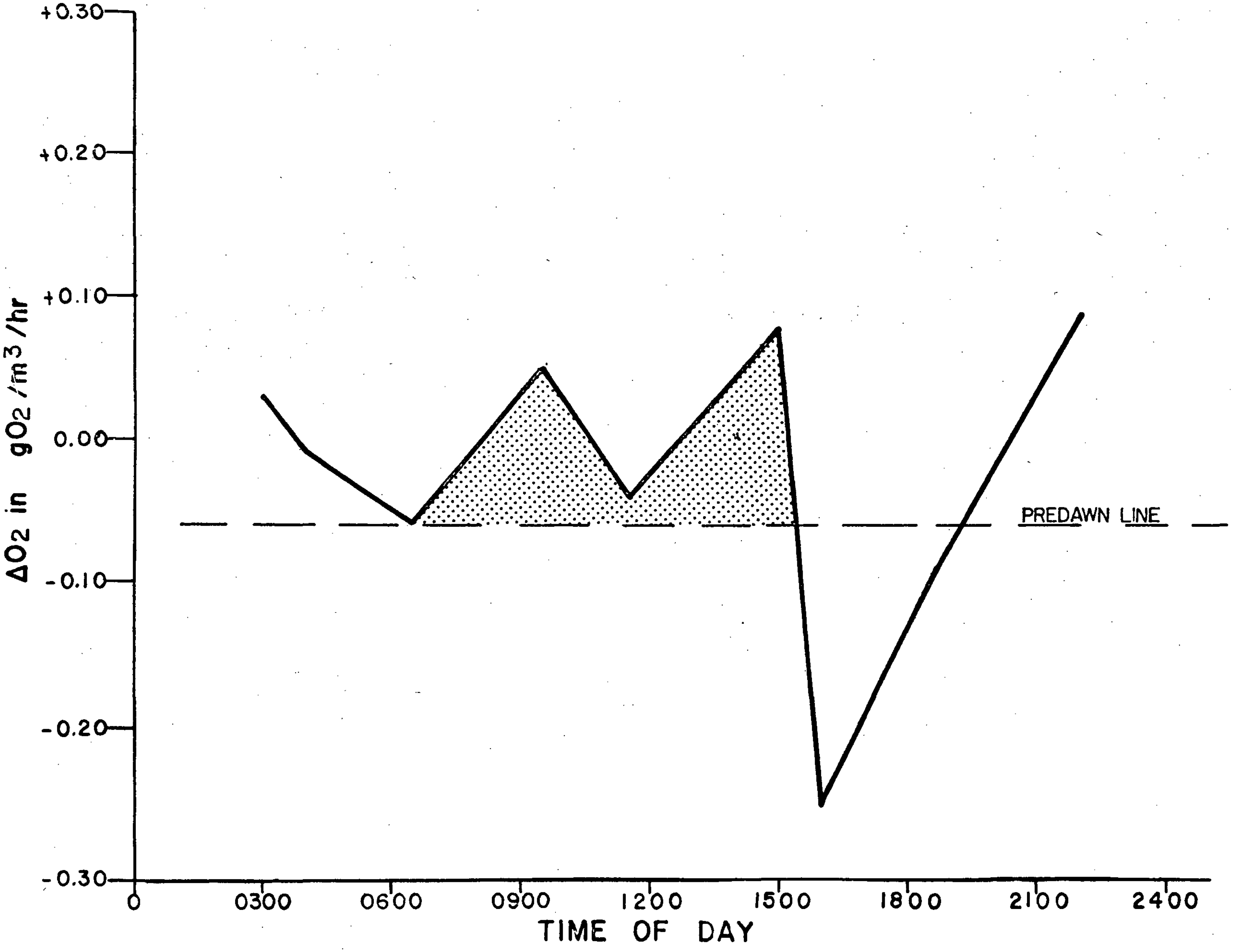

FIGURE 3.7.8 DIURNAL RATE OF CHANGE OXYGEN CURVE AT TRANSECT D IN BROAD RIVER 16 MAY 1973

May 1973. It must be emphasized that the single station curve assumes that the water passing a given point has had the same diurnal history in respect to oxygen changes as that preceding it. It is highly probable that this assumption is not valid at Transect D in the Broad River because of its variable levels of discharge and stream velocity.

The diurnal curve at Frees Creek on 15 November 1972 shows a more typical pattern and it is reasonable that the diurnal oxygen method is applicable to this station. Estimates at this site exceeded values from Transect D, although gross production was low for both sites. Highly productive systems may approach 60 g O_2/m^2/day (Odum 1956). Productivity rates in g O_2/m^2/day are shown in Table 3.7.4 and all were less than 5 g O_2/m^2/day. The metabolic rates reported in this study are similar to values reported in North Carolina (Hoskin 1959).

3.7.4 SUMMARY

Single station diurnal curve gross production estimates were determined for Transect D on the Broad River and Frees Creek. Both systems exhibited low primary productivity results.

The activities of the hydroelectric plant will probably influence estimates of production rates at Transect D because of variable discharge rates. Alkalinities of 15 to 20 mg/liter were too low to obtain significant carbon dioxide changes throughout a diurnal period for reliable productivity estimates.

Table 3.7.4 Gross production at Transect D and Frees Creek in the Broad River Study Area, 15 November 1972 - 6 May 1973.

Date	Gross Production ($g\ O_2/m^2/day$)
TRANSECT D	
15 November 1972	3.94
24 February 1973	3.92
16 May 1973	2.56
FREES CREEK	
15 November 1973	4.57

3.7.5 REFERENCES

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4.0 AQUATIC ECOLOGY OF THE BROAD RIVER STUDY AREA

The Broad River in the Study Area is characterized by having a high silt load, moderately high dissolved oxygen levels, low dissolved solids, and low buffering capacity. Parr Reservoir, being narrow and shallow, has a relatively high flow rate and a low storage ratio resulting in the main portion of the reservoir having more lotic characteristics than lentic. In the Cannons and Frees Creek arms, more lentic conditions prevail. The abundance of aquatic organisms appears to vary between reservoir areas. Phytoplankton production appeared to be greatest in the more lentic areas while benthic macroinvertebrate biomass was greatest in the lotic areas near the dam.

In the Broad River Study Area, as with many similar river systems, euplanktonic diatom species are numerically the dominant phytoplankton. Densities of net phytoplankton were always low and population levels were observed to fluctuate greatly throughout the study period.

Nannoplanktonic[1] algae are often important in turbid riverine reservoirs and can comprise the greatest portion of the total volume of planktonic algae (Bensen and Cowell 1967). The contribution of these small plankters to the primary productivity of the Broad River System is undoubtedly significant, as the total number of species was approximately 50 percent greater than the number of net phytoplankton species.

Nutrients are probably not limiting to primary productivity, even though phosphorus was measured in trace amounts. Turbidity, suggested as being the major limiting factor in primary productivity for most river systems

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[1] Very minute plankton not retained in a No. 25 silk bolting cloth plankton net (mesh, 0.03 to 0.04 mm).

(Williams 1965; 1966), is the primary factor limiting autotrophic production in the Broad River. As a consequence, phytoplankton contributes only small amounts to the productivity of the Broad River. Most rivers are in fact, net consumers of organic matter, most of which is provided from allochthonous materials washed in from the surrounding watershed (Hynes 1969). It is this allochthonous organic material that is believed to provide a large portion of the energy requirements for the Broad River biota. The presence of large amounts of partially degraded organic plant materials is believed to account for the frequently observed increases in the chemical oxygen demand (COD) of the water while biological oxygen demand (BOD) remains moderately low. Some nutrients may also be introduced into the system via upstream pollution. This is suggested by periodically high levels of BOD and the presence of some industrial contaminants in the bottom sediments.

The composition of net zooplankton of the study area is similar to many major river systems, in that it is numerically dominated by rotifers in characteristically low numbers for turbid rivers. Four of the six most frequently collected rotifer species are considered omnivores and ingest organic particles of appropriate size (Pennak 1953). Detritus is an important food source for these forms. In a similar southern Piedmont stream, primary consumer organisms were found to derive as much as 66 percent of their energy from allochthonous organic matter, consisting largely of leaf material (Nelson and Scott 1962). Other common genera in the study area, Asplanchna and Trichocera are considered predators on small metazoa. Copepods and cladocerns were present in small numbers.

The community of benthic macroinvertebrates is characterized by having relatively low diversity but high biomass in some portions of the reservoir and, in general, indicates moderate organic enrichment. The

Asiatic clam, Corbicula malinensis, has only recently invaded the study area and is now found in high densities in the reservoir. These pelecypods appear to serve as an important food source to the redear sunfish and possibly other sunfish. The burrowing mayfly, Hexagenia limbata, occurs throughout the system and contributes significantly to the benthic invertebrate biomass. These mayflies are known to be detritophages in their aquatic stages. Other ephemeropterans as well as dipterans and tubificids are common in the study area and serve as important food sources to several fishes.

Submergent vascular hydrophytes were found mainly in protected areas near the dam. The predominant emergents were found throughout the reservoir although their abundance was usually low. The paucity of submergent forms in the protected arms of the reservoir is undoubtedly due to the high turbidity and fluctuating water levels.

At first observation, the lack of submergent hydrophytes in the protected areas would appear to limit habitat diversity. However, qualitative littoral zone sampling indicated that the diversity of littoral zone invertebrate life was over four times greater than that of the profundal benthic invertebrates. A greater diversity of habitats formed by aquatic vegetation, fallen and submerged trees, and quiet back waters accounts for the great difference in species composition between littoral and profundal areas.

The fishes of the study area are represented by an diverse assemblage of at least 41 species, dominated numerically by the bluegill sunfish, an important sport and forage species. In fact, four of the five most numerically abundant fishes are considered sport fishes. Gizzard shad, a non-sport species, is an important primary consumer and forage species which ranks second in numerical abundance. In terms of biomass, standing crop data suggest that bluegill sunfish, gizzard shad, redear sunfish, and largemouth bass predominate. The composition of fishes in the study area contrasts with other turbid reservoir systems where carp, river carpsucker, and white crappie predominate (Walburg 1964; Gasaway 1970).

The low numbers of carp and carpsucker in the study area may be due in part to high levels of inter-specific competition, especially with the bluegill sunfish, which are notorious predators upon the eggs and fry of other species. The predominance of nest building centrarchids is especially important when considering any future modification of the reservoir environment.

The occurrence of gizzard shad as the second most abundant species attests to its importance in the trophic structure of the aquatic community. Gizzard shad are known to be the most important fish forage organism in warm water reservoirs (Miller 1960). As a forage base, gizzard shad in the study area are utilized mainly by largemouth bass, white and black crappies, catfish, and gar. Gizzard shad are important additionally, as they are believed to directly utilize allochthonous organic detrital material as well as plankton as a food source.

In summary, the Broad River system in the study area supports a moderately diverse assemblage of aquatic organisms whose primary consumers derive their major energy from allochthonous organic material.

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5.0 TERRESTRIAL SURVEY

5.1 DESCRIPTION OF SAMPLING STATIONS

The objectives of the terrestrial survey in the project area were: (1) to inventory birds, mammals, insects, and vegetation of the environs; (2) to provide indices of abundance of these species; and (3) to determine the role of the animals in the ecosystem of the Broad River Study Area.

5.1.1 STUDY SITES

Study Site 1 is approximately 2.4 km (1.5 miles) south of the town of Monticello (map, back cover). This study site was subdivided into three subunits: 1A represents second growth loblolly pine which best typify vegetation of the Broad River Study Area. Site 1B is predominately deciduous with some loblolly pine. Study Sites 1A and 1B will be flooded by the proposed Monticello Impoundment. Site 1C is predominately loblolly pine with deciduous trees occurring on areas of low elevation and will not be flooded by the impoundment. Mammal studies were conducted on Sites 1A and 1B, avian studies are being conducted on Sites 1B and 1C, and vegetation analyses were conducted on Study Sites 1A and 1B.

Specific location instructions are as follows: beginning at Keller's Grocery on Route 125 between Monticello and Jenkinsville, go north 0.5 km (0.3 miles) and turn left (west) on the first road. Study Site 1C is represented by a strip between 40 m (131 ft) and 180 m (591 ft) along this road. Study Site 1A is a total of 1.1 km (0.7 miles) and is located on the left side of the road. Study Site 1B is 1.1 km (0.7 miles) west and 120 m (394 ft) south to the center of the trap grid. The trapline on Site 1A is oriented north-south at right angles to the road with trapping stations marked by wooden stakes numbered 1 through 20.

The census of birds was conducted on Site 1C along a compass heading of 200°. The census at Site 1B occurred along a compass heading of 140° to the second creek; a westward direction was taken along the creek for approximately 0.96 km (0.60 mile).

Study Site 2 is approximately 3.2 km (2 miles) west and 0.8 km (0.5 mile) south of Monticello. This area has been clear-cut and replanted to loblolly pine and represents an early seral stage of succession. This area will not be flooded by the proposed impoundment. Vegetation, mammals, and birds were all studied at this site. Specific location instructions are as follows: from the junction of Route 257 and Route 99, go south 3.5 km (2.2 miles) on Route 257, turn left (south) on a dirt road toward the proposed dam site, go 0.3 km (0.2 mile) from Route 257 staying left at the fork. A stake marked 2S on the right side of the road marks the location of the small mammal trapline which begins approximately 6.1 m (20 ft) to the right of the road and follows a compass heading of 120°. Avian censuses began on the left (north) side of the road 100 m (328 ft) east of Route 257. The census occurred along a compass heading of 110° for 550 m (1805 ft) and returned paralleling the south side of the road for 490 m (1608 ft).

Study Site 3 is on the east side of the present Parr Reservoir near the Frees Creek embayment. Study Site 3 was subdivided into two subunits: 3A represented a mixed deciduous-pine forest in an area that will be flooded by the proposed impoundment. Deciduous trees, though not present in pure stands, are most abundant in low areas near the water course; 3B represented a mixed deciduous-pine forest on the north side of Frees Creek that will not be flooded, however, it may be affected by construction activities. Vegetation and small mammal studies were conducted at Study Site 3A. On Site 3B avian censuses have been conducted since May 1973. The small mammal trapline at Study Site 3A began approximately 40 m (131 ft) from the railroad trestle that crosses

Frees Creek and ran parallel to the creek. The avian survey route of Site 3A is located on the northeast side of the Frees Creek embayment, beginning approximately 200 m (656 ft) north of the embayment and paralleling the transmission line corridor.

Study Site 4 is located 2.7 km (1.7 miles) north of the existing power plant at Parr, on the east side of the road leading to the proposed nuclear station site. This site represents a stand of pine that will not be flooded by the proposed project. The vegetation has been relatively undisturbed by man and represents a later succession stage than Study Site 1. Pines were selectively cut for pulpwood on this site during March 1972. The resulting open canopy has allowed an increase in shrubs and herbaceous vegetation.

Specific location instructions are as follows: beginning at Monticello, travel approximately 6.4 km (4 miles) south on Route 215 to Route 311, a paved road running east-west. Turn west (right) for 2.5 km (1.6 miles) and turn right on an unimproved road and go 1.6 km (1.0 mile) to a stake on the left marked 4S. The trapline runs at right angles to the road.

Study Site 5 is located approximately 7.6 km (4.8 miles) south of Monticello on the south side of the road leading to the proposed Virgil C. Summer Nuclear Station. The site is a loblolly pine plantation of relatively even aged trees. This site was chosen because it represented an intermediate age stand of pine, a middle and lower story vegetation was absent, it was close to the construction zone, and the site will not be flooded. Bird censuses on this study site were intiated during March 1973.

Study Site 6 is located 2.5 km (1.6 miles) northwest of Monticello on Route 99. Bird censuses have been conducted in the grassland on the south side of the road since March 1973. The vegetation is typical of abandoned pasture land consisting of dense growth of annual and perennial vegetation. The site will be flooded by the proposed Monticello Impoundment.

Study Site 7 is located 5.4 km (3.4 miles) north of Monticello, 0.4 km (0.3 mile) west of Route 215 on Route 347. Bird censuses, parallel to Route 347, have been conducted on this site of predominately loblolly pine since March 1973. A small area of mixed deciduous-conifer forest was included as part of the study site. This site will not be flooded by the proposed Monticello Impoundment. Pine was selectively removed from this site between the May and August 1973 avian survey periods.

Study site adjacent to Aquatic Station G is located on upper Frees Creek north of the Route 99 bridge. The upper limits of the site was 160 m (512 ft) north of the bridge. The vegetation is predominately deciduous trees and a lower story of dense shrubs and herbaceous vegetation. A live-trap grid for medium sized mammals was located at this site during the November 1972 sampling period. This site would be flooded by the proposed Monticello Impoundment.

5.1.2 WILDLIFE SURVEY ROUTES

Three wildlife auto survey routes were established to obtain an index of bird species and abundance (see map, back cover). Identification was made by sightings and recognizing characteristic bird songs.

Wildlife Survey Route A, during the 1971, 1972, and 1973 sampling periods, began at the junction of Highways 215 and 347 and followed Highway 347 to Highway 99, proceeded east on Highway 99 and then followed Highway 215 south to the conclusion of the route. Wildlife Survey Route A was chosen because it could be followed without back-tracking (no dead-end roads) and it sampled the periphery as well as crossed the proposed Monticello Impoundment.

Survey Route B proceeded in a southerly direction for 3.2 km (2 miles) along Highway 257 from a point 0.3 km (0.2 mile) from the junction of

Highway 99 and 257. This survey route, initiated in January 1972, was established to provide a continuous survey during the construction of the Monticello Impoundment.

In March 1973, Route C was initiated which covered a distance of 4.8 km (3 miles). It then began 161 m (0.1 mile) north of the junction of Highways 215 and 99 and proceeded along Highway 215 to Highway 347. It is anticipated that travel along Highway 99 will be restricted in the area of Frees Creek during construction. When this occurs the Wildlife Survey Route will begin at Route C, continue along Route A following Highway 347 to Highway 257, and finish along Route B.

Survey Route D (control) began on Highway 99, 0.3 km (0.2 mile) north of its junction with Highway 347, proceeded north on Highway 99, west on Highway 34, and finally southeast on Highway 28. Highway 28 was followed to Cannons Creek where the survey was concluded. This survey route, initiated in March 1973, will provide a comparative index of the avian abundance and diversity in an area anticipated to be unaffected by the impoundment or construction activities which may influence portions of Wildlife Survey Routes A and B.

5.1.3 WATERFOWL SURVEY

Waterfowl and shorebird counts were made from a boat on the Broad River and its tributaries. This survey was initiated in March 1972 to: (1) obtain an index of seasonal abundance of waterfowl in the area to be affected by Parr Reservoir; (2) obtain an index of waterfowl in each major tributary; and (3) evaluate the effect of construction and operation of the facilities on this resource.

The survey route starts at the public boat launch in Blair, South Carolina, extends 3.5 km (2.2 miles) north to the southern end of Henderson's Island. The route proceeds southward to the mouth of the Enoree River and continues up river for approximately 5 km (3 miles). The survey then returns to the Broad River and continues south in the direction of Parr. Frees Creek, Hellers Creek, and Cannons Creek were examined by boat as far up each tributary as possible. Ponds, floodings, and river inlets along either side of the Broad River and its tributaries were checked for water birds. The route concluded after a survey of Parr Reservoir.

5.2 SOILS

5.2.1 INTRODUCTION

Previous surveys in the Broad River area of Fairfield County, South Carolina, for the South Carolina Electric and Gas Company, included detailed information relative to vegetation and fauna but included only a general description of soils on the site. The 1972 fall survey was expanded to obtain a more detailed examination of the soils, including an analysis to establish soil nutrient content, the presence of heavy metals and the presence of residual chlorinated pesticides. This survey was to develop information for a threefold purpose: (1) to establish base information on soils that will be flooded upon completion of Monticello Impoundment, (2) to examine the relationship of soils to plant communities, and (3) to determine recommendations to produce a wildlife habitat and establish upland recreational areas.

A majority of the wooded areas is a mixture of pine and hardwoods. Piedmont soils are naturally acidic with a pH of 5.0 to 5.5 which favors growth of pine as hardwoods grow best on soils with a pH of 6.5. However, cropping management of these areas has established a pine-hardwood mixture over the entire project area. Where areas have been denuded of trees, native grasses, forbs and legumes have become established indicating these soils will support a wide diversity of vegetation.

5.2.2 METHODS AND MATERIALS

Only generalized soil information was available for the site under study (Craddock and Ellerbe 1966) and this was used to determine soil associations for each sampling area. Detailed profile descriptions to determine soil class were taken from those reported for adjacent Newberry

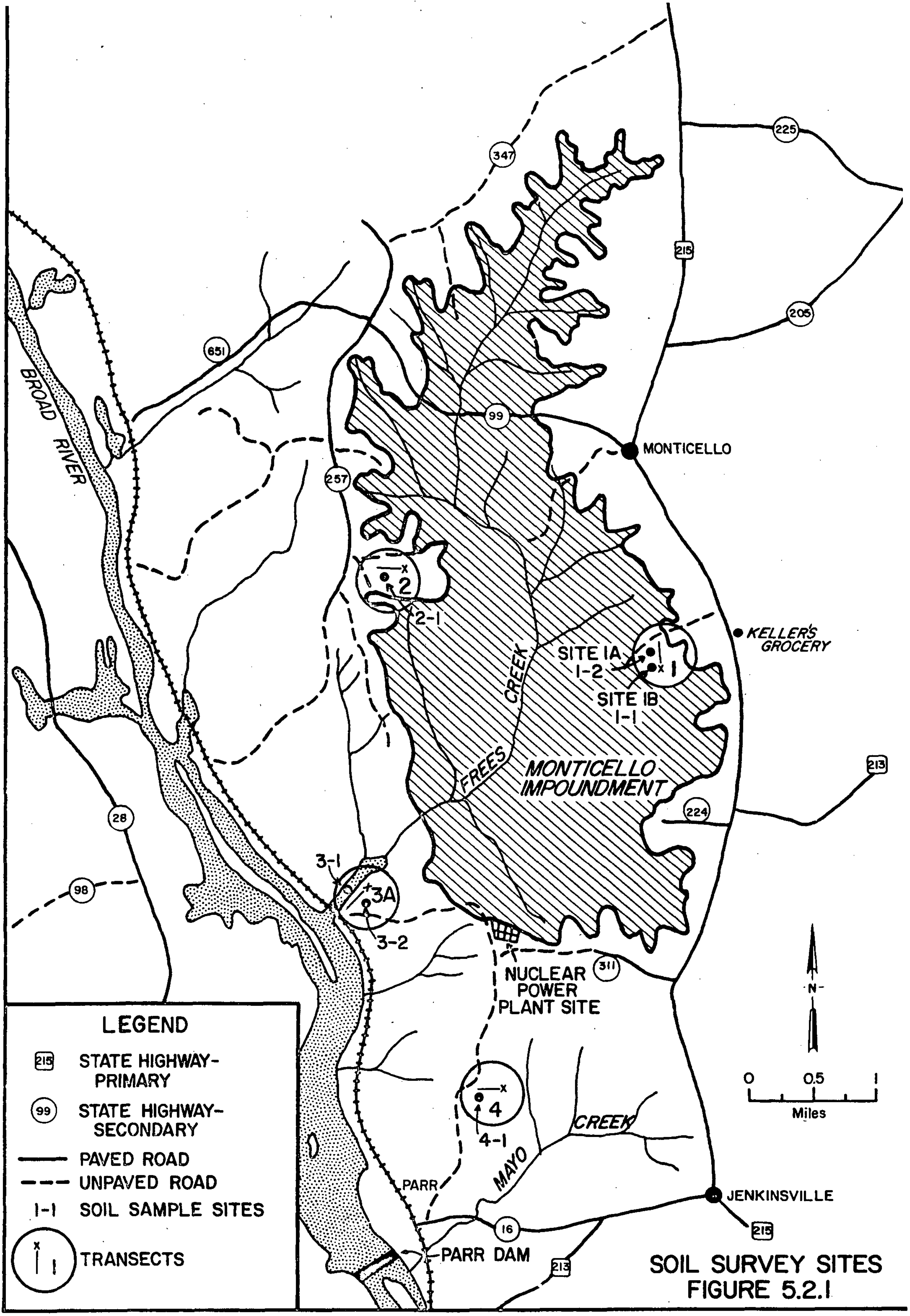
County (Camp et al. 1960).

Soil samples were collected from an area within previously established survey sites representing the dominant combination of vegetation and soil type for that site (Figure 5.2.1). In Study Site 1 there were two rather distinct types of woody vegetation and, therefore, two sub-areas were established; pine were the major trees in Site 1A while Site 1B had a dominance of hardwoods with a few pine. Site 2 was steep and had been cleared of trees but the area had been replanted to pine and growth of the young trees was quite good. Subsequent to removal of trees from Site 2, natural revegetation consisted of grasses, forbs and vines. Site 3A was primarily hardwoods with some pine. Soil sample 3-1 was located near the mouth of Frees Creek and will be flooded in the future. Sample 3-2 was taken from an area that is to remain as upland after completion of Monticello Impoundment. Site 4 was mixed pine-hardwoods and timber removal was in progress so that the final proportion of pine to hardwoods cannot be estimated at this time, however, it appeared pine was being removed in preference to hardwoods.

To observe and sample an undisturbed soil profile, a fresh pit was dug at each site. A field description of the vertical section, or soil profile, included variation in soil color, structure and texture with a notation of the depth where changes occurred. This field description was used to determine a soil class (Camp et al. 1960). Also, variations in the soil profile were determined where individual soil profile samples would be taken.

Litter cover, especially in the wooded areas, was removed to expose a firm soil surface before digging a pit and only the decomposed litter that had become incorporated into the firm uppermost portion of soil was considered part of the profile.

Samples were obtained by cutting a vertical section from the



SOIL SURVEY SITES
FIGURE 5.2.1

profile within limits of an observed soil variation. Two samples were collected from each profile. One sample was collected in plastic bags and transported to a field house where it was mixed and an aliquot was air dried, put into a soil sample box and taken to the Fairfield County Extension Agent at Winnsboro who forwarded them to Clemson University Soil Testing Laboratory at Clemson, South Carolina. Soil test results were returned to the Fairfield County Agent who made fertilizer recommendations for three conditions that may occur within the land site of South Carolina Electric & Gas Company:

1. For stands of pine and mixed hardwoods.
2. To establish and maintain native weed, grass and legume (lespedeza) species for improved wildlife habitat in areas that have been cleared or have had selective thinning of trees.
3. To establish and maintain common bermuda grass in recreational areas.

A second soil sample was placed in a glass jar that had previously been washed with petroleum ether, rinsed with acetone and air dried. The jar opening was covered with aluminum foil before closing with a screw lid. This sample was air dried and sent to the Environmental Science and Engineering Corporation at Mt. Juliet, Tennessee for analysis of heavy metals and residual chlorinated hydrocarbon pesticides. A hot 6 N hydrochloric acid extraction was used to remove heavy metals from the soil.

5.2.3 FINDINGS

5.2.3.1 Soil Nutrient Status

The general fertility level of all soils throughout the project site was about the same although two had some variation in pH; one was 4.8 and another was 6.1 (Table 5.2.1). All soils were low in

Table 5.2.1 Soil sample identification and soil test results.

Sample Number	Survey Site	Soil Sample	Profile Depth (cm)	Future Disposition	Soil Test Results*				
					pH	P	K	Ca	Mg
1	1A	1-2	0-12	Flooded	5.4	L+	M-	L+	M+
2	1A	1-2	12-35	Flooded	5.6	L+	L+	M	H
3	1B	1-1	0-3	Flooded	6.1	L+	H+	VH	H
4	1B	1-1	3-45	Flooded	5.6	L+	M	M	H
5	2	2-1	0-8	Upland	5.4	L+	H-	H-	H
6	2	2-1	8-40	Upland	5.6	L+	M	M	H
7	3A	3-2	0-30	Upland	5.1	L	M	L	H
8	3A	3-2	30-50	Upland	5.2	L+	H-	L-	H
9	3A	3-1	0-7	Flooded	5.5	L	H	VH	H
10	3A	3-1	7-21	Flooded	5.2	L-	M-	M+	H
11	3A	3-1	21-42	Flooded	5.3	L-	L+	M-	H
12	4	4-1	0-20	Upland	4.8	L	L+	L-	M-
13	4	4-1	20-42	Upland	5.1	L	L-	L-	M

*L-low, M-medium, H-high and VH-very high. (See Appendix A for relative level of plant nutrients).

phosphorus but had a relatively high level of magnesium (Table 5.2.2). Their calcium content varied from low to very high and there was some variation in potassium levels. The amount of lime recommended (Table 5.2.3) is the amount necessary to bring the soil pH to 6.5. None of the soil nutrients were a limiting factor for plant survival although an application of fertilizer will produce increased plant growth. An estimated productivity of soils under average and good management with the adaptability of bermuda grass and bicolor lespedeza to soil types is presented in Table 5.2.4. It is obvious that good management practices can increase production, and in most cases by about 100 percent. Except for bicolor lespedeza on Appling soil, the adaptability of both bermuda grass and bicolor lespedeza to various soil types is good.

5.2.3.2 Residual Pesticides in the Soil

The concentration of BHC, DDE and Aldrin was very low and generally below the minimum detection limits of 0.005 ppm (Table 5.2.5). Dieldrin, DDD, Hexachloro Benzene, Lindane, Heptachlor, Heptachlor Epoxide, Toxaphene, Technical Chlordane and Mirex were below detectable limits, if present at all.

Concentration of DDT in the topsoil of Study Site 1B, soil sample 1-1, Site 2, soil sample 2-1 and Site 3A, soil sample 3-1 was 0.016, 0.017 and 0.010 ppm respectively (Table 5.2.5).

5.2.3.3 Heavy Metal Concentration in the Soil

Boron had the highest concentration of all the heavy metals determined (Table 5.2.6). The concentration of copper, zinc, lead and chromium was approximately equal and in low concentration. Both arsenic and mercury have a very low concentration in the soil. The lithium concentration had considerable variability (Table 5.2.6). Of the six soil sample sites, four had the greatest lithium concentration in the topsoil. The topsoil of

Table 5.2.2 Relative level of plant nutrients from soil test results.

Nutrient Level	Nutrient Concentration Phosphorus (ppm)	Potassium (ppm)	Calcium (ppm)	Magnesium (ppm)
Low	0-13	0-35	0-200	<25
Medium	14-30	36-78	201-400	26-50
High	31-50	79-117	401-1000	>50
Very High	>50	>117	>1000	

Table 5.2.3 Fertilizer recommendations for pine and hardwoods, wildlife habitats and bermuda grass for recreational areas.

Soil Sample Number	Fertilizer Recommendations-Pounds per acre*							
	Pine and Hardwoods				Wildlife and Recreational Areas			
	Lime	N	P	K	Lime	N	P	K
1	2500	0	0	0	2500	60-180	100-200	20-40
2	2400	0	0	0	2400	60-180	100-200	80-110
3	1900	0	0	0	1900	60-180	100-200	0-20
4	3300	0	0	0	3300	60-180	100-200	20-40
5	4200	0	0	0	4200	60-180	100-200	0-20
6	3100	0	0	0	3100	60-180	100-200	20-40
7	4000	0	0	0	4000	60-180	100-200	20-40
8	3600	0	0	0	3600	60-180	100-200	0-20
9	4000	0	0	0	4000	60-180	100-200	0-20
10	3200	0	0	0	3200	60-180	100-200	20-40
11	3100	0	0	0	3100	60-180	100-200	80-110
12	5300	0	0	0	5300	60-180	100-200	80-110
13	4700	0	0	0	4700	60-180	100-200	80-110

*Expressed as elemental P and K, (P x 2.27 = P_2O_5; K x 1.20 = K_2O).

Table 5.2.4 Estimated productivity of soils under two levels of management and the adaptability of bermuda grass and bicolor lespedeza to soil types.

			Annual Lespedeza*			Pasture*			Adaptability	
			Tons per acre		%	Cow-Acre-Days**		%		
Survey Site	Soil Sample	Soil Type	A	B	Increase	A	B	Increase	Bermuda Grass	Bicolor Lespedeza
1A	1-2	Cecil sandy loam gently sloping phase	0.5	1.2	140	125	250	100	Very Good	Very Good
1B	1-1	Appling sandy loan, eroded strongly sloping phase	-	-	-	60	125	108	Good	Fair
2	2-1	Cecil clay loan, severely eroded sloping phase	0.3	0.6	100	75	125	66	Good	Good
3A	3-2	Cecil sandy loam, eroded moderately steep phase	-	-	-	80	140	75	Very Good	Very Good
3A	3-1	Mecklenburg sandy loan, eroded sloping phase	0.5	1.0	100	100	200	100	Good	Good
4	4-1	Cecil sandy loam, eroded sloping phase	0.4	1.0	150	110	225	105	Very Good	Very Good

*A-Average Management; B-Good Management

**Cow-Acre-Days = Number of days one acre will support one cow, steer or horse; or five hogs; or seven sheep or goats without injury to the pasture (Camp et al. 1960).

Table 5.2.5 Concentration of residual pesticides in soil samples from South Carolina Electric & Gas Company project area at Parr, South Carolina.

Survey Site	Soil Sample	Profile Depth (cm)	BHC (ppm)	DDE (ppm)	DDT (ppm)	Estimated PCB (ppm)	Aldrin (ppm)
1A	1-2	0-12	0.075	<0.005	<0.005	0.019	<0.005
1A	1-2	12-35	<0.005	<0.005	<0.005	0.008	0.006
1B	1-1	0-3	<0.005	0.006	0.016	0.018	<0.005
1B	1-1	3-45	<0.005	<0.005	<0.005	0.010	<0.005
2	2-1	0-8	<0.005	0.005	0.017	0.019	<0.005
2	2-1	8-40	<0.005	<0.005	<0.005	0.015	<0.005
3A	3-2	0-30	<0.005	<0.005	<0.005	0.008	0.006
3A	3-2	30-50	<0.005	<0.005	<0.005	0.024	<0.005
3A	3-1	0-7	<0.005	0.007	0.010	0.015	<0.005
3A	3-1	7-21	<0.005	<0.005	<0.005	0.011	<0.005
3A	3-1	21-42	<0.005	<0.005	<0.005	0.011	0.005
4	4-1	0-20	<0.005	<0.005	0.006	0.027	<0.005
4	4-1	0-42	<0.005	<0.005	<0.005	0.022	<0.005

Table 5.2.6 Concentration of heavy metals in soil samples from South Carolina Electric & Gas Company project area at Parr, South Carolina.

Survey Site	Soil Sample	Profile Depth (cm)	Arsenic (ppm)	Copper (ppm)	Zinc (ppm)	Lead (ppm)	Mercury (ppm)	Boron (ppm)	Chromium (ppm)	Lithium (ppm)
1A	1-2	0-12	<0.020	13.70	13.00	7.61	0.008	156	26.1	0.90
1A	1-2	12-35	<0.020	10.70	10.20	7.42	0.038	174	14.4	0.86
1B	1-1	0-3	0.028	5.76	34.00	20.80	0.017	160	25.0	1.26
1B	1-1	3-45	<0.020	7.38	27.10	16.20	0.004	268	15.3	1.54
2	2-1	0-8	0.060	8.16	10.40	20.80	0.004	196	18.6	1.06
2	2-1	8-40	<0.020	8.28	9.21	19.00	0.038	142	16.5	1.00
3A	3-2	0.30	0.040	13.70	14.10	9.21	0.031	102	46.8	0.82
3A	3-2	30-50	0.010	20.60	10.00	6.64	0.013	118	27.8	0.88
3A	3-1	0-7	0.029	20.00	24.20	14.60	0.033	184	31.8	2.12
3A	3-1	7-21	<0.020	18.40	22.10	10.20	0.013	180	43.2	1.48
3A	3-1	21-42	<0.020	16.50	10.30	7.23	0.008	122	54.5	0.86
4	4-1	0-20	<0.020	4.98	7.02	11.80	0.054	200	27.6	1.02
4	4-1	20-42	<0.020	5.22	4.03	12.40	0.125	130	21.9	0.56

sample 3-1 from Site 3A had the highest lithium concentration of all soils and there was a decrease in concentration with an increase in soil profile depth.

5.2.4 DISCUSSION

Soils in Fairfield County have severe erosion characteristics and most, if not all, topsoil has been washed away exposing the subsoil. Soil profile observations during the 1972 fall survey revealed that where forests have been established and undisturbed for several years, decaying litter has become incorporated into the uppermost soil layer. There are varying degrees of staining which extends into lower levels of the soil as streaks or there may be a general fading of the dark color. Where weathering has occurred for several years with little surface erosion, clay has moved down from the soil surface resulting in a sandy soil overlaying a much more dense lower layer that is very friable. However, there appears to have been sufficient outside influence from logging and general removal of trees that neither the soil nor plant communities have become stabilized under natural conditions.

5.2.4.1 Areas to be Flooded

Seven of the thirteen soil samples were collected from areas to be flooded upon completion of Monticello Impoundment (Table 5.2.1). These seven samples relate the nutrient status of the soils prior to submergence and also help to provide a broad overview of the soil types within the project area.

Upon submergence, the soil fertility is expected to increase through deposition of organic matter, however, because of the general steep slope and consistent fluctuation of the water level, no change in the nutrient status is expected in those soils subject to alternate flooding.

Parts of Monticello Impoundment will be sufficiently large to have waves during periods of strong wind. This may cause some erosion where wave action is against steep slopes.

5.2.4.2 Upland Areas

Soils in areas that will not be flooded have virtually the same nutrient status as those that will be submerged. This emphasizes the uniform soil conditions that exist over the entire project area.

Soils on the project area are subject to severe erosion and maintenance of a good plant cover is definitely recommended to minimize soil movement. Unless stabilized, excessive soil erosion will fill the water impoundments and shorten their expected time of efficient use.

5.2.4.3 Soil Nutrient Status

The low pH and phosphorus in these soils do not represent favorable conditions for satisfactory growth of legumes. If wildlife habitats are to be developed, application of lime and phosphorus will aid in establishing grasses, pigweed (Amaranthus retroflexus) and lamb's quarter (Chenopodium album) for cover and food sources.

Generally, neither fertilizer nor lime is recommended for wooded areas (Boggs 1972). Hardwoods grow best in a soil with pH 6.0 to 6.5 while pines tend to do better at a pH of 5.5 to 5.9 (Boggs 1972). The uppermost layer of all soils, except in Site 1B, soil sample 1-1, has a soil pH near optimum for growth of pine (Table 5.2.1). To adjust the soil pH for best growth of hardwoods, 2400 to 5300 pounds of lime per acre would be needed (Table 5.2.3). Since the soil in Site 1 will eventually be flooded, no further consideration of soils in this site need be given at this time. However, for growth of hardwoods, any soil with a very high calcium content and a pH of 6.1 need not have 1900 pounds of additional lime applied per acre, although this was suggested by the County Agent (Table 5.2.3). All soils that were sampled have a capacity to respond to good management (Camp et al.

1960) when known deficiences are corrected within practical limits.

5.2.4.4 Native Wildlife

The Piedmont Region of South Carolina consists of habitat types that can support deer, quail, squirrel, fox, rabbit, raccoon and opossum. However, these animals are generally in low abundance in the Broad River area of the South Carolina Electric & Gas project area, especially in pine communities. Most of the pine-hardwood areas are also quite sterile of desirable habitat for cover and source of food. A greater number and diversity of birds was observed in an area previously cleared for a power transmission line where re-vegetation included brambles, honeysuckle, bicolor lespedeza, wild lespedeza and shrubs. This indicates that if the total area of diverse habitat can be increased through soil and plant management, both diversity of wildlife and number of animals would also increase.

5.2.4.5 Residual Pesticides in the Soil

Presence of a detectable level of DDT in the topsoil of samples from Sites 1B, 2 and 3A, soil sample 3-1 (Table 5.2.5), indicates a low level of contamination. The time or reason for applying DDT is not known, however, the concentration is very low and is not expected to be of concern unless additional DDT is applied in this area. The concentration of all other pesticides in the soil is very low and is not expected to present a problem of contamination for existing or proposed impoundments unless materials are applied in the future.

5.2.4.6 Heavy Metal Concentration in the Soil

The boron concentration was the highest of all heavy metals determined and varied from 102 to 268 ppm. The boron concentration in soil as reported by Mortvedt (1972) may range from about 2 to 100 ppm and generally has a range between 7 and 80 ppm, however, the concentration is reported to vary between 0.1 and 1500 ppm (Bear 1964). The boron concentration found in the South Carolina soils is well within the range of total soil boron reported in the literature, however, boron is not strongly retained by South Carolina soils (Page 1973). The high boron content found in these soils is due to tourmaline, a complex silicate containing boron.

The concentration of boron in plants is very uneven. In the same leaf, necrotic (dead) areas usually contain more than 1500 ppm boron, chlorotic (chlorophyll deficient) areas about 1000 ppm and green (normal) areas vary from 100 to 1000 ppm (Mortvedt 1972). There is considerable variation in plant tolerance to boron. Soy beans accumulate up to 200 ppm boron in the tissue with only slight toxicity symptoms. The yield of sugar beets and sugar content reductions were not noted even when beets were grown in concentrations up to 40 ppm boron and the tissue concentration did not rise above 30 ppm. Boron is not expected to be of concern to the growth of native plants. Toxicity symptoms were not evident at the time of the 1972 fall survey and boron toxicity to plants is most often associated with alkaline soils.

The arsenic content of soils varies from less than 1 to 20 ppm, but may be as high as 80 ppm (Bear 1964). Arsenic concentrations in the Piedmont soil samples (Table 5.2.6) varied from less than 0.02 to 0.06 ppm, hence, the arsenic concentration is very low.

Copper normally varies from less than 10 to 100 ppm (Bear 1964), but generally varies from 10 to 80 ppm in the soil (Mortvedt 1972). The copper concentration of the South Carolina soils varied from 4.98 to 20.60 ppm (Table 5.2.6) which is about normal concentration for mineral soil.

Zinc is reported to vary from 9 to 500 ppm (Bear 1964) and generally confirmed to vary between 10 and 300 ppm (Mortvedt 1972). The South Carolina soil varied from 4.03 to 34.00 ppm (Table 5.2.6) which is well within the normal soil concentration for zinc.

The lead content of the Piedmont soil (Table 5.2.6) was about average as a normal soil may contain from 2 to 200 ppm, but generally varies from about 20 to 80 ppm (Bear 1964).

Mercury may vary from 10 to 500 ppm with an average of about 100 ppm for U.S. soils (Mortvedt 1972). The soils from South Carolina varied from 4 to 125 ppm (Table 5.2.6).

Chromium varies from 6 to 1000 ppm in soil but in Scotland it reached 3000 ppm in some surface soils derived from Serpentine (Bear 1964). The chromium content of Parr, South Carolina soils varied from 14.4 to 54.5 ppm (Table 5.2.6). The chromium content of the South Carolina soils is relatively low and not expected to be a problem. During the past 15 years, chromium has been added as an element required by animals (Mortvedt 1972).

Lithium in the South Carolina soil (Table 5.2.6) varied from 0.56 to 2.12 ppm which is below the normal expected concentration of 6 to 200 ppm (Bear 1964).

5.2.4.7 Impounding of Water

No adverse effects are expected on soils from impounded water. There may be some change in tree species near the impoundments to species associated with a high water table or periodic flooding, i.e., cottonwood, willow, alder and beech. However, this would only be spotted around the impoundments and constitute only a small percentage of the total wooded area.

There is no indication that a rise in water table associated with the impoundments will cause formation of saline or alkaline conditions to the soil.

5.2.5 SUMMARY

A baseline level for residual pesticides and certain heavy metals has been established for soils that will remain as upland areas and also for some soils that will be flooded.

The nutrient status was virtually the same for all soils that were sampled and the pH was about 5.5 which favors growth of pine more than hardwood.

All the soils that were tested have a capacity to respond to good management when known deficiencies are corrected.

Most of the pine-hardwood areas are quite sterile of desirable wildlife habitat for food and cover. Proper soil and plant management will increase the diversity of vegetation and provide for a greater number and diversity of birds and other wildlife.

The concentration of residual pesticides in the soil is very low. There was an indication of some DDT contamination in surface soils at Sites 1B, 2 and 3A, soil sample 3-1, but the concentration is sufficiently low that it is not expected to be of concern unless additional DDT is applied in the area.

The boron concentration of the soil is somewhat higher than the general range of 7 to 80 ppm, but boron is not expected to be a problem as boron toxicity to plants is most obvious in alkaline soils and boron toxicity was not evident on plants during the fall survey.

The soil concentration of arsenic, copper, zinc, lead, mercury, chromium and lithium are at a normal level or below and will not present a problem.

No adverse soil salinity or alkalinity is expected from an increased water table due to impounding of water.

Erosion must be controlled or movement of soil will fill the impoundments and shorten their effective use.

There has been a constant disturbance from logging so that all soil and plant communities are in a state of flux and plant succession has not stabilized under natural conditions.

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5.3 VEGETATION

5.3.1 INTRODUCTION

The Broad River Study Area is located in the Piedmont Region and bordered on the south by the Coastal Plains (Johnson 1964). Vegetation of the area is typical pine-hardwood of the southern Piedmont of South Carolina. Prior to white settlement in 1752 (Camp et al. 1960), oak-hickory-pine forests prevailed (Küchler 1964). These forests were apparently free of brushy undergrowth.

Loblolly pine, slash pine, and long leaf pine dominated upland, well-drained sites characterized by sandy soil, low in nutrients and water retention properties.

Lowlands were at least 75 percent dominated by hardwoods. Species composition varied, depending upon drainage. On well-drained first bottom flood plain, yellow poplar, cottonwood, ash, oak, and sycamore were the dominant tree species. Trees growing on poorly drained flood plains included willow, birch, black gum and tupelo species, water oak, and red maple (Camp et al. 1960).

Continuous rotation type farming resulted in a change from the original mixed pine-hardwoods forests to pine. While oak-hickory forest would normally be climax for the area, routine removal of trees, eroded top soils, and recurrent fires have maintained stands of pine. Loblolly pine is currently cultivated in the area for pulp production. Most hardwoods which exist are scrubby and inferior in quality compared to the virgin forest.

A map (back cover) was prepared from 1970 U.S.G.S. aerial photographs showing the distribution of pine, deciduous, mixed pine-hardwoods, and grassland communities. The concurrent timber harvest prevented accurate portrayal of existing plant communities at the present time.

A comprehensive study was conducted of the Broad River Study Area in 1971 to inventory and quantitatively describe woody vegetation which currently exists in the areas based on stands considered representative of the Broad River plant communities. The study was expanded in 1972 to complement vegetative description of the overstory vegetation with a quantitative analysis of existing herbaceous and shrubby understory vegetation. Soil data were utilized in the description of vegetative communities.

5.3.2 METHODS AND MATERIALS

Plant collections were made from sites within the Broad River Study Area. The sites included an immediate vicinity around four small mammal trap lines and have corresponding site numbers. Particular care was taken to determine species composition nearest the trap line at each site.

Quantitative analysis of perennial woody vegetation on Study Sites 1A, 3A, and 4 was accomplished using the point-centered quarter method (Cottam and Curtis 1956). This technique provides quantitative information on relative, absolute, and total density, as well as relative frequency, relative dominance, and age class composition of the forest habitat (Phillips 1959). Study Site 2 was not included because it had been recently cleared of all commercial timber and woody underbrush (clear-cut).

On Study Sites 1A and 4, using the quarter method, the two point centers were 10 m (32.8 ft) to the right and 10 m (32.8 ft) to the left of each trapping station. Each point was considered the center of four quarters and the nearest tree (2.5 cm or greater in diameter) to this point in each of four quarters was sampled. Forty point centers for 160 trees were obtained in this manner. Each tree was measured for distance to the point and dbh (diameter at breast height) at 1.3 m (4.5 ft). The dbh provides an estimate of the tree's basal area.

Because Frees Creek was northwest of Study Site 3A, all point centers were located three meters to the southeast side of the established trapping stations and the mid points between stations (including one point center beyond Station 20 to obtain forty point centers for 160 trees).

Point-centered quarter data were processed using the following equations from Cottam and Curtis (1956):

Distance = distance from point center to species.

$$\text{Mean distance} = \frac{\text{sum of distances}}{\text{number of measurements}}$$

$$\text{Mean area} = (\text{mean distance})^2$$

$$\text{Total density (plants/hectare)} = \frac{\text{10,000 square meters 1 hectare}}{\text{mean area } (m^2) \text{ of plants}}$$

$$\text{Relative density} = \frac{\text{number of individuals/species x 100}}{\text{number of individuals of all species}}$$

$$\text{Frequency of species} = \frac{\text{number of points at which species occurs x 100}}{\text{total points (40)}}$$

$$\text{Relative frequency} = \frac{\text{frequency of individual species x 100}}{\text{sum of frequency values of all species}}$$

$$\text{Basal area per tree} = \frac{\text{total basal area}}{\text{number of trees}}$$

$$\text{Relative dominance} = \frac{\text{total basal area of the species x 100}}{\text{total basal area of all species}}$$

Forty one-meter square quadrats were employed to determine species distribution of understory vegetation within the sites (Phillips 1959). Study Site 2 had recently been clear-cut and planted to loblolly pine. A dense grass cover indicated a need for more detailed study of the area, therefore, quantitative analysis of the grass community was obtained by using the point-center quarter method (Cottam and Curtis 1956).

Litter accumulation was estimated by collecting all surface organic material within four, 1/4 m^2 quadrats per site. The material was air-dried at the South Carolina Electric & Gas Company field office at Parr, South Carolina to keep weight loss due to microbial activity to a minimum.

The samples were then shipped to the Dames & Moore Environmental Services Laboratory at Cincinnati, Ohio, oven-dried at 80°C for forty-eight hours and weights reported.

5.3.3 FINDINGS

5.3.3.1 Floristic Composition

Flora of the Broad River Study Area consisted of 51 families represented by 99 genera and 108 identified species (Table 5.3.1). Phenological conditions of 15 specimens prohibited identification to the species level. Thirty-six tree species were best represented by pines, oaks, and hickories. The flora also was well represented by a variety of herbaceous species which included grasses, legumes, and composites. The diversity of species within these three groups is significant considering the area is predominatly closed canopy forest.

Eighteen species of vascular hydrophytes were collected from the study area. This group is discussed in Section 3.4.

5.3.3.2 Vegetative Communities

Total area scheduled for inundation by Monticello Impoundment included 47 percent pine, 15 percent hardwood (deciduous), 26 percent mixed pine-hardwood, and 12 percent grassland. Hardwood forests are predominately in the bottomlands of Frees Creek.

The coniferous communities to be inundated consisted mainly of loblolly pine which produces a closed canopy forest with a sparce understory of herbaceous vegetation. Only limited numbers of pine seedlings and saplings are capable of growing under the dense canopy which reduces light penetration to the substrate.

Of the area described as mixed community, 73 percent consisted of areas where pine was selectively removed. The hardwood understory was predominant

Table 5.3.1 Summary of flora identified in the environs of the Broad River Study Area.

Family Scientific Name Common Name	COLLECTION SITES				
	1A	2	3A	4	General
Pteridaceae					
Pteridium aquilinum					
Bracken Fern	0*	0	X*	0	0
Polypodiaceae					
Asplenium platynuron					
Fern	X	0	X	0	0
Polystichum acrostichoides					
Fern	0	0	X	0	0
Pinaceae					
Pinus echinata					
Short Leaf Pine	0	0	0	0	X
Pinus palustris					
Long Leaf Pine	0	0	X	0	X
Pinus taeda					
Loblolly Pine	X	X	X	X	X
Pinus virginiana					
Scrub Pine	0	0	0	X	0
Cupressaceae					
Juniperus virginiana					
Eastern Red Cedar	X	0	X	X	0
Alismataceae					
Sagittaria latifolia					
Arrowhead	0	0	X	0	X
Gramineae					
Alopecurus carolinianus					
Foxtail	0	X	0	0	0
Andropogon virginicus					
Broomsedge	0	X	0	0	0
Aristida purpurascens					
Three-awned Grass	0	X	0	0	0
Arundinaria gigantea					
Cane	0	0	X	0	0
Bothriochloa sp.					
Beardgrass	0	X	0	0	0
Cynodon dactylon					
Bermuda Grass	X	0	0	0	X
Panicum scribnerianum					
Scribner's Panicum	X	X	X	X	X

Table 5.3.1 (Continued)

Family Scientific Name Common Name	COLLECTION SITES				
	1A	2	3A	4	General
Gramineae					
Panicum sp.					
Panic Grass	0	X	0	0	0
Paspalum plicatulum					
Brownseed	0	X	0	0	X
Schizachyrium scoparium					
Little Bluestem	0	X	0	X	0
Setaria sp.					
Foxtail Grass	0	X	0	X	0
Sorghastrum nutans					
Indiangrass	0	0	X	X	X
Sorghum halepense					
Johnson Grass	0	X	0	X	0
Uniola latifolia					
Sea Oats	0	0	X	0	0
Cyperaceae					
Rhynchospora corniculata					
Beak Rush	0	0	X	0	0
Carex sp.					
Sedge	X	0	X	X	0
Cyperus erythrorhizos					
Sedge	0	0	X	0	0
Bromeliaceae					
Tillandsia usneoides					
Spanish Moss	0	0	0	0	X
Pontederiaceae					
Pontederia cordata					
Pickerel Weed	0	0	X	0	0
Liliaceae					
Allium canadense					
Wild Onion	0	X	0	0	0
Polygonatum pubescens					
Solomon's Seal	0	0	0	0	X
Smilax glauca					
Greenbrier	0	X	0	0	0
Smilax walteri					
Walter's Smilax	X	0	X	X	X

Table 5.3.1 (Continued)

Family Scientific Name Common Name	COLLECTION SITES				
	1A	2	3A	4	General
Juglandaceae					
Carya glabra					
Pignut Hickory	0	0	X	0	0
Carya laciniosa					
Shellback Hickory	0	0	X	0	0
Carya ovata					
Shagbark Hickory	0	0	X	0	0
Carya tomentosa					
Mockernut Hickory	0	0	X	0	0
Betulaceae					
Carpinus caroliniana					
American Hornbeam	X	0	X	0	0
Ostrya virginiana					
Eastern Hophornbeam	X	0	X	X	0
Fagaceae					
Quercus alba					
White Oak	0	0	X	0	0
Quercus borealis var. *rubra*					
Red Oak	0	0	X	0	0
Quercus laevis					
Turkey Oak	0	0	0	X	X
Quercus laurifolia					
Laurel Oak	X	0	X	X	X
Quercus nigra					
Water Oak	X	0	X	X	0
Quercus phellos					
Willow Oak	0	0	X	0	0
Quercus schumardii					
Schumards Oak	0	0	X	0	0
Quercus stellata					
Post Oak	0	0	X	0	0
Quercus velutina					
Black Oak	X	0	0	0	0
Ulmaceae					
Celtis laevigata					
Sugarberry	X	0	0	0	X
Ulmus alata					
Winged Elm	X	0	X	0	X
Loranthaceae					
Asarum sp.					
Wild Ginger	0	0	X	0	0

Table 5.3.1 (Continued)

Family Scientific Name Common Name	COLLECTION SITES				
	1A	2	3A	4	General
Aristolchiaceae					
Hexastylis arifolia					
Heartleaf	0	0	X	0	X
Phytolaccaceae					
Phytolacca americana					
Pokeberry	0	X	0	0	0
Portulacaceae					
Claytonia virginica					
Spring Beauty	0	0	X	0	0
Caryophyllaceae					
Silene antirrhina					
Sleepy Catchfly	0	X	0	0	0
Menispermaceae					
Cocculus carolinus					
Coralbeads	0	0	0	0	X
Magnoliaceae					
Liriodendron tulipifera					
Tulip Poplar	X	0	0	0	0
Hamamelidaceae					
Hamamelis virginiana					
Witch Hazel	0	0	X	0	0
Liquidamber styraciflua					
Sweet Gum	X	0	X	X	0
Rosaceae					
Amelanchier sp.					
Juneberry	0	0	0	0	X
Crataegus sp.					
Hawthorn	X	0	0	0	0
Potentilla sp.					
Cinquefoil	X	0	X	0	0
Prunus americana					
Wild Plum	0	X	0	0	0
Prunus serotina					
Black Cherry	X	X	0	X	0
Rosa bracteata					
Rose	X	X	0	0	0
Rubus allegheniensis					
Blackberry	X	X	0	0	0

Table 5.3.1 (Continued)

Family Scientific Name Common Name	COLLECTION SITES				
	1A	2	3A	4	General
Leguminosae					
Albizzia julibrissin					
Mimosa	0	X	0	0	0
Astragalus sp.					
Milk Vetch	0	0	X	0	0
Cassia nictitans					
Sensitive Plant	0	0	X	0	0
Cercis canadensis					
Redbud	0	X	X	0	0
Desmanthus sp.					
Bundle Flower	0	0	0	X	0
Gleditsia tricanthes					
Honey Locust	0	0	0	0	X
Lespedeza procumbens					
Lespedeza	0	X	0	X	0
Lespedeza repens					
Lespedeza	0	X	X	X	0
Lespedeza stuevei					
Lespedeza	0	X	0	X	0
Lespedeza virginica					
Lespedeza	X	0	X	X	X
Pueraria lobata					
Kudzu Vine	0	0	0	0	X
Vicia caroliniana					
Carolina Vetch	0	0	X	0	0
Oxalidaceae					
Oxalis sp.					
Wood Sorrel	X	0	0	0	0
Guttiferae					
Hypericum denticulatum					
St. John's Wort	X	0	0	0	0
Meliaceae					
Melia azedarach					
China Berry	0	0	0	0	X
Euphorbiaceae					
Euphorbia corollata					
Spurge	0	X	0	0	0
Anacardiaceae					
Rhus copallina					
Winged Sumac	0	0	0	X	X
Rhus glabra					
Smooth Sumac	0	0	0	0	X

Table 5.3.1 (Continued)

Family Scientific Name Common Name	COLLECTION SITES				
	1A	2	3A	4	General
Aquifoliaceae					
Ilex opaca					
American Holly	X	0	X	X	X
Celastraceae					
Euonymus americanus					
Strawberry Bush	X	0	0	0	0
Aceraceae					
Acer rubrum					
Red Maple	X	X	X	X	0
Acer saccharum					
Sugar Maple	0	0	X	0	0
Balsaminaceae					
Impatiens capensis					
Jewel Weed	0	0	0	0	X
Vitaceae					
Parthenocissus quinquefolia					
Virginia Creeper	0	X	0	0	0
Vitis rotundifolia					
Muscadine Grape	0	X	0	0	0
Tiliaceae					
Tilia americana					
Basswood	0	0	X	0	0
Passifloraceae					
Passiflora incarnata					
Passion Flower	0	X	0	0	0
Elaeagnaceae					
Elaeagnus umbellata					
Silver Berry	0	0	X	0	X
Cornaceae					
Cornus florida					
Dogwood	X	0	X	X	0
Ericaceae					
Chimaphila maculata					
Spotted Wintergreen	X	0	0	0	0
Nyssaceae					
Nyssa sylvatica					
Black Gum	0	X	X	0	0

Table 5.3.1 (Continued)

Family Scientific Name Common Name	COLLECTION SITES				
	1A	2	3A	4	General
Oleaceae					
Fraxinus americana					
White Ash	0	0	X	0	0
Ligustrum sp.					
Privet	0	0	0	X	0
Asclepiadaceae					
Asclepias tuberosa					
Milkweed	X	0	X	0	0
Convolvulaceae					
Convolvulus arvensis					
Bindweed	X	0	0	0	0
Verbenaceae					
Callicarpa americana					
Beauty Berry	0	0	X	X	0
Verbena riparia					
Verbena	0	X	0	0	0
Labiatae					
Prunella vulgaris					
Selfheal	0	X	0	0	0
Solanaceae					
Physalis sp.					
Ground-cherry	0	X	0	0	0
Solanum carolinense					
Nightshade	0	X	0	0	0
Bignoniaceae					
Campsis radicans					
Trumpet-creeper	X	0	0	0	0
Acanthaceae					
Ruellia caroliniensis					
Ruellia	0	0	X	0	0
Plantaginaceae					
Plantago aristata					
Plantain	0	X	0	0	0
Plantago lancealata					
Buckhorn	0	X	0	0	0
Rubiaceae					
Cephalanthus occidentalis					
Button-bush	0	0	X	0	0

Table 5.3.1 (Continued)

Family Scientific Name Common Name	COLLECTION SITES				
	1A	2	3A	4	General
Caprifoliaceae					
Lonicera japonica					
Honeysuckle	X	X	X	0	X
Compositae					
Ambrosia artemisiifolia var. *elator*					
Common Ragweed	0	X	0	0	0
Antennaria sp.					
Pussy's-toes	0	0	0	X	0
Aster pilosus					
Aster	0	X	0	X	0
Elephantopus tomentosus					
Elephant's-foot	X	0	0	0	0
Erigeron strigosus					
Daisy-fleabane	0	0	0	0	X
Eupatorium capillifolium					
Dog-fennel	0	0	0	0	X
Eupatorium lineaifolium					
Eupatorium	0	X	0	0	0
Helenium amarum					
Bitter-weed	0	X	0	0	0
Lactuca scariola					
Prickly Lettuce	0	X	0	0	0
Pyrrohopappus carolinianus					
Leafy Stemmed Dandelion	0	X	0	X	0
Senecio vulgaris					
Groundsel	0	X	0	0	0
Solidago sp.					
Goldenrod	X	0	0	0	0
Taraxacum sp.					
Dandelion	X	0	0	0	0

* 0 = not present in area sampled; X = present.

as viewed from aerial photographs, resulting in those areas being classified as mixed pine-hardwood community.

The grassland community type included seven percent cultivated or pasture and five percent abandoned farmland. Abandoned farmland included communities representing several seral stages of succession.

The area to be inundated by enlargement of Parr Reservoir contained 2 percent pine, 86 percent hardwood, 8 percent mixed pine-hardwood, and 4 percent grassland communities. Grasslands were abandoned farmlands or clear-cut timber lands, predominately in early stages of succession.

5.3.3.3 Study Sites

5.3.3.3.1 Study Site 1

Study Site 1 was subdivided into Site 1A consisting of second growth pine and Site 1B which was predominately hardwood. Tree data were collected only on Site 1A. Density of trees greater than 2.5 cm dbh was 2,422 trees per ha (980 trees per acre), with a mean basal area of 4.2 m^2 per tree. Average height per tree was 15.8 m (51.8 ft) with a height range from 12.2 m (40 ft) to 21.9 m (71.4 ft).

Species diversity was low with loblolly pine being the most important canopy species (Table 5.3.2) on the site. Loblolly pine was represented in each of six diameter classes ranging from 5 to 30 cm (2 to 12 in), however, 69 percent of these were in the 5 and 10 cm class sizes. All other tree species present had a dbh of 10 cm or less.

Honeysuckle was the most frequently occurring understory species in the pine stand (Table 5.3.3). Other species which occurred in more than 25 percent of the quadrats included Schribner's panicum, blackberry, and dandelion. Litter accumulation weighed 13.8 x 10^3 kg/ha (Table 5.3.4), and was composed primarily of pine needles.

Table 5.3.2 Relative frequencies, densities, dominance and importance values of tree species (2.5 cm or greater dbh) growing in Site 1A of the Broad River Study Area, June 1971.

Species	Relative Frequency	Relative Density	Relative Dominance	Importance* Value
Loblolly Pine	52.9	69.4	80.8	203.1
Sweet Gum	21.4	18.0	13.9	53.3
Flowering Dogwood	11.4	6.3	2.7	20.4
Eastern Red Cedar	7.1	3.1	1.5	11.7
Tulip Tree	2.9	1.3	.6	4.8
Hop-hornbeam	2.9	1.3	.4	4.6
Red Maple	1.4	0.6	.2	2.2
Totals	100.0	100.0	100.1	300.1

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*Importance Value is the sum of relative frequency, relative density, and relative dominance.

Table 5.3.3 Frequency of occurrence (%) of understory, herbaceous, and woody plant species growing within pine, hardwood, mixed pine-hardwood, and grassland environs in the Broad River Study Area.

Growth Form	COLLECTION SITES				
Common Name	1A	1B	2	3A	4
Vascular Cryptogams					
Fern	4	-	-	10	-
Herbaceous					
Forbs					
Arrowhead	-	-	10	10	-
Aster	-	-	10	-	10
Bundle Flower	-	-	-	-	15
Cinquefoil	-	8	-	5	-
Common Ragweed	-	-	5	-	-
Dandelion	28	-	-	-	-
Goldenrod	12	-	20	-	5
Heartleaf	-	-	-	20	-
Lespedeza	-	-	5	-	10
Pussy's Toes	-	-	-	-	5
St.John's Wort	4	-	-	-	-
Wild Ginger	-	-	-	20	-
Wood Sorrel	20	-	-	-	-
Grasses					
Bamboo	-	-	-	35	-
Bermuda Grass	24	-	-	-	-
Broom Sedge	-	-	65	-	40
Brownseed	-	-	10	-	-
Cane Bluestem	-	-	4	-	-
Indiangrass	-	-	-	10	30
Little Bluestem	-	-	45	-	30
Scribner's Panicum	28	-	30	15	25
Three-awned Grass	-	-	40	-	-
Sedges					
Sedge	-	20	-	45	-

Table 5.3.3 (Continued)

Growth Form Common Name	COLLECTION SITES 1A	 1B	 2	 3A	 4
Woody					
Shrubs					
American Holly	8	16	-	15	15
Blackberry	28	-	5	-	-
Rose	4	8	15	-	-
Trees (<5 cm d.b.h.)					
American Hornbeam	-	4	-	-	-
Black Cherry	4	-	-	-	-
Black Oak	-	8	-	-	-
Dogwood	-	4	-	-	15
Eastern Red Cedar	4	-	-	10	-
Hawthorn	4	4	-	-	-
Laurel Oak	4	28	-	15	10
Loblolly Pine	40	20	5	35	25
Pignut Hickory	-	-	-	5	-
Red Maple	-	-	-	5	-
Sugarberry	-	8	-	-	-
Sweet Gum	8	4	-	5	-
Water Oak	4	8	-	5	5
White Ash	-	-	-	5	-
Winged Elm	12	20	-	15	-
Vines					
Honeysuckle	72	16	25	-	-
Walter's Smilax	4	52	-	50	15

Table 5.3.4 Mean litter production from the various sites within the Broad River Study Area.

Collection Sites	Litter Production (thousands) kg/ha*
1A	13.8
1B	15.5
2**	2.7
3A	12.1
4	13.5

* kg/ha x 0.891 = lb/acre
**Standing and accumulated litter from within a pine plantation.

Walter's smilax was the most frequently occurring understory species in the hardwood stand on Study Site 1B (Table 5.3.3). Seedlings of laurel oak and loblolly pine also were present. A sedge was the most frequently encountered herbaceous plant. Litter production under hardwood was 1.7×10^3 kg/ha greater than under the pine stands (Table 5.3.4). Litter composition was predominately leaves and twigs, since sampling was accomplished shortly after leaf fall.

5.3.3.3.2 Study Site 2

Site 2 consisted of plantation pine approximately three years after planting. Vegetation on the site typifies an early successional stage of a disturbed site. The site had been clear-cut and replanted to loblolly pine. No tree on the site had a dbh greater than 2.5 cm.

Density of grass species (bunch grasses, with each bunch considered a plant) was 6,756 plants/ha (2,735 plants/acre). Protection of the soil surface was provided by basal cover of nearly 0.15 m^2 per plant, for a total basal cover of 978 m^2/ha (4,260 sq ft/acre). This represents a total ground cover of 9.8 percent.

Broomsedge was the most important grass species on the site (Table 5.3.5) with triple-awned grass being the next most important. Although the importance value of little bluestem was not as high as triple-awned grass, relative dominance of little bluestem was somewhat greater. This would indicate that, while the density and frequency of little bluestem were low, the plants which did occur were well established.

Honeysuckle, rose, goldenrod, and aster were frequently occurring forbs within the site (Table 5.3.3). No substantial amount of litter had accumulated (Table 5.3.4) since the area had been clear-cut.

Table 5.3.5 Relative frequency, density, and dominance of the various grass species within a pine plantation (Site 2) in the Broad River Study Area.

Species	Relative Frequency	Relative Density	Relative Dominance	Importance Value*
Broomsedge	34.1	38.7	61.3	134.1
Triple-awned Grass	31.7	27.5	14.7	73.9
Little Bluestem	22.0	23.7	16.6	62.3
Witchgrass	7.3	6.3	3.5	17.1
Brownseed	4.9	3.7	3.9	12.5
Total	100.0	99.9	100.0	299.9

*Importance Value is the sum of relative frequency, relative density, and relative dominance.

5.3.3.3.3 Study Site 3A

This site was located along Frees Creek and supported a diverse community of woody species. A total of 2,219 trees/ha (898 trees/acre), representing 16 species, occupied a mean area of 4.5 m^2 per tree. Loblolly pine, eastern red cedar, and red maple were the most important species (Table 5.3.6). Loblolly pine was the dominant species within the area, but eastern red cedar was the most dense.

Clinometer height samples revealed a range from 15.2 m (49.8 ft) to 21.3 m (70 ft) with an average tree height of 19.2 m (63 ft). Forty-two percent of all trees sampled had a dbh of 5 cm or greater, while eight percent had a dbh greater than 25 cm. The largest tree on the site, a loblolly pine, measured 45 cm (17.7 in) dbh. Only loblolly pine, ash, and oak species had dbh's greater than 25 cm (9.8 in). Walter's smilax was the most frequent understory plant species within the site (Table 5.3.3) and sedge was the most frequent herbaceous species. Bamboo was common along the water margin. Loblolly pine seedlings were found throughout the site. Litter accumulation, chiefly pine needles, was lowest of the forested areas, 12.1 X 10^3 kg/ha (Table 5.3.4).

5.3.3.3.4 Study Site 4

Study Site 4 consisted of a mature stand of plantation pine as indicated by the range of size classes. Loblolly pine trees were represented in each of the 5 cm diameter class intervals from 5 to 35 cm. Diversity of other woody species also indicated a mature stand. The area supported a population of 1,930 trees/ha (780 trees/acre) with a mean area of 5.2 m^2 per tree. The heights averaged 20.4 m (67 ft) and ranged from 19.2 m (63 ft) to 22.8 m (74.8 ft).

Loblolly pine was the most important woody species in the area

Table 5.3.6 Relative frequencies, densities, dominance and importance values of tree species (2.5 cm or greater dbh) growing in Site 3A of the Broad River Study Area, June 1971.

Species	Relative Frequency	Relative Density	Relative Dominance	Importance Value*
Loblolly Pine	16.0	18.6	21.7	56.3
Eastern Red Cedar	16.0	19.2	13.0	48.2
Red Maple	13.4	14.8	13.5	41.7
Ash	8.4	6.2	9.2	23.8
Hop-hornbeam	7.6	5.6	6.8	20.0
Oak sp. 1	7.6	6.2	5.4	19.2
Shagbark hickory	5.9	4.7	6.0	16.6
Hickory sp.	5.0	4.7	4.3	14.0
Oak sp. 2	3.4	3.8	4.6	11.8
Oak sp. 3	4.2	3.1	4.1	11.4
Ironwood	2.5	4.7	3.3	10.5
Basswood	3.4	3.8	3.3	10.5
Live Oak	2.5	1.8	3.0	7.3
Flowering Dogwood	1.7	1.2	0.5	3.4
Redbud	1.7	1.2	0.5	3.4
Willow Oak	0.7	0.6	0.8	2.1
Total	100.0	100.2	100.0	300.2

*Importance Value is the sum of relative frequency, relative density, and relative dominance.

(Table 5.3.7). Eastern red cedar was the most important sub-dominant species. Other woody species over 2.5 cm dbh were only of minor importance, with over 50 percent occurring in the 5 and 10 cm diameter size classes.

Understory vegetation of Study Site 4 was well represented by graminoids (Table 5.3.3). Broomsedge, the most frequent species, occurred in small herbaceous communities in areas created by the removal of scattered mature pines. Little bluestem and Indiangrass also were quite common. Loblolly pine seedlings occurred throughout the open areas.

Accumulated litter on the forest floor was comparable to litter accumulated in Study Site 1A (Table 5.3.4). Pine needles contributed most to the total weight.

5.3.4 DISCUSSION

5.3.4.1 Habitat Description

Southern pine forests of the South Atlantic and Gulf States are considered part of the temperate-deciduous forest since they represent a seral stage rather than climax. The physiognomy is medium-tall to tall forest of needle leaf evergreen and broad leaf deciduous trees. Unless maintained by fire and cutting, these forests are succeeded by such hardwoods as oak and hickory (Smith 1966). Physiognomy of flood plain forest is dense, medium-tall to tall forest of broad leaf deciduous and evergreen trees, inter-mixed with shrubs and needle leaf deciduous trees.

Forests are often stratified because of an existing variety of life forms. Four strata are usually recognized in a highly developed, uneven-aged, deciduous forest: the upper canopy consists of dominant or co-dominant trees; the lower tree canopy of subdominant tree species; the shrub layer; and the ground or field layer consisting of herbs, ferns, and mosses. Species composition of the ground layer varies with the season.

Table 5.3.7 Relative frequencies, densities, dominance and importance values of tree species (2.5 cm or greater dbh) growing in Site 4 of the Broad River Study Area, June 1971

Species	Relative Frequency	Relative Density	Relative Dominance	Importance Value*
Loblolly Pine	60.7	81.3	85.9	227.9
Eastern Red Cedar	12.2	6.3	5.1	23.6
Holly	6.1	3.1	1.5	10.7
Black Cherry	4.5	2.5	2.4	9.4
Oak sp. 1	4.5	1.9	1.8	8.2
Red Maple	4.5	1.9	0.9	7.3
White Oak	1.5	0.6	0.9	3.0
Hop-hornbeam	1.5	0.6	0.6	2.7
Oak sp. 2	1.5	0.6	0.3	2.4
Willow Oak	1.5	0.6	0.3	2.4
Sweet Gum	1.5	0.6	0.3	2.4
Total	100.0	100.0	100.0	300.0

*Importance Value is sum of relative frequency, relative density, and relative dominance.

Even-aged stands resulting from disturbances such as fire and clear-cutting have a poorly developed understory. The low tree, shrub, and ground layers are thin and poorly developed except in small, open areas.

Forest communities of the Broad River Study Area are basically poorly developed. Planting loblolly pine for pulp production results in even-aged stands with closed canopies, thereby eliminating any consistent stratification within the community. Seeding to harvest of marketable loblolly pine in the area requires 35 to 50 years.

The forest floor plays a dominant role in the life and distribution of many plants and animals and in maintenance of soil fertility. A constant interchange of materials takes place from the surface to the soil through vegetation and back again. Plants utilize nutrients from the soil and deposit them on the surface as litter. Decomposition of plant and animal material reverses the process. The nature and quality of the organic layer is dependent in part on the kind and quality of litter, and the litter in turn influences the abundance and composition of soil fauna.

Plant littler, composed of pine needles, is high in lignins and resins which resist decomposition and which inhibit the decomposition of cellulose. Coniferous forest soils are characterized by a well defined unincorporated, compact organic deposit resting on mineral soil. The layer is a result of slow mineralization and no mixing with the mineral soil. The soil characteristics support only limited population of small soil organisms, of which most live at the interface of the decaying organic layer and the mineral surface.

Acid characteristics of these soils make them more suitable to pines than hardwoods. Pines generally thrive on soils with a pH of 5.0 to 5.5 which supply too little potassium, phosphorous, and nitrogen for most hardwood trees. Soils of the Broad River Study Area generally were slightly acidic in nature and very low in phosphorus. Potassium content varied from low to high. While supplemental nitrogen was not required for growing hardwood trees, lime appeared to be necessary to ameliorate the environment for optimum growth of hardwood species.

Litter accumulation for the coniferous forest was approximately 15 metric tons which agreed with accumulations reported by Switzer and Nelson (1972) for a 20-year old loblolly pine plantation. Age data are not available for the older loblolly pine stands of the Broad River Study Area, therefore comparisons cannot be made with accumulations reported in the literature. Low accumulation for Site 2 has to be attributed to the age of the stand and the influence of recent clear-cutting.

Soils of mixed or hardwood forests have a better developed humus layer. Chemical composition of deciduous leaves allows faster decomposition and mineralization of the leaf litter. Thus, the litter is incorporated with the mineral soil much faster.

More litter was accumulated on Site 1B than on the pine stands. Usually the opposite would be true due to differential decomposition rates of the type litter within each system. However, the fall sampling occurred immediately after leaf fall, resulting in an accumulated litter mass.

5.3.4.2 Ecologically Important Species

Thirty-six woody species were identified growing in the Broad River environs. Although several species can be considered important, loblolly pine was the most important species in the area. Most of the area was composed of second growth loblolly. Consequently, this species was the dominant canopy species and contributed much of the accumulated litter to the forest floor. Accumulation of litter, which is a demise of pine seedlings, provides a protective medium for hardwood fruits and drought resistant seedlings. Loblolly is an intolerant species and new seedlings will not establish in the heavy litter.

Because of its wide range occurrence in pure stands, its abundance and its versatility in use, loblolly is a principal commercial pine in the southeastern United States. This also is true for the Broad River Study Area. Site indices, an estimate of total height attained by the average dominant and co-dominant trees in a 50-year stand, generally increase from rich upper slopes to bottomlands, but variations are related to soil differences rather than to slope position or steepness. Loblolly pine grows best on sandy soils with poor surface drainage, a deep surface layer, and a firm subsoil (Forest Service 1965).

Loblolly pine had a potential site index of 80 (Ellerbe and Smith 1964) on the Cecil sandy loam soil of Site 1A. The same site index would have applied to the Appling sandy loam of Site 1B. However, loblolly pine was not a major species at that site.

The Appling and Cecil sandy loams are well drained soils with a moderate moisture supplying capacity. These soils are moderately high in natural fertility and in well-stocked unmanaged stands at fifty years of age could produce an average annual growth of 466 board feet of loblolly pine per acre (Ellerbe and Smith 1964).

Site 2 and 4 occur on severely eroded Cecil clay loam and have a site index of 60. While moisture supplying capacity is medium to high, these soils are moderately low in natural fertility. Annual production of 390 board feet can be expected on a well-stocked unmanaged stand at fifty years of age (Ellerbe and Smith 1964). Wind fall can be severe, especially on Site 4, where shallow phases of the soil restrict root development.

Site 3A was characterized by two soil types; a Cecil sandy loam on the upper slopes and a Mecklenburg sandy loam on the lower slopes. The Cecil sandy loam soils were more severely eroded than those identified on Site 1A.

Thus, production could not be expected to be as high on Site 3A. The site index for Site 3A was 70 to 80.

An average site index of 60 can be expected for loblolly pine on Mecklenburg sandy loam soils. The surface layer overlays a very firm, slightly plastic clay subsoil with medium moisture supplying capacity. Wind throw does not pose any particular problem on this soil type.

Other woody species in the Broad River Study Area did not occur in sufficient numbers to be of any apparent economic importance, however, their importance as food sources and habitat for wildlife cannot be ignored. These discussions, however, must be limited to potential habitat since the wildlife populations were very limited within the study area.

Fruits from oaks, eastern red cedar, and holly provide a valuable food source for turkeys and song birds. Small scattered patches of grasses and forbs occur in openings in the trees which offer potential habitat for turkey and quail. Lespedeza and seeds from other forbs and grasses growing within these open areas serve as a food source.

Japanese honeysuckle was the most common understory species in the area. According to Segelquist, Rogers, and Ward (1972) honeysuckle plantings provide emergency winter rations for deer. Nutrient quality of the leaves is apparently very consistent throughout the year, being especially high in protein. Honeysuckle leaves are retained during the winter and more digestible than any native forage, including eastern red cedar leaves.

No plant species were collected or observed in the Broad River Study Area which could be classified as rare or endangered.

5.3.4.3 Environmental Stresses and Ecological Succession

Original forest of the Broad River Study Area consisted of pines, oaks, and hickories, which was practically free of brush undergrowth. Early settlers destroyed most of the timber they cut to clear for farm. They cultivated their cleared fields until yields began to decline, then cleared new land or abandoned the entire settlement. The significant effect of the clearing and abandonment was a conversion of most of the original forest to pine stands.

There is a fairly definite succession of vegetation on land abandoned after cultivation. When a cultivated field is abandoned it produces a crop of annual weeds the first year, numerous perennials the second year and a community of perennials thereafter. In the interim of change, the open, low herbaceous cover alludes to a closed and elevated forest canopy, usually near the end of the second decade. Oosting (1942) outlined the successional sequence of an abandoned field in the Piedmont Region:

Approximate Age Years	Vegetative Character
0	Abandoned field.
1	Herbaceous weedy forbs and grasses.
2	Herbaceous weedy forbs dominated by annuals and perennials.
3-10	Transitional to perennial grasses with pine seedlings becoming established.
10-20	Canopy of loblolly pine stand closes.
Approximately 200	Stable stand of white and red oaks.

These vegetational changes effect a shift to moderation of microclimatic extremes, influence the disposition of precipitation and the character and composition of the microflora and fauna; all of which, directly and indirectly influence the disposition of nutrients within the system.

The successional stage of Site 2 is currently in the third year. The area is dominated by broomsedge among the small planted loblolly pines.

Grasses are important soil stabilizers. Soils of the Broad River Study Area are very subject to erosion, especially after clear-cutting. Triple-awned grass is an early invader since it is capable of colonizing on low fertility soils. Broomsedge is another grass characteristic of low fertility areas. Little bluestem is characteristic of more fertile areas. The combination of these three species within Site 2 would indicate a moderate level of fertility and that the succession described is progressing as expected.

Young pine seedlings were becoming established among the planted pines. Since pine seedlings can only become readily established on exposed mineral soil, this must occur in the early succession process. After the loblolly pines are well established and the ground cover has improved, an understory of hardwood begins to develop.

Loblolly pine is normally followed by hardwood in natural succession. On the fine-textured soils characteristic of the Piedmont, the single-stem selection method of harvesting favors the succession of hardwoods, but clear-cutting in patches or strips of limited size, or cutting everything except selected seed trees, favors reproduction of pine.

Other stresses may be imposed upon the vegetative communities of the Broad River Study Area, but were not identified during this survey. These include rust diseases caused by the genus <u>Fusiformis</u> which is the most prevalent of diseases that effect loblolly pine. The cankers cause deformation and losses in stem volume. Canker diseases also attack hardwoods and cause the stems to decay.

Little leaf disease, a disease of short leaf pine, also can affect loblolly. The disease is most prevalent in loblolly where the disease is particularly severe in short leaf pine. This usually occurs on sites where aeration and internal drainage are poor. However, short leaf pine is not very abundant within the Broad River Study Area.

Pine-tipped moths also can affect loblolly pine in the area by deforming the trees which prevent growth to a normal height.

5.3.5 SUMMARY

The Broad River Study Area has undergone various disturbances since early white settlement in 1752. While hardwood forest is the climax for the area, disturbances have kept the plant communities in a seral stage with loblolly pine being the dominant species. Disturbance also has inhibited the development of a vertical structure within the community resulting in poorly developed shrub and ground layer.

Successional patterns appear to follow seral stages described for other areas of the Piedmont Region. Grasses and forbs, desirable for wildlife habitat, develop within openings in the forest.

Loblolly pine is the most important economic plant species within the study area. Most of the wood fiber produced by this species is utilized in pulp production. Potential wood production is related to soil type. The turnover rate for marketable timber is 35 to 50 years.

Hardwoods occur as small scattered stands on the uplands and predominate on the river bottoms. No hardwood species occur in numbers great enough to be of economic importance.

No rare or endangered plant species were found in the project area.

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5.4 INSECTS AND OTHER ARTHROPODS

5.4.1 INTRODUCTION

The objectives of arthropod and insect collections on the Parr Reservoir Study Area were to assess the species of insects present at selected areas, their density, diversity, and distribution patterns. Insects are important to the ecological system because of their great numbers. Several hundred-thousand species of insects exist in the world along with numerous species of other arthropods (Borror and DeLong 1971). Therefore, the insects can provide the basic data on species diversity of an area simply by their numbers and accessibility. Trapping insects is not extremely difficult and since there are many species, a great deal of information can be extracted from a careful collection taken at the proper time. This information along with similar information for plants and vertebrates will allow comparisons to be made among the various terrestrial parts of the area. The plants are the primary producers of any ecosystem. That is, the plants are the only part of any biological system which is able to fix carbon compounds in a biologically usable form using the energy from the sun. Many insects are primary consumers, that is, they feed directly upon the tissues and juices of plants. Other insects are of different trophic or feeding levels, preying upon the primary or secondary consumers or feeding upon the detritus, the non-living remains of plants. These insects would be considered secondary or tertiary consumers. Thus, the arthropod studies fill the gap between primary production studies and studies of small mammals and birds which are tertiary or quarternary consumers.

The scope of work with respect to insects and other arthropods was limited. Concentrated terrestrial arthropod collecting was done only in March 1972. Information on species having an economic importance are continually being obtained and recent infestations recorded.

Previous biological studies in Fairfield County, South Carolina, have been limited, especially the western portion of the county which is bordered by the Broad River. The primary reason for lack of investigations appears to be the area's inaccessability. Only one reference, Kirk (1970), was located which listed terrestrial insects collected from Fairfield County.

5.4.2 METHODS AND MATERIALS

Insects were collected on the study area by three methods. The first method involved staking out two 50 by 100 m (164 by 328 ft) quadrats.

Quadrat 1 was located at Study Site 1C on the eastern shore of the proposed Monticello Impoundment, about 300 m (984 ft) east of the small mammal transect and just about 20 m (66 ft) west of State Highway 215 (see map, back cover). This location was chosen because it is on the top of a hill supporting a dense and virtually pure stand of pines. This hilltop will not be flooded when the reservoir is filled.

Quadrat 2 was located at Study Site 2 on the northwest shore of the proposed Monticello Impoundment. The small mammal trapline runs through the quadrat. Both quadrats are oriented with their long axis on a due east-west line. Quadrat 2 was established in order to sample the cut-over habitat. The vegetation consists of grasses, forbes, and small pine; thus approximating the classical old field successional communities.

The inside of Quadrat 2 was lined along both axes at five meter intervals. A stake was driven where the lines intersected and pitfall traps were buried in the ground so the top of the trap was at or just below ground level. The pitfall traps were steel cylinders, 11.8 cm (4.6 in) high and 10.7 cm (4.2 in) in diameter. They were placed on the east side of each stake with the quadrat on the inside of all stakes around the periphery. A total of 231 pitfall traps were set out on Quadrat 2. Quadrat 1 was not completed in time for sampling.

The second method of collecting insects was by sweep netting in various parts of the study area. Unfortunately, no systematic sweep netting was done during the March sample due to unusually cold temperatures. The temperature was too cold for a sufficient number of flying insects and, therefore, comparative sweep netting was not possible.

The third method of sampling was by blacklight trapping at selected areas. A blacklight trap consists of a long-wave ultra-violet bulb, with directing vanes and a catch basin into which alcohol is poured. The insects are attracted to the ultraviolet light, to which their eyes are sensitive, directed into the basin by the vanes, become trapped in the alcohol, and die. All specimens captured in a blacklight trap were kept and preserved in the alcohol. Blacklight trapping was carried out at Cannons Creek in the same area that the littoral zone collection was made.

All arthropods captured by terrestrial means were pinned with standard insect pins. Millipedes collected in pitfall traps were preserved in alcohol. The pinned specimens were separated by taxon, their location within the quadrat described, and stored in cabinets in the laboratory. Specimens trapped by blacklight were separated by taxon, preserved in 85 percent ethanol, and stored in vials. These vials were labeled and stored in a storage cabinet at the laboratory.

There was not enough successful light trapping done to allow for numerical analysis. Since only one quadrat was completed for sampling, there were no paired data available for comparative statistical or numerical testing.

5.4.3 FINDINGS

Table 5.4.1 lists the identified insects collected on Quadrat 2 by pitfall traps. Several specimens have yet to be positively identified, i.e., millipedes, spiders, etc. Two orders of insects were identified: Coleoptera

Table 5.4.1 Identified insects collected on Site 2, northwest shore of proposed Monticello Impoundment, 22 and 24 March 1972

- Coleoptera
  - Carabidae
    - *Triplectrus rusticus* (Say) - (11) adults
    - *Chlaenius tomentosus* (Say) - (1) adult
    - *Stenolophus* sp. - (5) adults
    - *Notiophilus* sp. - (1) adult
    - Misc. Carabidae representing 3 spp. - (4) adults (unidentified)
  - Scarabaeidae
    - *Phyllophaga* sp. - (1) adult
  - Cantharidae
    - *Silis latilabus* Blatchley - (1) adult
    - *Cantharis bilineatus* Say - (2) adults
  - Dermestidae
    - *Attagenus* sp. - (1) adult
  - Curculionidae
    - *Hypera postica* (Gyllenhal) - (2) adults
  - Chrysomelidae
    - *Systena elongata* (Fab.) - (13) adults
    - *Oedionychis indigoptera* LeC. - (21) adults
    - *Monomacra tibialis* (Oliv.) - (6) adults
    - *Chaetocnema cribrifrons* LeC. - (1) adult

- Hemiptera
  - Cydnidae
    - *Pangaeus* sp. - (2) adults
    - *Amnestus* sp. - (1) adult

(beetles) and Hemiptera (bugs), with Coleoptera having the majority of species.

Quadrat 2 was divided into two parts on the basis of vegetative cover. The relative abundance of vegetative cover was determined by field observation. Determinations made of spatial patterns relative to these separated communities revealed several very interesting relationships. As expected, different species were distributed differently within the quadrat. Those animals more adapted to terrestrial life, the millipedes, were most uniformly distributed. They were collected from barren, eroded areas as well as the grassy parts of the quadrat. The soft, easily dessicated animals such as slugs and the earthworms were largely confined to the intermediately vegetated areas. The chrysomelid beetle, Oedionychis indigoptera was clearly confined to the more vegetated parts of the quadrat.

The adults of the predatory carabid beetle, Triplectrus rusticus, were found in the more heavily vegetated areas. The spiders which were collected also are predators. It is of interest, however, to note that they were distributed in a manner quite different from the carabids. Spiders were more uniformly distributed, the majority being found where vegetation was less dense.

The trap success with the blacklight was rather poor. This was probably due to the cold, wet weather which characterized the sampling dates. One trapnight, 29 March 1972, at Cannons Creek along the shoreline where qualitative samples were taken, was quite successful. Table 5.4.2 lists the insects trapped.

5.4.3.1 Insect Infestations

Insect infestation of pine trees was noted during the summer of 1973. There are three bark beetles of major importance in this area; 1) Southern pine beetle, 2) Ips beetle, and 3) Black turpentine beetle. Of these, the Southern pine beetle is the most damaging and was the one of importance during

Table 5.4.2 Insects collected by blacklight trapping on the shore of Cannons Creek, Newberry County, South Carolina, 23 March 1972.

Trichoptera
Psychomyiidae
Phylocentropus placidas (?) Banks - (7) adults
Lype diversa Banks - (8) adults
Hydroptilidae
Hydroptyla sp. Dalman - (5) adults

Diptera
Chironomidae
Genus sp. - (534) adults
Tipulidae
Genus sp. - (1) adult
Psychodidae
Genus sp. - (1) adult
Cyclorrapha
Family unidentified
Genus sp. - (2) adults

Hymenoptera
Ichneumonidae
Genus sp. - (1) adult

Lepidoptera
Psychidae
Genus sp. - (2) adults
Family unidentified
Genus sp. - (1) adult

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this recent infestation. They study area was generally considered out of the epidemic area although there was some "spillover" near Frees Creek (Stan Clark, pers. comm.).

5.4.4 DISCUSSION

The majority of insects collected by the pitfall traps were beetles. This was probably due to greater pitfall trap susceptibility of beetles and, also, early seasonal trapping during which many of the other insects had not emerged.

Of the beetles collected only Hypera postica had previously been described from Fairfield County. This is not surprising since the collecting done for the records was done primarily in the northern-most four counties of South Carolina.

Distribution of organisms in relation to vegetative and non-vegetative areas indicates several interesting patterns. The slugs, which were generally confied to vegetated areas, would be expected to be found in this habitat since they depend on the vegetation for food. Also, along with the earthworms, they would be much more susceptible to dessication in the non-vegetated areas.

Oedionychis indigoptera is a leaf-eating beetle constrained in distribution by food availability rather than the harshness of the environment. These beetles can and do fly about and are thus able to escape from unsuitable conditions, such as high temperatures near the ground, dryness, or runoff water, much more quickly than can the slug. This quick mobility is important in an environment such as at Quadrat 2.

The carabids are hunting beetles which run along the ground and search for food to kill and eat. The majority were found in the more vegetated areas, probably due to the availability of prey species in these areas.

Spiders are among the heartiest terrestrial arthropods physiologically. This accounts for some of their more widespread distribution within the quadrat. However, Triplectrus rusticus is a heavily armored beetle and quite well equipped to deal with harshness in the physical environment. Yet, even though both T. rusticus and the spiders are predators, the spiders are much more widely distributed spatially. This indicated that the spiders are feeding upon a different prey than are the carabids. This conclusion is supported by the observations of spiders building webs. Webs are designed optimally to catch small, lightweight flying insects such as flies, mosquitoes, and small moths. These small insects have a much thinner cuticle than the heavier ground insects. Thus they would be more suited to the spiders' piercing-sucking type of feeding than would the heavily armored types. The carabids, on the other hand, possess heavy mandibles to crush and masticate their prey. They would not be capturing small fast-flying insects, as a general rule. The conclusion is that the spider is more widely distributed because their prey, the small flying insects, are more widely and uniformly distributed. Also, optimum sites for spider webs would be in more open areas where vegetation is less dense. The carabid beetles' prey is found in more densely vegetated areas where the short range chemical and tactile sensors of the beetles would be of greater use. Thus the anatomy, ecology, and nature of prey serve to delimit the distribution of these species.

The species-dependent spatial distribution patterns outlined above underscore the utility of a fairly large quadrat size and intensive sampling. Small quadrats can give a very misleading picture of faunal spatial distribution. For example, if the quadrat was one-fourth hectare instead of one-half hectare, the spatial distribution of slugs would be different depending on which area had been sampled.

Blacklight trapping success was low because of the cold weather.

It is instructive to note that not only the adults of the Chironomidae were obtained by blacklighting, of which literally thousands of larvae were collected in the benthos samples, but several adults of a genus of caddis flies, *Lype diversa*, were collected which had not been collected in any life stage by other methods. Unfortunately blacklight trapping is a method which yields only qualitative data. That is, it reveals only the presence of certain species and nothing about their absolute abundance. Moreover, because multiple habitats can be sampled simultaneously (an open field and surrounding woods, for example), it does not yield data suitable for comparative analysis. Blacklight trapping is, therefore, a tool for qualitative determination of the presence or absence of a species, nothing more.

Meteorological conditions play an important role in defining arthropod activity. Temperature is known to be an extremely critical parameter in regulating activity. The millipedes captured in pitfall traps indicate a fairly direct relationship to the minumum temperature.

Date	No. of Millipedes Captured	Minimum Temperature
3-22	9	52°F
3-23	13	38°F
3-24	2	22°F
3-25	10	36°F
3-27	1	20°F

5.4.4.1 Insect Infestations

Although recent observations did record an epidemic outbreak of the Southern pine beetle, it occurred only in isolated areas within the study area. Mild winters allow overwintering survival and several consecutive mild winters have allowed a build-up of these insects to an epidemic proportion (Stan Clark, pers. comm).

Mr. Clark indicated that an insecticidal program was not recommended. The procedure involves spotting infested areas and notifying owners to salvage trees by cutting. Although no definite charting has been done, weather conditions do allow a cyclic build-up of the Southern pine beetles about every 7 to 10 years on the average. The normal activity of this insect is to attack trees that are not healthy, but when epidemics occur, the beetles will attack any tree. Basically, the beetles tunnel just under the bark eating through the phloem and cambium layers which produces the same effect as girdling the tree. Needles die very rapidly, often within two weeks following infestation. After build-up of beetles, the natural predators tend to provide control, however, due to a lag in predator build-up, the beetles can do severe damage when in epidemic proportions.

5.4.5 SUMMARY

Since Quadrat 2 has already been planted to slash pine, rapid plant succession to slash pine subclimax forest will occur (Golley and Gentry 1966; Golley 1965; Oosting 1942; Odum 1960; Odum, Connell, and Davenport 1962). Concomitant with this plant succession, the arthropods will undergo a rapid change in both species present and in numbers of individuals. Since the microclimate in Quadrat 2 will probably change when the Monticello Impoundment shoreline is established, there will be a contemporaneous change in the arthropod fauna.

Southern pine beetle infestations observed within the study area were of minor importance. Serious epidemic outbreaks did occur outside the study area and were related to several consecutive mild winters. Since local microclimatic warming in the vicinity of Monticello Impoundment will occur, background information on these beetles could be very important.

5.4.6 REFERENCES

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5.5 AMPHIBIANS AND REPTILES

5.5.1 INTRODUCTION

Amphibians and reptiles are often important links in terrestrial and aquatic food webs. A search of the literature revealed that very little has been published on the distribution of hereptofauna in the Piedmont of South Carolina and apparently nothing has been published on this group from Fairfield County.

5.5.2 METHODS AND MATERIALS

Amphibians and reptiles on the Broad River Study Area were collected as they were encountered in the field or along roads. Several specimens were collected in the Broad River and its tributaries incident to invertebrate and fish sampling operations. All specimens were preserved in 10 percent formalin and either identified in the field or in the laboratory. Common and scientific names are from Conant (1958).

5.5.3 FINDINGS AND DISCUSSION

Amphibians and reptiles were observed and collected during the June and September 1971 sampling periods (Table 5.5.1) and were observed in March and November 1972 and March and May 1973, although few were collected. None were observed during the March 1971 and January 1972 sampling periods. Activity of hereptofauna appears to extend from March through November with hibernation occurring during the cooler months from about November to March.

The number of hereptofaunal species expected to range in this area include: 5 toads; 17 frogs; 19 salamanders; 9 turtles; 9 lizards; and 34 snakes (Conant 1958). A much lower count was actually observed or collected on the study site (Table 5.5.1). Because hereptofauna were recorded only as they were encountered, the list represents only a portion of the amphibians and reptiles likely to occur on the Broad River Study Area.

Table 5.5.1 Species list of amphibians and reptiles observed or collected by location and date from the Broad River Study Area.

Species	Study Site or Location	Sampling Period*
Class Amphibia		
Bufo americanus		
American Toad	2	1
Bufo woodhousei fowleri		
Fowler's Toad	2; road	1; 2
Rana palustris		
Pickerel Frog	3A; Frees Cr.	2; 6,7
Desmognathus sp.		
Dusky Salamander	C	3
Eurycea bislineata		
Two-lined Salamander	C	2,3
Class Reptilia		
Sternothaerus odoratus		
Stinkpot Turtle	A; C	1; 7
Kinosternon s. subrubrum		
Eastern Mud Turtle	C	1,7
Terrapene c. carolina		
Eastern Box Turtle	Road; forest road	1; 7
Chrysemys p. picta		
Eastern Painted Turtle	A; C	1; 7
Pseudemys s. scripta		
Yellow-bellied Turtle	A; B,E; C	1; 7
Pseudemys c. concinna		
River Cooter	C; E	1,7; 1
Pseudemys rubriventris		
Red-bellied Turtle	C	7
Trionyx spinifer asper		
Gulf Coast Softshell Turtle	E; C	1,7
Sceloporus undulatus		
Fence Lizard	1B,3B; 3A,4	6,7; 1,7
Cnemidophorus sexlineatus		
Six-lined Racerunner	4	1
Eumeces laticeps		
Broad-headed Skink	3A	1
Anolis carolinensis	Fenceline forest edge	4,6
Green Anole	Fenceline forest edge	4,6
Natrix sipedon		
Water Snake	Broad R.; Frees Cr.	5; 7
Natrix taxispilota		
Brown Water Snake	C	1
Opheodrys aestivus		
Rough Green Snake	C	1
Agkistrodon c. contortrix		
Southern Copperhead Snake	Roadkill 2 mi. N.	1

Table 5.5.1 (Continued)

Species	Study Site or Location	Sampling Period*
Class Reptilia		
Lampropeltis calligaster rhombomaculata		
Mole Snake	Roadkill 1 mi. S.	5
Thamnophis sauritus		
Eastern Ribbon Snake	Near G	6

*Sampling Period	Date
1	6-71
2	9-71
3	3-72
4	11-72
5	3-73
6	5-73
7	8-73

Five of the 23 species of hereptofauna recorded were amphibians, represented by two toads, one frog and two salamander species. The American toad and Fowler's toad were collected at Study Site 2, a grassland-pine plantation. The American toad is found in a wide variety of habitats from grassland to backyards in suburban developments. The Fowler's toad is more restricted in its distribution. Inland from the Coastal Plain, it is found chiefly in sandy areas near lake shores or in river valleys.

A pickerel frog was collected near Study Site 3A along the shore of Frees Creek. Pickerel frogs are usually found near water, ponds, streams, or springs, but wander into grassy fields in the summer. Collection of the pickerel frog is of interest because this species was not previously known from the Piedmont, although Conant (1958) records it in the northwestern part of South Carolina. It has been collected in the Coastal Plain of South Carolina since Conant's work appeared (Albert Sanders, Curator of Natural History, Charlestown Museum, pers. comm.).

Five two-lined salamander larvae were collected during littoral zone sampling in upper Frees Creek during the September 1971 sampling period. During March 1972, five larvae and one adult female two-lined salamanders were collected along with five larvae and one adult male of a species of the dusky salamander at Transect G. The dusky salamander and two-lined salamander are typically found near small brooks and streams in the water or under debris along the shores. They are usually absent from larger streams where predatory fish occur.

Desmognathus sp., a dusky salamander, may represent a previously undescribed species (Dr. Barry Valentine, Ohio State University, pers. comm.). The color pattern resembles D. fuscus although their gill structure is closer to D. auriculatus. The possibility that it represents a new species is being investigated by Dr. Valentine.

The amphibians are largely primary consumers during early life stages and become secondary or tertiary consumers as adults. The American toad, Fowler's toad, and pickerel frog are carnivores and require an abundance of invertebrates for survival. The pickerel frog may often be at the top of the food web since few snakes will eat this supposedly distasteful frog (Conant 1958).

Eighteen reptile species were observed in the study area. Eight were turtles, five were snakes and five were lizards. All the turtles collected from the Broad River are typically aquatic or semi-aquatic in their habitat preferences. The stinkpot, Eastern mud turtle, and Eastern painted turtle generally prefer shallow freshwater ponds, streams, rivers or lakes. The Eastern painted turtle is most abundant where dense aquatic vegetation grows on soft mud bottoms.

The river cooter is largely a vegetarian (Conant 1958). Yellow-bellied turtles are primarily carnivorous as juveniles but are mainly herbivorous as adults (Clark and Gibbons 1969). The painted turtle has been reported to consume large numbers of mosquito larvae during the summer (Oliver 1955). According to studies made by Karl F. Lagler, the stinkpot turtle is an important scavenger with more than 40 percent of its food being made up of carrion (Oliver 1955).

Many aquatic turtles often bask in the summer sun on logs, stumps, and tree roots along the shore of swamps and water courses of the Broad River Study Area. The sand bars and similar areas of sandy soil found along the bays and creeks of the Broad River serve as sites where some aquatic turtles deposit their eggs. The sun heats the sand which acts as a natural incubator until the young turtles hatch from the eggs and seek water.

The Eastern box turtle, the only land turtle observed on the Broad River Study Area, was observed in deciduous forests and on highways near pine forests and grasslands during the August 1973 sampling period. The Eastern box turtle is found in a variety of terrestrial habitats from woodlands to backyards. It is sometimes found soaking in puddles. It is omnivorous and will feed on leaves, fruits, berries and carrion.

The most frequently observed reptile during the terrestrial program was the fence lizard. This lizard was observed in almost every habitat category (grassland, pine, mixed pine-deciduous, and deciduous forest).

Only one six-lined racerunner and one broad-headed skink were encountered throughout the terrestrial program.

The fence lizzard, broad-headed skink, and green anole favor brush and woodlands where cover is readily available. The fence lizard frequents open pine woods. The green anole is an abundant southern lizard often seen on fences and near buildings. All the fence lizards, broad-headed skinks, and green anoles are active climbers in contrast to the six-lined racerunner which seeks food and shelter on the ground. The racerunner prefers well-drained areas of sandy or loose soils. Its habitats include cavities under dead trees or under other debris in fields, open woods and thicket margins, river floodplains, etc.

The fence lizard, six-lined racerunner, broad-headed skink, and green anole are carnivorous whose diets consist mainly of insects and spiders.

Snakes are common on the Broad River Study Area but they were infrequently observed. Both the copperhead snake and mole snake were found dead along highways near the study area.

The two species of water snakes occur in or near water where they obtain food. The Eastern ribbon snake and rough green snake are seldom found far from water but prefer stream-side vegetation in which to search for food. The southern copperhead also frequents swamp and river borders of lowland forests.

The mole snake is a burrower found near thickets, woodlots, cultivated fields, or near residential areas, and is seldom found above ground except when turned up by the plow or following heavy spring or summer rains (Conant 1958).

The rough green snake feeds on insects and spiders while the copperhead snake consumes small rodents, insects, and birds. Both water snakes feed on aquatic or semi-aquatic animals such as frogs, salamanders, small fish and crustaceans.

5.5.4 SUMMARY

Twenty-three species of hereptofauna, including five amphibian, eight turtle, four lizard and six snake species were recorded during the sampling periods. Two species were of particular interest; Desmognathus sp., a dusky salamander which could represent a new species, and Rana palustris, the pickerel frog which has not been previously reported from the Piedmont of South Carolina.

Amphibians and reptiles are important consumers and scavengers in both the aquatic and terrestrial environments and are important prey for other hereptofauna, fish, birds, and mammals.

5.5.5 REFERENCES

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5.6 BIRDS

5.6.1 INTRODUCTION

The relative abundance of various avian species may serve as indicators of environmental changes. As the habitat is altered by man or as natural succession proceeds, the species and numbers of birds using the area will change. The baseline study provides the basis for detecting and evaluating these changes in the avian fauna which correspond to environmental changes.

5.6.2 METHODS AND MATERIALS

5.6.2.1 Survey Periods

Bird observations were made by systematic auto surveys during June and September 1971, January and March 1972, and March and May 1973. Waterfowl and shorebird counts were conducted on the Broad River during March and November 1972, and March and July 1973. Quantitative estimates of birds were obtained by strip census in various vegetation communities during March and May 1973. Common names and scientific names are taken from Robbins, Bruun, and Zim (1966) and Peterson (1947). The residency status is taken from Sprunt and Chamberlain (1970) and the Columbia Bird Club (1967).

5.6.2.2 Wildlife Auto Survey Routes

Four Wildlife Auto Survey Routes (map, back cover) were established to obtain an index of game bird, song bird, and game mammal abundance.

Morning surveys were conducted beginning at the time of official sunrise (U.S. Government Printing Office 1962) during June and September 1971 and January and March 1972. The final two survey periods included in this report, March and May 1973, began one hour following official sunrise when the visibility had increased. Evening surveys were conducted on Wildlife Survey Route A beginning one hour before official sunset during January and March 1972.

Three minutes were spent listening and observing at Stop 1, the specified distance was driven at the rate of 32 to 48 kilometers per hour (20 to 30 miles per hour), and another three minutes were spent listening and observing at Stop 2. This procedure was followed until completion of each survey route during which all birds and game mammals seen at and between stops were recorded.

The four survey routes were initiated during different survey periods. Before 1973, the distance interval between stops was 1.6 kilometers (1.0 miles) whereas, in March and May 1973, the distance between stops was reduced to 0.8 kilometers (0.5 mile). These changes are summarized as follows:

Survey Route	Total Miles	Number of Stops	Initiating Period
A	9.0	10	June 1971
B	2.0	3	January 1972
A	9.0	19	March 1973
B	2.0	5	March 1973
C	2.5	6	March 1973
D	14.5	31	March 1973

The driver noted time and mileage as well as counted wildlife while the second observer recorded the observations and also counted wildlife. The survey routes were continuous from (C to A to B to D) and ended when all stops had been made (approximately six hours).

Route D was established as a control out of the Broad River Study Area to compare seasonal and annual fluctuations in avian abundance in and out of the study area. The diversity of avian species can also be compared between routes.

At each stop the numbers of calling bobwhite males and calling mourning doves were recorded (the number of calling individuals, not the number of calls).

A mourning dove and bobwhite quail call count survey conducted in May 1973 followed modified procedures described by the United States Bureau of Sport Fisheries and Wildlife. The standardized procedure is described as follows: The survey is conducted on one day only between May 20 and 31 along an established 20 mile route. The survey begins one half hour before official sunrise. Three minutes are spent listening at Stop 1, 1.6 kilometers (one mile) is driven at an average speed of 40 kph (25 mph), three minutes are spent listening at Stop 2, etc. The number of calling mourning doves are recorded at each stop. The number of mourning doves seen at each stop or during travel are also recorded. Only the driver makes and records all observations and the survey is terminated one mile following the 20th stop.

Modifications were made in the standardized procedure while conducting the survey on the Broad River Study Area. The number of calling bobwhite quail were also counted at each stop. The survey was conducted by two observers for two mornings and contained 25 stops so as to terminate at the end of Wildlife Survey Route D.

5.6.2.3 Strip Census

The Forbes-Gross strip census method described in Graber and Graber (1963) was used to estimate bird populations in various habitats. The method requires two observers to walk in parallel lines a specified distance apart. All birds between and 100 yards in front of the individuals and a specified distance on the outside of the strip were recorded. The area censused was calculated from strip width and distance traveled.

The strip census method was employed in March and May 1973 in a number of areas representing three habitat types on the Broad River Study Area, pine forest, mixed deciduous-conifer forest, and grassland. Birds were censused in forest communities during the mornings and the grassland communities during the afternoons. The width of each strip in all habitats censused was approximately 60 meters (200 feet); 30 meters (100 feet) between the observers and approximately 15 meters (50 feet) on each side of the strip.

5.6.2.4 Bird Census Transects

Birds were also recorded by one observer while walking in relatively homogeneous habitat types. This method was employed in March and May 1973 to obtain additional information about the avian diversity in pine, mixed deciduous conifer, deciduous, and grassland communities.

5.6.2.5 Waterfowl Survey

Waterfowl and shorebird counts were made from a boat on the Broad River and its tributaries. The survey usually began within one hour after official sunrise. Observations were recorded by area: 1) north of Blair, 2) Blair to Hellers Creek, 3) Hellers Creek, 4) Hellers Creek to Frees Creek, 5) Frees Creek, 6) Cannons Creek, and 7) Parr Reservoir. Observations were made by two individuals during the overall survey time of approximately eight hours. Waterfowl surveys were conducted in March and November 1972 and March and July 1973.

5.6.2.6 Additional Sources of Information

During the November 1973 sampling period, four areas on the Broad River flood plain were examined qualitatively for habitat characteristics that would support wood ducks and other game birds. The four sites were: 2.5 miles of lower Frees Creek; a pond at Dawkins; a pond near the mouth of Terrible Creek; and approximately 1.9 kilometers (1.2 miles) of the Broad River between Dawkins and Terrible Creek.

A few ground feeding birds were inadvertently caught and collected in snap traps set for small mammals.

5.6.3 FINDINGS

A list of 117 species of birds was compiled from all field activities on the Broad River Study Area during the six survey periods, excluding the waterfowl survey conducted in November 1972 (Table 5.6.1). Most of the

Table 5.6.1 Birds observed on the Broad River Study Area during six survey periods during 1971-1973.

Family	Scientific Name	Common Name	6-71	9-71	1-72	3-72	3-73	5-73 7-73	Status*
Podicipedidae	*Podilymbus podiceps*	Pied-billed Grebe	0	0	0	X	0	0	P
Phalacrocoracidae	*Phalacrocorax auritus*	Double-crested Cormorant	0	0	0	X	0	0	W
Anatidae	*Anas platyrhynchos*	Mallard	X	X	X	X	X	X	W
	Anas rubripes	Black Duck	0	0	0	X	X	0	W
	Anas acuta	Pintail	0	0	0	0	X	0	W
	Anas discors	Blue-winged Teal	0	0	0	X	X	0	W
	Aix sponsa	Wood Duck	X	0	0	X	X	X	P
	Aythya collaris	Ring-necked Duck	0	0	0	0	X	0	W
	Aythya affinis	Lesser Scaup Duck	0	X	X	X	X	0	W
	Bucephala albeola	Buffle-head	0	0	X	X	X	0	W
	Lophodytes cucullatus	Hooded Merganser	0	0	0	X	0	0	W
	Mergus merganser	Common Merganser	0	0	0	X	0	0	W
Cathartidae	*Cathartes aura*	Turkey Vulture	X	X	X	X	X	X	P
	Coragyps atratus	Black Vulture	X	X	X	X	X	X	P
Accipitridae	*Accipiter cooperii*	Copper's Hawk	0	0	0	0	X	0	P
	Circus cyaneus	Marsh Hawk	0	0	X	X	X	X	P
	Buteo jamaicensis	Red-tailed Hawk	0	0	X	X	X	X	P
	Buteo lineatus	Red-shouldered Hawk	0	0	0	0	X	0	P
	Buteo platypterus	Broad-winged Hawk	X	0	0	0	0	X	S
Pandionidae	*Pandion haliaetus*	Osprey	0	X	0	X	0	0	P
Falconidae	*Falco sparverius*	Sparrow Hawk	0	X	X	X	X	0	P
Phasianidae	*Colinus virginianus*	Bobwhite	X	X	0	X	X	X	P

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*P-Permanent Resident; S-Summer Resident; W-Winter Resident; T-Transient

Table 5.6.1 (Continued)

Family	Scientific Name	Common Name	6-71	9-71	1-72	3-72	3-73	5-73 7-73	Status*
Ardeidae	Casmerodius albus	Common Egret	X	0	0	X	0	X	P
	Bubulcus ibis	Cattle Egret	0	0	0	0	0	X	T
	Ardea herodias	Great Blue Heron	X	X	X	X	X	X	P
	Florida caerulea	Little Blue Heron	X	0	0	0	0	0	P
	Butorides virescens	Green Heron	0	0	0	0	0	X	P
	Nycticorax nycticorax loactli	Black-crowned Night Heron	0	0	0	X	0	0	P
Rallidae	Fulica americana	American Coot	0	0	0	X	0	0	P
Charadriidae	Charadrius vociferus	Killdeer	0	0	0	0	X	X	T
Scolopacidae	Actitis macularia	Spotted Sandpiper	0	0	0	0	0	X	S
Laridae	Larus argentatus	Herring Gull	0	0	0	X	0	0	T
	Larus delawarensis	Ring-billed Gull	0	0	0	0	X	0	T
Columbidae	Columba livia	Rock Dove	X	X	X	X	0	X	P
	Zenaidura macroura	Mourning Dove	X	X	X	X	X	X	P
Cuculidae	Coccyzus americanus	Yellow-billed Cuckoo	X	X	0	0	0	X	S
	Coccyzus erythropthalmus	Black-billed Cuckoo	X	0	0	0	0	0	T
Strigidae	Otus asio	Screech Owl	0	X	X	0	0	0	P
Caprimulgidae	Caprimulgus carolinensis	Chuck-will's-widow	X	0	0	0	0	0	S
	Caprimulgus vociferus	Whip-poor-will	0	0	0	X	0	0	S
	Chordeiles minor	Nighthawk	0	0	0	X	0	0	S

*P-Permanent Resident; S-Summer Resident; W-Winter Resident; T-Transient

Table 5.6.1 (Continued)

Family	Scientific Name	Common Name	6-71	9-71	1-72	3-72	3-73	5-73 7-73	Status*
Apodidae	*Chaetura pelagica*	Chimney Swift	X	X	X	0	0	X	S
Trochilidae	*Archilochus colubris*	Ruby-throated Hummingbird	X	0	0	0	0	X	P
Alcedinidae	*Megaceryle alcyon*	Belted Kingfisher	0	0	X	0	X	X	P
Picidae	*Colaptes auratus*	Yellow-shafted Flicker	0	X	X	X	X	X	P
	Dryocopus pileatus	Pileated Woodpecker	0	X	X	X	X	0	P
	Centurus carolinus	Red-bellied Woodpecker	0	0	0	X	X	X	P
	Sphyrapicus varius	Yellow-bellied Sapsucker	0	0	X	X	0	0	W
	Dendrocopos villosus	Hairy Woodpecker	0	0	0	0	X	0	P
	Dendrocopos pubescens	Downy Woodpecker	X	X	X	X	X	X	P
Tyrannidae	*Tyrannus tyrannus*	Eastern Kingbird	X	0	0	0	0	X	S
	Myiarchus crinitus	Great Crested Flycatcher	0	0	0	0	0	X	S
	Sayornis phoebe	Eastern Phoebe	0	0	X	X	X	X	W
	Contopus virens	Eastern Wood Pewee	X	0	0	0	0	X	S
Hirundinidae	*Hirundo rustica*	Barn Swallow	X	0	0	X	0	X	S
	Iridoprocne bicolor	Tree Swallow	0	0	0	0	0	X	T
	Riparia riparia	Bank Swallow	0	X	0	0	0	0	T
	Stelgidopteryx ruficollis	Rough-winged Swallow	0	0	0	0	X	0	S
	Progne subis	Purple Martin	X	0	0	X	0	X	S

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*P-Permanent Resident; S-Summer Resident; W-Winter Resident; T-Transient

Table 5.6.1 (Continued)

Family	Scientific Name	Common Name	6-71	9-71	1-72	3-72	3-73	5-73 7-73	Status*
Corvidae	*Cyanocitta cristata*	Blue Jay	X	X	X	X	X	X	P
	Corvus brachyrhynchos	Common Crow	X	X	X	X	X	X	P
	Corvus ossifragus	Fish Crow	0	0	0	X	X	X	P
Paridae	*Parus carolinensis*	Carolina Chickadee	0	X	X	X	X	X	P
	Parus bicolor	Tufted Titmouse	X	X	X	X	X	X	P
Sittidae	*Sitta pusilla*	Brown-headed Nuthatch	X	0	X	X	X	X	P
Certhiidae	*Certhia familiaris*	Brown Creeper	0	0	0	0	X	0	W
Troglodytidae	*Thryomanes bewickii*	Bewick's Wren	0	0	0	X	0	0	W
	Thrythorus ludovicianus	Carolina Wren	X	X	0	X	X	X	P
Mimidae	*Mimus polyglottos*	Mockingbird	X	X	X	X	X	X	P
	Dumetella carolinensis	Catbird	0	X	0	0	0	X	P
	Toxostoma rufum	Brown Thrasher	X	X	0	X	X	X	P
Turdidae	*Turdus migratorius*	Robin	X	0	X	X	X	X	P
	Hylocichla mustelina	Wood Thrush	X	0	0	0	0	X	S
	Hylocichla guttata	Hermit Thrush	0	0	X	X	X	0	W
	Sialis sialis	Eastern Bluebird	X	X	X	X	X	X	P
Sylviidae	*Polioptila caerulea*	Blue-gray Gnatcatcher	0	0	0	X	0	X	S
	Regulus satrapa	Golden-crowned Kinglet	0	0	X	X	X	0	W
	Regulus calendula	Ruby-crowned Kinglet	0	0	X	X	X	0	W

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*P-Permanent Resident; S-Summer Resident; W-Winter Resident; T-Transient

Table 5.6.1 (Continued)

Family	Scientific Name	Common Name	6-71	9-71	1-72	3-72	3-73	5-73 7-73	Status*
Bombycillidae	*Bombycilla cedrorum*	Cedar Waxwing	0	0	X	0	0	0	W
Laniidae	*Lanius ludovicianus*	Loggerhead Shrike	X	X	X	X	X	X	P
Sturnidae	*Sturnus vulgaris*	Starling	X	X	X	X	X	X	P
Vireonidae	*Vireo olivaceus*	Red-eyed Vireo	0	0	0	0	0	X	S
Parulidae	*Mniotilta varia*	Black and White Warbler	0	0	0	X	0	0	S
	Vermivora pinus	Blue-winged Warbler	0	0	0	0	X	X	T
	Dendroica petechia	Yellow Warbler	X	0	0	0	0	0	S
	Dendroica coronata	Myrtle Warbler	0	0	X	X	X	0	W
	Dendroica dominica	Yellow-throated Warbler	0	0	0	X	0	0	P
	Dendroica striata	Blackpoll Warbler	0	0	0	0	0	X	T
	Dendroica pinus	Pine Warbler	0	0	X	X	X	X	P
	Dendroica discolor	Prairie Warbler	0	0	0	0	0	X	S
	Seiurus aurocapillus	Oven-bird	0	X	0	X	0	0	T
	Geothlypis trichas	Yellowthroat	0	0	0	0	0	X	P
	Icteria virens	Yellow-breasted Chat	X	0	0	0	0	X	S
	Wilsonia citrina	Hooded Warbler	0	0	0	0	0	X	S
Ploceidae	*Passer domesticus*	English Sparrow	X	X	0	X	X	X	P
Icteridae	*Sturnella magna*	Eastern Meadowlark	X	X	X	X	X	X	P
	Agelaius phoeniceus	Red-winged Blackbird	X	0	0	X	X	X	P
	Quiscalus quiscula	Common Grackle	X	0	0	X	X	X	P
	Molothrus ater	Brown-headed Cowbird	X	0	0	X	0	X	P
	Icterus spurius	Orchard Oriole	0	0	0	0	0	X	S

*P-Permanent Resident; S-Summer Resident; W-Winter Resident; T-Transient

Table 5.6.1 (Continued)

Family	Scientific Name	Common Name	6-71	9-71	1-72	3-72	3-73	5-73 7-73	Status*
Thraupidae	Piranga rubra	Summer Tanager	X	0	0	0	0	X	S
Fringillidae	Richmondena cardinalis	Cardinal	X	X	X	X	X	X	P
	Guiraca caerulea	Blue Grosbeak	X	X	0	0	0	X	S
	Passerina cyanea	Indigo Bunting	X	0	0	0	0	X	S
	Hesperiphona vespertina	Evening Grosbeak	0	0	0	X	0	0	W
	Carpodacus purpureus	Purple Finch	0	0	X	0	X	0	W
	Spinus tristis	American Goldfinch	0	0	X	X	0	X	P
	Loxia curvirostra	Red Crossbill	0	0	0	0	X	0	W
	Pipilo erythrophthalmus	Rufous-sided Towhee	X	X	X	X	X	X	P
	Passerculus sandwichensis	Savannah Sparrow	0	0	0	X	0	0	W
	Pooecetus gramineus	Vesper Sparrow	0	0	X	0	X	X	W
	Junco hyemalis	Slate-colored Junco	0	0	X	X	X	0	W
	Spizella passerina	Chipping Sparrow	0	X	X	X	X	X	P
	Spizella pusilla	Field Sparrow	0	0	X	X	X	X	P
	Zonotrichia leucophrys	White-crowned Sparrow	0	0	0	X	X	0	W
	Zonotrichia albicollis	White-throated Sparrow	0	0	X	X	X	0	W
	Melospiza melodia	Song Sparrow	0	0	X	X	X	X	W
Total Species per Survey Period			45	36	46	74	63	63	

Totals: 40 Families; 117 Species

*P-Permanent Resident; S-Summer Resident; W-Winter Resident; T-Transient

117 species of birds recorded were permanent residents (55 species) while 28 species were winter residents, 24 species were summer residents, and 10 species were transients.

5.6.3.1 Wildlife Survey Routes

5.6.3.1.1 Abundance of Birds

The number of birds recorded per route per stop is presented by season in Figure 5.6.1. The highest numbers of birds were recorded during the summer season. Wildlife Survey Routes A and B during the spring and Route A during the summer represent two year averages. The high number recorded on Route C during the spring is because migratory robins and grackles contributed to 72 percent of the total birds in 1973.

The variability of habitats at each stop influences the variety and number of birds recorded. The least number of birds were recorded at stops where loblolly pine was the dominant habitat type while the greatest number were recorded at stops where grassland was the most prevalent habitat. An increase in the diversity of species was usually associated with wildlife-survey-route stop locations surrounded by a variety of habitat types. The high abundance of birds associated with grassland communities was the result, in part, of an increase in the area visible to the observer. In comparison, forested areas effectively reduce visibility, especially when foliage was present.

The evening wildlife surveys conducted in January and March 1972 reflect similar results, with greater abundance of birds at stops from grassland communities as compared to pine communities. The downy woodpecker, Eastern phoebe, and Eastern purple finch were the only species recorded during an evening survey that were not observed during one of the four seasonal morning wildlife surveys conducted in 1971 and 1972. In addition, fewer total birds were observed during the two evening surveys and, consequently, the evening surveys were dis-

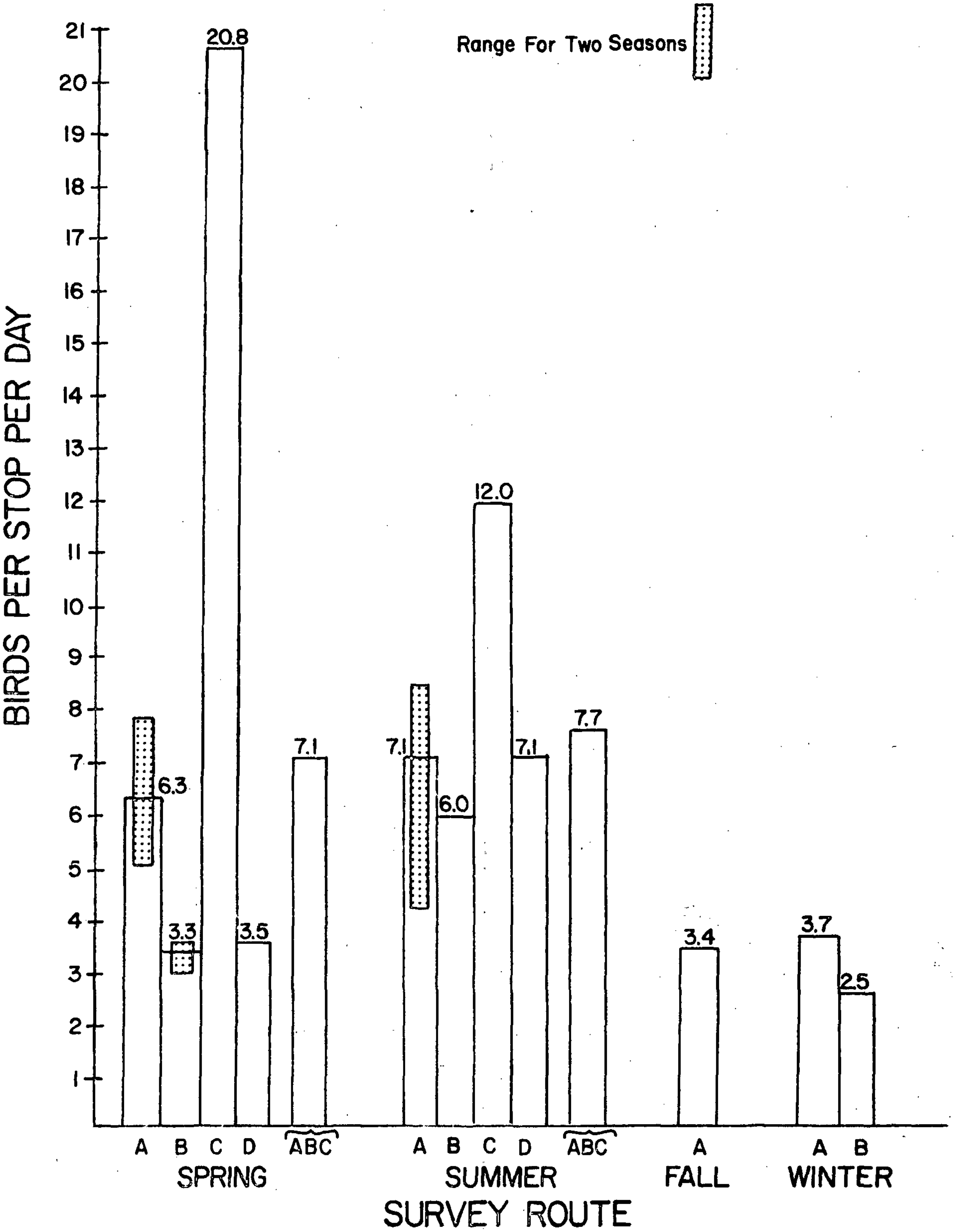

Figure 5.6.1 Average number of birds recorded on each wildlife survey route.

continued.

5.6.3.1.2 Diversity of Birds

It was indicated that the diversity of avian species recorded by the auto wildlife surveys on the Broad River Study Area was usually highest at stops where a variety of habitats occurred.

Survey Route D, initiated in March 1973, was chosen as a control to show whether changes in the abundance and diversity of birds were occurring off as well as on the site. A Chi-square test was used to indicate whether the similarity of avian species was different between the two areas; Route D off the study area, and combined Routes A, B & C on the study area during March and May, 1973. In May the species diversity was not significantly different (26 percent dissimilar). In March, 37.5 percent of the 40 species observed were dissimilar and a significant difference was recorded. The species listed as dissimilar were normally low in abundance with sparce distribution and they were infrequently sighted.

5.6.3.1.3 Fluctuations in Indicator Species

The Wildlife Survey Routes provide information on seasonal abundance and diversity of birds on the Broad River Study Area. An analysis of the seasonal abundance and annual trend in avian populations on the Broad River Study Area will be restricted to a few species chosen as indicators of change in the environment. Before identifying the select species it is important to first describe the criteria used to select indicator species.

Environmental changes, either slight or wide ranging, should cause change in the abundance indices of many avian species. Such avian species would be indicators of these changes in the environment. In order to select indicator species, the following four criteria were used; 1) particular habitat preference, 2) relative abundance, 3) random distribution within the limits of its habitat, and 4) small home range of movement. In addition to these criteria, birds that are permanent residents provide a continuous, more desirable annual index and it is also desirable that each trophic level be represented among the indicator species.

Avian species that have a narrow tolerance limit toward change in the environment, including being limited by preference or selective forces toward a single community type are ideal species as indicators of change. Birds that accept a variety of habitats are least likely candidates as indicators of change.

The second criteria, relative abundance, requires that each species chosen be numerous on the study area such that they are readily observable and a mathematical mean and variance can be calculated during the baseline investigations. It is recognized that the accumulation of observations of several indicator species may prove a better measure of environmental change than an individual species.

A random distribution negates recording several specimens with aggregate distribution on one day and then not recording any on the following day of survey when the group was not observed. The effect of this behavior would result in indices having wide natural fluctuations.

The final criteria requires that the species have a narrow range of movement. If the daily movement of a species covers too large an area, it would result in wide fluctuations in the index.

It is recognized that every likely indicator species will not fit all of these criteria. The following species recorded on the Broad River Study Area have been designated as potential indicators of environmental change based on the above four criteria, however, additions and deletions may occur during the course of the study:

Wood Duck
Great Blue Heron
Mourning Dove
Eastern Bluebird
Mockingbird
Loggerhead Shrike
Red-winged Blackbird
Eastern Meadowlark
Belted Kingfisher

5.6.3.1.4 Game Bird Call Counts

Calling mourning doves were counted during all wildlife auto surveys with the exception of June 1971. The number of doves recorded per stop per survey period was as follows:

Period	Survey Route	Stops	Doves/Stop/Day
Sept. 1971	A	10	0.04
Jan. 1972	A & B	13	0.00
March 1972	A & B	13	0.03
March 1973	A, B, C, & D	61	0.02
May 1973	A, B, & C	30	0.08
May 1973	D	31	0.04

The greatest number of doves heard or seen per stop per day occurred during May 1973. Also, in May 1973, a special two day dove survey was conducted during the two week period that the national dove-call-counts were conducted. The average number of calling doves per stop for the first twenty stops can be used for comparison with the nationally conducted surveys. A total of 15 doves were heard on the two mornings. This represents an average of 0.38 calling doves per stop per day.

The number of calling bobwhite quail heard during each stop along the Wildlife Auto Survey Routes is presented below:

Period	Route	Days	Stops	Quail/Stop/Day
June 1971	A	3	10	1.53
Sept. 1971	A	5	10	0.00
Jan. 1972	A & B	5	13	0.00
March 1972	A & B	5	13	0.04
March 1973	A, B, C, & D	2	61	0.00
May 1973	A, B, & C	3	30	0.35
May 1973	D	3	31	0.22

The data for June 1971 represents an average of 1.53 quail heard per stop per day. The data for May 1973 represents an average of 0.35 quail heard per stop per day on Routes A, B, and C combined. This suggests a decline in quail abundance from 1971 to 1972. Only 0.22 quail were heard per stop per day on Route D. Twenty-five bobwhite quail were heard on twenty stops during the two day special dove survey. This represents an average of 0.63 bobwhite per stop per day.

5.6.3.2 Bird Census

The variety and number of birds per 40 hectares (100 acres) recorded by the strip census method in three general habitat types are shown in Tables 5.6.2 and 5.6.3. Each location chosen for the census of birds is variable in the age structure and species composition of vegetation. Data collected from similar sites, such as pine, were combined to provide a more accurate assessment of bird abundance and species diversity found in each major habitat category. Sampling Site 4, however, where loblolly pine had been selectively removed in March 1972, is presented separately in Table 5.6.2. Another exception, is the separate tabulation of bird abundance on the two grassland communities (Sites 2 and 6). The species diversity between the two grassland communities was significantly different as tested by Chi-square in March (0.05>P>0.025) and in May (0.05>P>0.025).

Nineteen species of birds were recorded by strip census in grassland habitat, 17 in pine forest, and 16 in mixed deciduous-pine forest in March 1973. In May 1973, 20 species of birds were recorded in the grassland habitat and 15 in the pine communities. A strip census was not conducted in the mixed deciduous-pine forest. The greatest number of birds per 40 hectares (100 acres) occurred in the grassland habitat during both sampling periods.

The combined strip census and census transect data (Tables 5.6.2 and 5.6.3) show that 25, 16, and 17 species were recorded in the pine, grass-

Table 5.6.2 Birds recorded by strip census and census transects in various habitats on the Broad River Study Area, March 1973.

	Strip Census					Census Transects	
Common Name	Pine Forest	Cut Pine Site 4	Grassland Site 2	Grassland Site 6	Mixed	Grassland	Mixed
Turkey Vulture	1	-	-	-	1	-	-
Cooper's Hawk	1	-	-	-	-	-	-
Marsh Hawk	-	-	-	-	-	1	-
Red-shouldered Hawk	-	-	-	-	1	-	-
Unidentified Hawk	-	-	-	-	1	-	-
Bobwhite	-	-	-	2	6	11	9
Belted Kingfisher	-	-	-	1	-	-	-
Yellow-shafted Flicker	2	-	-	-	-	1	-
Red-bellied Woodpecker	-	-	-	-	1	-	-
Hairy Woodpecker	-	1	-	-	1	-	-
Unidentified Woodpecker	1	-	-	-	-	-	-
Blue Jay	1	-	-	-	-	-	-
Carolina Chickadee	6	2	1	-	2	1	-
Tufted Titmouse	1	-	1	-	-	-	-
Brown-headed Nuthatch	2	-	-	-	-	-	-
Unidentified Nuthatch	1	-	-	-	-	-	-
Brown Creeper	-	-	-	-	2	-	-
Carolina Wren	1	-	-	-	6	4	-
Unidentified Wren	-	-	-	-	1		-
Mockingbird	-	-	-	-	-	1	-
Brown Thrasher	-	-	-	-	-	1	-
Robin	1	-	-	-	-	2	-
Hermit Thrush	2	-	-	-	-	-	-
Unidentified Thrush	-	1	-	-	3	-	-
Golden-crowned Kinglet	7	-	-	-	-	-	-
Ruby-crowned Kinglet	1	-	-	-	1	-	-
Unidentified Kinglet	1	-	-	-	2	-	-
Blue-winged Warbler	6	-	-	-	-	-	-
Myrtle Warbler	-	-	-	-	3	-	-
Unidentified Warbler	-	-	-	-	9	-	-
Eastern Meadowlark	-	-	20	2	-	2	-
Common Grackle	1	-	-	-	-	-	-

Table 5.6.2 (Continued)

	Strip Census					Census Transects	
		Cut Pine	Grassland	Grassland			
Common Name	Pine Forest	Site 4	Site 2	Site 6	Mixed	Grassland	Mixed
Cardinal	-	-	-	-	3	4	-
Rufous-sided Towhee	1	1	-	-	1	5	-
Slate-colored Junco	-	-	-	-	-	8	-
Chipping Sparrow	-	1	-	1	-	4	-
Field Sparrow	-	-	-	3	-	-	2
White-throated Sparrow	-	-	-	-	3	3	3
Song Sparrow	5	-	-	-	5	2	-
Unidentified Sparrow	1	-	7	7	-	3	2
Unidentified Birds	3	-	-	-	5	-	-
Total Birds	46	6	29	16	57	53	16
Number of Species	17	5	4	5	17	15	3
Area censused (ha)	20.2	5.6	5.8	7.3	11.0	-	-
Birds per 40 hectares	92	44	201	89	63	-	-

Table 5.6.3 Birds recorded by strip census and census transects in various habitats on the Broad River Study Area, May 1973.

	Strip Census			Transect		
	Pine	Grassland Site 2	Grassland Site 6	Pine Site 3B	Selectively Cut Pine Site 4	Mixed
Black Vulture	-	-	2	-	-	-
Broad-winged Hawk	-	-	-	-	1	-
Bobwhite	-	3	4	-	-	-
Mourning Dove	-	1	-	-	-	-
Yellow-billed Cuckoo	4	-	-	-	-	-
Chimney Swift	2	-	3	-	-	-
Unidentified Woodpeckers	-	-	-	-	-	2
Eastern Kingbird	-	-	4	-	-	-
Great Crested Flycatcher	1	-	-	-	-	-
Eastern Wood Pewee	1	-	-	-	-	8
Barn Swallow	-	3	1	-	-	-
Tree Swallow	2	-	-	-	-	-
Blue Jay	5	-	1	-	-	1
Fish Crow	-	-	-	-	-	3
Carolina Chickadee	-	-	-	2	-	1
Tufted Titmouse	2	-	-	-	-	3
Brown-headed Nuthatch	-	-	-	4	-	-
Carolina Wren	-	-	-	-	3	-
Mockingbird	2	2	-	-	-	-
Robin	1	-	-	-	-	2
Wood Thrush	1	-	-	-	-	-
Blue-gray Gnatcatcher	-	-	-	-	2	-
Red-eyed Vireo	-	-	-	-	-	1
Blackpoll Warbler	4	-	-	-	-	-
Pine Warbler	2	-	-	-	-	-
Prairie Warbler	5	8	1	-	1	-
Yellowthroat	-	-	3	-	-	-
Yellow-breasted Chat	-	-	3	-	-	-
Unidentified Warbler	7	-	-	-	-	2
Eastern Meadowlark	-	5	4	-	-	-

Table 5.6.3 (Continued)

	Strip Census			Transect		
	Pine	Grassland Site 2	Grassland Site 6	Pine Site 3B	Selectivity Cut Pine Site 4	Mixed
Red-winged Blackbird	-	-	9	-	-	-
Common Grackle	-	2	10	-	-	3
Brown-headed Cowbird	-	1	-	-	-	-
Summer Tanager	-	-	-	-	-	3
Cardinal	2	-	-	1	-	1
Blue Grosbeak	-	-	5	-	-	-
Indigo Bunting	-	2	7	-	-	-
American Goldfinch	-	-	1	-	-	-
Rufous-sided Towhee	1	-	-	2	2	-
Vesper Sparrow	-	1	-	-	-	-
Field Sparrow	-	3	6	-	-	-
Unidentified Sparrow	-	4	1	-	-	-
Unidentified Birds	17	4	3	2	1	17
Total Birds	59	39	68	11	10	47
Number of Species	15	11	16	4	5	10
Area censused (ha)	11.1	6.4	7.3	-	-	-
Birds per 40 hectares	216	252	378	-	-	-

land, and mixed deciduous-conifer communities respectively, in March, and 18, 20, and 11 species, respectively, were observed in May 1973. As expected, the species diversity between habitats for each season was not similar.

5.6.3.3 Waterfowl Survey

Twenty-two species of waterfowl and shorebirds were observed along the Broad River between the Enoree River and Parr Reservoir during four sample periods; March and November, 1972, and March and July, 1973 (Table 5.6.4). It was assumed that the occurrence of waterfowl in specific areas indicates seasonal preference and use. Table 5.6.4 shows that migratory and wintering waterfowl were found in all of the assigned divisions of the survey route, however, most of them were flushed near Frees Creek, Cannons Creek, and the broad expanse of water retained by Parr Dam. Wood ducks, the major breeding waterfowl in South Carolina, were most abundant in the Enoree River during the spring and fall as well as in Hellers Creek and near Frees Creek during the fall season.

Two wood duck broods were observed during the July 1973 waterfowl survey. A single brood (7 ducklings) was seen in a pond adjacent to the mouth of the Enoree River. The second brood (one duckling) was seen at the west end of the impounded portion of Hellers Creek.

5.6.3.4 Additional Findings

5.6.3.4.1 Suitable Wood Duck and Other Game Bird Habitat

An assessment was made of the vegetation composition in upper, middle, and lower story; crown density; and the presence of visible cavities in each of the four areas examined during the November 1972 sample period.

The hike along lower Frees Creek commenced at the Southern Railroad Railway bridge that spans Frees Creek near its confluence with the Broad River and ended some 4.1 km (2.5 miles) upstream. The lowland deciduous forest was composed primarily of oak, sycamore, ash, and hickory. Pine formed the

Table 5.6.4 Maximum waterfowl and shorebirds seen any one day along the boat survey route during four study periods.

	Broad & Enoree River north of Blair, S.C.				Broad River from Blair south to Hellers Creek				Hellers Creek				Broad River from Hellers Creek to Frees Creek			
	1972		1973		1972		1973		1972		1973		1972		1973	
Common Name	Mar	Nov	Mar*	Jul*	Mar	Nov	Mar*	Jul*	Mar	Nov*	Mar*	Jul*	Mar	Nov	Mar*	Jul*
Eared Grebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pied-billed Grebe	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Unidentified Grebe	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mallard	7	1	2	1	4	-	2	-	2	13	-	-	5	-	-	-
Black Duck	-	-	-	-	-	-	-	-	-	5	-	-	4	-	-	-
Pintail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shoveler	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blue-winged Teal	2	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-
Wood Duck	23	24	15	10	2	9	2	1	1	32	10	2	-	1	2	-
Ring-necked Duck	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
Unidentified Scaup	-	-	-	-	-	-	-	-	-	-	19	-	-	-	-	-
Bufflehead	-	1	-	-	-	3	-	-	-	-	-	-	4	-	-	-
Ruddy Duck	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
Common Merganser	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Hooded Merganser	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Unidentified Merganser	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
Common Egret	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Great Blue Heron	4	3	-	1	5	11	1	1	2	5	1	3	-	5	3	1
Green Heron	-	-	-	2	-	-	-	4	-	-	-	3	-	-	-	3
Black-crowned Night Heron	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
American Coot	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Spotted Sandpiper	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Ring-billed Gull	-	-	-	-	-	-	3	-	-	-	4	-	-	-	-	-
Belted Kingfisher	-	1	2	2	-	2	-	8	-	3	1	4	-	1	2	2
Unidentified Ducks	6	7	3	-	2	30	-	-	1	-	-	-	2	-	31	-
Minimum No. of Species	5	7	3	5	6	6	5	5	4	5	6	5	4	4	3	3

* Two day observation
** One day observation

Table 5.6.4 (Continued)

	Frees Creek				Cannons Creek				Parr Reservoir			
	1972		1973		1972		1973		1972		1973	
Common Name	Mar	Nov*	Mar*	Jul*	Mar	Nov**	Mar*	Jul*	Mar	Nov	Mar*	Jul*
Eared Grebe	-	-	-	-	-	-	-	-	-	1	-	-
Pied-billed Grebe	-	1	-	-	-	-	-	-	-	-	-	-
Unidentified Grebe	-	-	-	-	1	-	-	-	-	-	-	-
Mallard	2	-	14	2	2	5	-	-	18	1	17	-
Black Duck	7	12	-	-	-	-	-	-	12	-	4	-
Pintail	-	-	1	-	-	-	-	-	-	-	-	-
Shoveler	-	-	-	-	-	-	-	-	-	-	-	-
Blue-winged Teal	-	-	-	-	-	-	1	-	3	-	-	-
Wood Duck	-	28	13	4	-	3	-	-	-	-	4	2
Ring-necked Duck	-	-	-	-	-	-	-	-	-	2	6	-
Unidentified Scaup	-	-	-	-	-	-	-	-	71	15	54	-
Bufflehead	-	-	-	-	-	-	-	-	5	3	24	-
Ruddy Duck	-	6	-	-	-	-	-	-	-	22	-	-
Common Merganser	-	-	-	-	-	-	-	-	1	-	-	-
Hooded Merganser	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified Merganser	-	-	-	-	-	-	-	-	-	-	-	-
Common Egret	-	-	-	1	-	-	-	-	-	-	-	-
Great Blue Heron	4	12	5	1	4	5	3	1	2	2	2	1
Green Heron	-	-	-	6	-	-	-	3	-	-	-	-
Black-crowned Night Heron	-	-	-	-	-	-	-	-	-	-	-	-
American Coot	-	-	-	-	-	1	-	-	4	34	-	-
Spotted Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-
Ring-billed Gull	-	-	-	-	-	-	-	-	-	-	-	-
Belted Kingfisher	-	3	2	4	-	-	2	-	-	-	1	-
Unidentified Ducks	2	-	2	-	2	-	2	-	4	-	-	-
Minimum No. of Species	3	6	5	6	3	4	3	2	8	8	8	2

* Two day observation
** One day observation

forest on the upland sides of the flood plain valley.

Both pine and deciduous trees with a dbh between 23 and 38 cm (9 and 15 in) at cut surface, had been removed in several localities along Frees Creek. Sedge, spikerush, cane, raspberry, and honeysuckle were beginning to develop under the open canopy. A transmission line right-of-way contained the highest density of middle and lower story vegetation encountered during the hike.

Tree cavities were most frequently observed in the first quarter-mile of the hike, near the railroad bridge. Oak, shagbark hickory, and sycamore trees contained visible cavities. Few cavities were observed in trees in more northern areas of the 4.1 km traveled.

The pond at Dawkins was entirely surrounded by a lowland deciduous forest with a closed canopy. A middle story was absent and a mixture of grass-sedge was found on the flooded south end. Only a few cavities in sycamore and cottonwood trees were noticed.

The pond on Terrible Creek was bordered on the east, north, and west by a forest of cottonwood, ash, and oak. The more upland, southern side, consisted of loblolly pine with a middle story absent. Willow and other shrubs bordered the eastern side of the pond. Lower story vegetation bordering the pond was predominantly smartweed and sedge. Tree cavities were not noticed around Terrible Creek.

A lowland forest of oak, cottonwood, ash, and pine bordered the Broad River between Dawkins and Terrible Creek. The middle story consisted primarily of cottonwood, especially where the ground had been cleared for cultivation and abandoned. Infrequent patches of cane and smartweed were observed under the partially open forest canopy. A few cavities were seen in sycamore and cottonwood trees.

5.6.3.4.2 Birds Inadvertently Snap Trapped

During the March 1972 sample period, three savannah sparrows (Passerculus sandwichensis) were collected in snap traps on the grassland, Site 2 (map, back cover). On Study Site 4, a pine forest, a broad-winged hawk (Buteo platypterus) was caught during the June 1971 sample period and a hermit thrush (Hylocichla guttata) was caught during the March 1972 sample period. An oven-bird (Seiurus aurocapillus) was caught in a snap trap on Study Site 1 in March 1972.

5.6.4 DISCUSSION

A total of 234 bird species may utilize the Broad River Study Area during their seasonal migrations (Peterson 1947; Robbins, Bruun and Zim 1966; Columbia Bird Club 1967; Sprint and Chamberlain 1970). This includes 65 permanent residents, 50 winter residents, 43 summer residents, and 76 transient residents. Of these, 81 percent, 56 percent, and 13 percent, respectively, were observed and included in the 117 species recorded on the Broad River Study Area (Table 5.6.1).

An annual Christmas bird countin the Columbia, South Carolina area was initiated in 1959 under the direction of the National Audubon Society. Eighty-six species of birds have been recorded during the last five annual Christmas bird counts (Table 5.6.5). These counts are taken in Richland and Lexington Counties within a 24.1 km (15 mile) diameter circle with its center at the intersection of Gills Creek and Bluff Road approximately 48.2 km (30 miles) southeast of the project site. The sampled area is 25 percent deciduous forest along river and creek swamps, 20 percent pine woods, 30 percent fields, 20 percent lake shores, and 5 percent urban. This area is quite different from the Broad River Study Area in which pine woods are more abundant, the proportion of deciduous forest, fields, and lake shores is less, and urban areas are nearly absent.

Table 5.6.5 Annual Christmas Bird Counts taken by National Audubon Society near Columbia, South Carolina in 1968, 1969, 1970, 1971, and 1972 (Cruikshank 1969; 1970; 1971; Gilbert Bristow, pers. comm.).

Common Name of Species Observed	Number of Individuals Counted				
	1968	1969	1970	1971	1972
Pied-billed Grebe	9	4	7	7	10
Great Blue Heron	6	0	1	3	2
Common Egret	0	0	0	0	4
Mallard	6	6	8	0	4
Black Duck	0	8	0	0	0
Wood Duck	1	11	0	2	10
Ring-necked Duck	116	22	2	2	34
Lesser Scaup	0	14	0	1	0
Ruddy Duck	0	0	1	0	0
Turkey Vulture	0	1	0	3	0
Black Vulture	3	7	0	7	3
Cooper's Hawk	0	1	0	1	1
Red-tailed Hawk	3	7	1	10	27
Red-shouldered Hawk	7	3	2	6	2
Marsh Hawk	2	3	2	1	15
Sparrow Hawk	12	4	5	8	16
Bobwhite	23	1	22	4	22
American Coot	20	20	21	22	36
Killdeer	12	19	12	22	44
American Woodcock	0	1	0	0	0
Common Snipe	0	1	0	0	0
Herring Gull	1	0	0	8	0
Ring-billed Gull	123	33	115	71	210
Mourning Dove	175	252	19	154	16
Barn Owl	0	1	1	0	0
Great Horned Owl	1	0	0	0	0
Belted Kingfisher	2	5	1	7	2
Yellow-shafted Flicker	7	14	16	60	39
Pileated Woodpecker	1	2	2	2	5
Red-bellied Woodpecker	4	4	5	24	10
Red-headed Woodpecker	0	5	0	7	11
Yellow-bellied Sapsucker	7	4	5	17	18
Hairy Woodpecker	2	1	1	3	1
Downy Woodpecker	17	6	3	8	2
Red-cockaded Woodpecker	0	0	0	1	0
Eastern Phoebe	5	3	1	7	0

Table 5.6.5 (Continued)

Common Name of Species Observed	Number of Individuals Counted 1968	1969	1970	1971	1972
Blue Jay	37	61	43	52	94
Common Crow	26	20	18	50	24
Carolina Chickadee	18	32	12	39	23
Tufted Titmouse	4	7	11	6	9
White-breasted Nuthatch	0	0	0	0	4
Brown-headed Nuthatch	15	2	2	3	3
Brown Creeper	2	0	1	0	0
Winter Wren	0	0	0	0	1
House Wren	0	0	1	0	0
Carolina Wren	5	12	8	27	31
Mockingbird	25	42	31	28	69
Catbird	0	0	1	0	0
Brown Thrasher	9	10	11	3	22
Robin	152	31	108	23	68
Hermit Thrush	2	2	4	5	0
Eastern Bluebird	31	4	8	12	11
Golden-crowned Kinglet	5	3	1	4	2
Ruby-crowned Kinglet	8	18	12	24	37
Water Pipit	19	0	150	25	0
Cedar Waxwing	17	0	27	17	4
Loggerhead Shrike	9	1	8	8	9
Starling	1,100	680	311	182	290
Solitary Vireo	1	0	0	0	0
Myrtle Warbler	0	13	1	4	7
Pine Warbler	3	14	1	7	0
Palm Warbler	0	0	0	0	8
English Sparrow	91	248	0	0	141
Eastern Meadowlark	118	297	180	205	147
Red-winged Blackbird	11,350	10,350	1,521	2,442	3,477
Baltimore Oriole	0	0	0	2	0
Rusty Blackbird	1	1	0	0	0
Brewer's Blackbird	0	0	40	3	40
Common Grackle	31	611	38	610	422
Brown-headed Cowbird	35	451	200	220	160
Cardinal	88	314	53	90	95
Evening Grosbeak	37	0	0	22	150
Purple Finch	2	88	0	3	17
Pine Siskin	10	24	0	0	0

Table 5.6.5 (Continued)

Common Name of Species Observed	Number of Individuals Counted				
	1968	1969	1970	1971	1972
American Goldfinch	46	211	103	53	87
Rufous-sided Towhee	43	130	31	47	97
Savannah Sparrow	15	17	51	506	185
Vesper Sparrow	19	1	0	0	13
Slate-colored Junco	133	57	232	5	64
Chipping Sparrow	11	6	3	2	7
Field Sparrow	59	41	71	25	145
White-crowned Sparrow	3	0	0	0	0
White-throated Sparrow	264	202	221	219	420
Fox Sparrow	1	0	5	2	2
Swamp Sparrow	3	2	0	2	6
Song Sparrow	45	64	31	37	81
Species per Year	67	66	60	66	64
Total Individuals	14,456	14,530	3,803	5,475	7,009

The evening grosbeak observed during the March 1972 sampling period was the only bird recorded that was not listed as a bird occurring in South Carolina (Sprunt and Chamberlain 1970). However, it also was observed during the 1968, 1971, and 1972 Christmas bird counts.

The three red crossbills observed on Survey Route D in March 1973 are considered a rare and irregular winter resident in South Carolina according to Sprunt and Chamberlain (1970).

5.6.4.1 Endangered or Threatened Species

The American osprey recorded on the Broad River Study Area during the June 1971 and March 1972 sampling periods (Table 5.6.1) is listed as "Status Undetermined" (e.g., additional information needed to determine status) by the U.S. Bureau of Sport Fisheries and Wildlife (1973). National Audubon Society biologists now feel that the number of osprey appears to be declining and have included it on their "Blue List" (Anon. 1971). Other populations observed on the study area that may be declining and thus appear on the "Blue List" include the double-crested cormorant, black-crowned night heron, turkey vulture, black vulture, marsh hawk, Bewick's wren, and loggerhead shrike.

The eastern pigeon hawk, also included as "status - undetermined" by the U.S. Bureau of Sport Fisheries and Wildlife (1973), has not been recorded on the Broad River Study Area. This bird of prey winters from southern Texas, east to South Carolina and south to the West Indies and northern South America. According to Sprunt and Chamberlain (1970), the eastern pigeon hawk is a fairly common winter resident over much of the state but most frequent along the coast. The pigeon hawk frequents open country, fields, beaches, and marshes.

The southern bald eagle, red-cockaded woodpecker, and Bachman's warbler, known from South Carolina, are listed as threatened species by the U.S. Bureau of Sport Fisheries and Wildlife (1973).

The southern bald eagle is a fairly common permanent resident of the coastal region of South Carolina (Sprunt and Chamberlain 1970). Nesting primarily in estuarine areas of the Atlantic and Gulf Coasts, the bald eagle is locally common from New Jersey to Texas, and lower Mississippi Valley southward from eastern Arkansas and western Tennessee, and through southern states west to California and Baja California.

Eagles nest in mid-winter and actively migrate during the spring and summer, remaining in the southeast, or traveling as far north as southeastern Canada. They return in the fall and early winter. One adult bald eagle was observed at Parr Reservoir by personnel of the South Carolina Electric and Gas Company in early August, 1973, during this migratory period. No nests have been seen during any of the field work conducted by Dames & Moore personnel.

The red-cockaded woodpecker is not known to be on the Broad River Study Area, although it was observed near Columbia during the 1971 Christmas bird count (Table 5.6.5). Recent investigations have not discovered this species in Fairfield or Newberry Counties, South Carolina (Jackson 1971). The red-cockaded woodpecker has a strong habitat preference for open, mature pine forests and a nest site preference for pines that are infected with red heart disease.

Bachman's warbler is listed as a threatened species by the Office of Endangered Species and International Activities of the Department of the Interior (U.S. Bureau of Sport Fisheries and Wildlife 1973). The warbler's present distribution is known only from recent observations of non-breeding individuals in Virginia, Alabama, and near Charleston and the Francis Marion National Forest, South Carolina. So few individuals are seen that little is known of its present breeding or wintering distribution. The former breeding distribution included the river swamp forests of southeastern Missouri, northeastern Arkansas, western Kentucky, central Alabama, and South Carolina.

Migrations to and from the wintering range in Cuba, is during early spring and fall (Chapman 1968). Spring migration, through Florida, occurs in March and fall migration occurs in July and August.

The nesting habitat described from near Charleston, South Carolina, in 1906 included heavily timbered, swampy land with more or less stagnant water. The few nests found in Missouri, South Carolina, and Kentucky were in low brushes, briers, or canes less than one meter (two to three feet) above the ground. Habitat comparable to this description only occurs in small, local areas on the Broad River Study Area.

5.6.4.2 Song Birds

5.6.4.2.1 Diversity

The three different terrestrial bird census methods employed on the Broad River Study Area contributed to the accumulative list of birds. The morning wildlife survey routes conducted during six seasons contributed 62.6 percent of the total 117 species identified on the study area. The avian strip census and census transects contributed 50.4 percent of the total species observed in March and 64.4 percent of the 90 species identified in May. The majority of waterfowl and shorebirds were recorded during the censuses on the Broad River.

The comparison of bird diversity between the control Route D and Routes A, B, and C showed that the on-site and off-site routes were comparable during May 1973. A significant difference was found in March 1973 but the species that were dissimilar were low in abundance, therefore, it was concluded that the species diversity was similar between routes during the spring as well as the summer.

5.6.4.2.2 Abundance

Only a general consideration of the abundance of birds will be made at this time. Each of the nine avian species that were selected as indicators of environmental change will be looked at more intensely once the construction phase has begun.

The degree to which the chosen indicator species meets each of the four previously mentioned selection criteria varies. All of the indicator species meet the first criteria except the mockingbird. The mockingbird utilizes a variety of habitat types throughout the year. The relative abundance of all nine species is considered sufficient for analysis. However, the relative abundance of the loggerhead shrike is low, but it is included in the list because shrikes are seen with some regularity. The criteria of random distribution is met by the great blue heron, mockingbird, loggerhead shrike, and belted kingfisher. Breeding behavior or gregarious behavior in the spring and fall are the primary reasons that the remaining species do not comply with this criteria. The fourth criteria, that of having a restricted range of movement, is met by the Eastern meadowlark, and belted kingfisher. The wood duck and great blue heron are generally restricted to the aquatic environs of the Broad River and adjoining tributaries. The mourning dove and mockingbird are usually wide-ranging in their movements.

The aquatic species, wood duck, great blue heron, red-winged blackbird, and belted kingfisher, should show changes in abundance and distribution with the proposed increase in aquatic environs and a change in shorelines. The direction and amount of change should be detected during future operational investigations.

The abundance of birds, based on the auto survey routes, was highest in the spring and summer seasons. The most abundant species in the pine forest in March 1973 were the Carolina chickadee, golden-crowned kinglet, blue-winged warbler, and song sparrow. In May, the blue jay and prairie warbler were most abundant.

In the grassland habitats censused, an increase in avian abundance corresponded to an increase in diversity, as well as changes in behavior. The number of bobwhite quail and field sparrows increased whereas the number of meadowlarks declined as a result of the population establishing territories.

5.6.4.2.3 Distribution

The ecology of an area, such as the Broad River Study Area, is the result of the interrelationships that exist among the numerous species of invertebrates, vertebrates, flora and the physical environment. Natural selection among birds has developed a diverse avifauna which utilize the broad spectrum of vegetation communities, food sources, and physical environment. Habitat and food preferences are two attributes of an ecosystem that influence the diversity, abundance, and distribution of birds.

Monticello Impoundment will inundate approximately 47 percent pine forest, 12 percent grassland, 15 percent deciduous forest and 26 percent mixed pine-deciduous forest. The percentage of habitat types represented on the wildlife survey routes is shown below:

	ROUTE		
Habitat	A and B (1 mile interval) 14 Stops	A, B, and C (1/2 mile interval) 30 Stops	D (1/2 mile interval) 31 Stops
Pine	50	47	46
Grassland	35	38	29
Deciduous	1	1	8
Mixed pine-deciduous	15	14	15
Adjacent to water	0	0	2

The diversity and abundance of species were varied along the wildlife survey route as a result of the configuration of habitats at each stop. A change in the habitat configuration of the Broad River Study Area will lead to a change in species diversity, abundance, and distribution.

Habitat preference is a major factor in determining the distribution of birds on the Broad River Study Area. Chickadees, kinglets, warblers, and nuthatches typically associated with pine communities are widely distributed because of the predominance of pine. The kingbirds, meadowlarks, grackles, indigo buntings, hawks, and other species associated with grassland habitats will be less widely distributed because of the limited amount of grasslands available on the study area. Most species like the bobwhite quail, towhees, and sparrows are not habitat specific and are found in various habitats, thus having a broad distribution.

Figure 5.6.1 shows the seasonal abundance of birds as recorded by the morning wildlife survey routes. The strip census and census transect methods (Table 5.6.2 and 5.6.3) show composition and abundance in specific habitats. The strip census method is best suited for more or less open country (cropland or old field habitat). The reduced visibility of birds in woodland or dense shrub habitat probably affect the accuracy of this census technique (Graber and Graber 1963).

The food habits of birds also describes some of the interrelationships and adaptations of birds toward the flora and fauna. The principle foods of each bird provides a clue to its role in the food web and flow of energy in the Broad River Study Area.

Plants, macroinvertebrates, and vertebrate animals known to occur in the diet of birds in the southeast are discussed by Martin, Zim, and Nelson (1951). Only food items that occur in at least two percent of the diet are considered for the following discussion. The degree that a particular plant or animal is used would depend on the abundance of the plant or animal and the abundance of other palatable plant or animal species.

Grebes, cormorants, herons, egrets, and mergansers are secondary and tertiary consumers that feed on aquatic macroinvertebrates and fish. Waterfowl and coots are primary, secondary, and occasionally tertiary consumers feeding on macroinvertebrates as well as seeds, leaves, and roots of plants. Raptors (hawks and owls) are secondary or tertiary consumers that feed on macroinvertebrates, reptiles, amphibians, small birds, and small mammals. However, the osprey feeds primarily on fish and hence is principally a tertiary consumer. Carrion feeders include the turkey and black vultures, raptors, and herring gull. The herring gull is also a predator (secondary or tertiary consumer).

Birds that feed almost exclusively on invertebrates include the members of the following families: Cuculidae, Caprimulgidae, Tyrannidae, Hirundinidae, Sylviidae, and a few members of the Parulidae family. All other families are primary and secondary or tertiary consumers with plant and animal foods in their diets.

5.6.4.3 Game Birds

5.6.4.3.1 Diversity

Game birds present on the Broad River Study Area include the wild turkey, American woodcock, mourning dove, bobwhite quail, wood duck, and mallard duck. Additional migratory waterfowl are also common during the late fall and winter seasons.

5.6.4.3.2 Abundance and Distribution

The wild turkey was reintroduced into the Enoree District of the Sumter National Forest in 1951. The first legal hunt was in the spring of 1960 and a spring "gobbler" hunt has continued to the present year. The wild turkey population has increased in response to management; consequently the range of the wild turkey population has also expanded and small flocks have been sporadically sighted in the Frees Creek and adjacent Broad River watersheds. The approximate boundary of wild turkey distribution includes a portion of the Piedmont along the Broad River flood plain (Spinks 1966), including the Broad River Study Area.

According to Spinks (1966), the most favorable habitat for turkeys is composed mainly of mature open hardwoods, with some brushland, grassland, and cultivation.

The Frees Creek watershed is reported to be fair to good wild turkey habitat (Walter Schrader, pers. comm.). The mixture of bottomland oak, pine, and upland abandoned fields is potentially good habitat that may provide seasonally abundant food and shelter for males, nesting females, and poults. The diet of the turkey, a primary and secondary consumer, includes invertebrates, fruits, leaves, and buds of numerous plants.

One American woodcock was observed on the Broad River Study Area during November 1972 and one was observed during the Christmas bird count near Columbia (Table 5.6.5). Sprunt and Chamberlain (1970) indicate that woodcock breed regularly in South Carolina. However, the breeding population is too low to warrant the establishment of woodcock singing-ground surveys (Eldon R. Clark, pers. comm.).

The mourning dove is a permanent resident and hunted as a game bird in South Carolina. In North Carolina, migration activity reaches its peak in March and the number of doves is variable until the end of April (Quay 1954). Nesting begins in late March and increases steadily during April and numbers become stabilized in May (Quay 1954). Flocks are common until nesting begins and the sighting of pairs becomes a regular occurrence. A similar sequence of events would occur in South Carolina. Duever and Fatora (1968) found the peak of annual morning and evening dove activity (frequency of sightings) occurs principally in May at the AEC Savannah River Plant. The number of calling doves also reaches its peak in the morning during May in North Carolina (Quay 1954) and in Florida (Winston 1954).

Call-count surveys have been established and run in May since the early 1950's (Ruos 1971a; Southeast Association of Game and Fish Commissioners 1957). This survey technique for obtaining abundance indices by calling male counts is well established (Bennitt 1951; Hanson and Kossack 1963; Preno and Labisky 1971; Robel, Dick, and Krause 1969; Ruos 1971a and b). State-wide trends in mourning dove breeding density indices in South Carolina were significantly greater in 1970 than in 1960 (Ruos 1971a). Breeding population density indices continued to increase from 1970 to 1971 (Ruos 1971b).

An increase in hunter success is an index to an increase in population density. Ruos (1970) records a state-wide increase of the average number of successful hunts per hunter from 2.1 hunts in 1967 to 2.7 hunts in 1969. During the same years the average daily bag per hunter increased from 6.6 birds to 8.5 birds. The average seasonal kill per hunter increased from 14.0 birds in 1957 to 22.9 birds in 1969.

Amend (1969) counted the numbers of mourning doves heard on "....25 call-count routes in a 10-county intensive study area and 45 call-count routes in a 33-county extensive study area" in South and North Carolina. The 43 counties are located in the Coastal Plain and Piedmont physiographic regions. Mourning dove densities are reported to be the highest in the nation around the Carolina Sandhills National Wildlife Refuge, near McBee, South Carolina. During the May-June period, 49.0 doves were heard per route in 1968 and 49.7 doves were heard per route in 1969 on the intensive study area. On the extensive area, 38.8 and 37.5 doves were heard per route in 1968 and 1969, respectively.

Twenty of the 33 extensive survey routes represent the 20 national mourning dove call-count survey routes in South Carolina. One of these routes (#0100, Union-Chester), is approximately 16 km (10 miles) north of the Broad River Study Area and extends east. On this route, seven doves were heard in May 1971, eight were heard in May 1972, and six doves were heard in May 1973 (Ruos, pers. comm.). A similar number of mourning doves (seven) were heard on the call-county survey on the Broad River Study Area in May 1973. The number of cooing doves was fewer than the average number of doves recorded on all 20 call-count survey routes in South Carolina. Duever and Fatora (1968) observed between 72 and 76 mourning doves during two two-week periods in May near the AEC Savannah River Plant. This represents an average of 4.9 doves per 20 miles per day and 5.2 doves per 20 miles per day, respectively.

The mourning dove is not an abundant game bird in the Broad River Study Area. If the environs of the study area included an adequate habitat, mourning doves would probably be seen and heard at a much greater frequency during the spring. There appears to be sufficient nesting habitat for the doves but the abundance of small grain crops for food is limited. The mourning dove's diet is almost 100 percent plant material during each of the four seasons.

A breeding population of bobwhite was present on the Broad River Study Area. According to the results of the wildlife surveys, calls of non-breeding males had ceased by early September 1971 but resumed by the March 1972 sampling period. According to Fatora and Duever (1968) the activity (frequency of sightings) of bobwhite in South Carolina was highest in May. Morning was considered the peak period of male calling activity. The evening surveys during the March 1972 sampling period did not record calling males even though morning surveys indicated their presence. Earlier studies in South Carolina have found an evening period of bobwhite activity (Factora and Duever 1968). Rosene (1969) found that the highest number of bobwhite in the southern United States occurs in the June 15 to July 10 interval.

The June 1971 and May 1973 sampling periods provide two years of indices to bobwhite quail abundance on the Broad River Study Area. Bobwhite call-count surveys, to our knowledge, are not being conducted elsewhere in South Carolina to provide comparative data.

Seasonal sampling programs in the Broad River Study Area, and in particular, the vicinity of Monticello Impoundment, have not flushed many quail in the pine stands. The majority were near field borders or forested areas where lower story vegetation provided suitable cover.

The adult bobwhite quail feeds primarily on plant foods throughout the year (primary consumer). The young chicks feed primarily on animal foods (secondary consumer). A low abundance and sparse distribution of preferred seed producing and leafy plants may also be a factor limiting their abundance in the pine communities.

South Carolina State Game Biologists conducted a midwinter waterfowl survey on the Broad River from Lockhart through Parr Dam. On the 5 January 1972 Survey, biologists counted 40 mallards, 6 black ducks, 51 wood ducks, and 53 Canada geese (Walter Schrader pers. comm.). Migratory waterfowl utilize the Broad River and its tributaries in the fall and spring as verified by November and March surveys.

The number of wood ducks fluctuated seasonally. The variability in the number of wood ducks observed in the seven areas (Table 5.6.4) provides a clue to the suitability of habitat.

Habitat requirements of the wood duck are briefly summarized (McGilvrey 1968) so they may be compared with the habitat conditions of the area.

Breeding Habitat

Hardwood bottomlands along streams or temporarily flooded lowlands attract breeding pairs of wood ducks. A fairly closed crown cover and a middle story of young trees and shrubs which provide lateral cover are important for broods and breeding pairs. Nest cavities need not be near water. Sycamore, water oak, willow oak, and red maple readily form and retain usable cavities and are common to the Broad River Study Area. Adult wood ducks, in general, are vegetarians except during the breeding period when invertebrates form a part of their diet.

Brood Rearing Habitat

Food, cover, and water are all necessary for brood survival. Invertebrates found in association with the shrub vegetation are the primary food supply of the young. Dense shrub cover, permitting broods to move beneath the foliage, is considered optimum. Herbaceous emergents are also important. Waterways of at least 30.5 m (100 ft) in width are desirable for broods to insure safety from predators.

Fall and Winter Habitat

Wood ducks will utilize almost any flooded timber or shrub area that affords visibility of their surroundings. They may travel several miles from feeding areas to evening roost. Acorns, domestic grains, smartweed, buttonbush, ash, bulrush, and burreed supply seeds and fruits in the fall and winter.

Frees and Terrible Creeks may provide acceptable brood habitat but not optimum because of insufficient cover and food. The ponds at Dawkins and Terrible Creek have the necessary components to be considered as fair to good breeding habitat. Ideal brood rearing habitat, however, is limited in these areas as well as along the Broad River. According to Hopkins et al. (1969), the forest north-east of the pond at Terrible Creek floods several times each year. The seeds of ash, gum, and oak trees in this area become readily available to many waterfowl.

The Enoree River bank appears to have many of the qualities of good wood duck breeding habitat, especially tree cavities. Overhanging trees and shrubs for brood cover are present but limited. This area appears to have cover for staging wood ducks gathering in the spring and fall, the time when the ducks were most frequently observed. Ponds located near the mouth of the Enoree River probably have good breeding and brood rearing habitat during spring high water periods. One brood of seven wood ducks was observed here in July 1973. However, low fall water levels may restrict wood duck utilization and increase the likelihood of predation.

Wood ducks were most numerous in Hellers Creek during the November 1972 and March 1973 surveys. The broods seen during the July 1973 survey indicate that wood ducks were nesting in the vicinity. The perimeter of the flooded mouth of Hellers Creek was bordered by overhanging trees and shrubs, which provide a limited amount of brood cover. The better wood duck areas were away from regular public use and located in the upper reaches of Hellers Creek.

The flooded portions of Frees Creek, east of the Southern Railway and paralleling the Broad River, were assessed as fair to good breeding habitat but poor brood rearing habitat. Flooded timber provides an excellent source of cavities for nesting as well as protective cover for adults in the fall. Shrubs that border the flooded areas form a narrow strip along the shoreline, hence, brood cover is limited. However, portions of this area does provide adequate brood cover as well as food in the form of aquatic invertebrates and plants.

The flooded portion of Cannons Creek was quite similar to the habitat at Hellers and Frees Creeks. The amount of flooded lowland is a function of water levels maintained at Parr Reservoir. Nesting habitat appears to be available along the shoreline but brood rearing habitat is limited and restricted to the flooded western end of the creek.

5.6.5 SUMMARY

Changes in the environment are reflected in the abundance, diversity, and local distribution of the avian populations. The baseline investigations, through the utilization of several techniques, are designed to provide a basis to assess future changes in these populations.

A total of 117 species of birds were identified on the Broad River Study Area. The diversity, abundance, and distribution of birds were seasonal and habitat related. More birds were recorded along the auto survey routes during the spring and summer than the fall and winter. The abundance of birds was higher at auto survey stops in grassland communities than selectively cut forests of mixed deciduous-conifer forests and lowest at stops where pine was the major vegetative type.

The density of birds as measured by strip census was also highest in grassland communities. This method is especially suitable in open country. Reduced visibility caused by trees and shrubs may affect the accuracy in woodland habitats. The bird census transects recorded additional species associated with forest habitats and grasslands which were not observed by the strip census method.

Each avian species fulfills a role in cycling energy through the environment. The majority of bird species are omnivores but some are specialized as insectivores or granivores.

Game birds that occur on the study area include the wild turkey, American woodcock, mourning dove, bobwhite quail, and various species of waterfowl. Only a few wild turkey have been reported or seen on the Broad River Study Area. The few sightings are believed to be from a population in the Sumter National Forest, north of the study area. Only one American woodcock was observed on the area and does not represent a significant game resource.

The mourning dove is not an abundant game bird on the study area. This is verified by comparing the number of doves heard on a special calling-dove-survey route on the study area to results obtained by other investigators in South Carolina. These results are not absolute numbers but only an index of a breeding population.

Bobwhite represent another game bird resource on the study area. Our indices and the limited habitat suggest that their abundance is low, however, published literature was not available to support these contentions.

Migratory waterfowl utilize the Broad River and its tributaries during the fall, winter, and spring. Particular emphasis has been placed on the wood duck because it is the major nesting duck in South Carolina. Wood ducks are abundant during the fall and spring on the tributaries and embayments created by Parr Reservoir.

Breeding habitat for the wood duck appears to be abundant on the Broad River and the tributaries where the census was conducted. The absence of brood nesting habitat appears to be a major limiting factor controlling wood duck production on the study area.

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5.7 MAMMALS

5.7.1 INTRODUCTION

The presence and relative abundance of the various mammalian species is dependent on the environmental conditions, or factors, of an area. Some of these environmental factors are: the amount and diversity of food; the amount and kind of vegetative cover; the quality of the soil; the microclimate of the soil and vegetation; frequency of severe storms, floods, fire, etc. The mammals of the Broad River Study Area reflect a series of ecological communities that are succeeding one another in biotic development. Little work has been done on the mammals of the general area although Golley (1966) gives known distributions of mammals collected in the state. Only a few species, such as the oldfield mouse, Peromyscus polionotus, have been studied intensively (Biggers and Dawson 1971).

Information on large mammals was obtained through field observation and conversations with state and local game officials. Detailed field surveys were not conducted on large mammals because their wide ranging habits makes them very difficult to study. Smaller mammals have a much more limited range and are relatively easy to capture. These smaller animals serve as good indicators of the areas productivity and habitat condition.

5.7.2 METHODS AND MATERIALS

5.7.2.1 Sampling Locations

Six sampling sites were established to census mammal populations in the study area (see map, back cover). Study Site 1A, located approximately 2.4 km (1.5 miles) south of Monticello, was chosen because its primary vegetation was second growth pine. Study Site 1B located 0.32 km (0.2 miles) southeast of Site 1A represented a mixed deciduous-conifer upland forest with a 20 to 80 percent crown cover and a moderately dense understory. Study Site 2, located approximately 4.0 km (2.5 miles) southwest of Monticello, was clear cut in 1967 and replanted in pine. Primarily a grassland in an early seral stage of community succession, it eventually will become dominated by the pine. Study Site 3A, on the east side of Parr Reservoir along the Frees Creek embayment, consisted of a mixed hardwood-conifer forest. Study Site 4, located 2.7 km (1.7 miles) north of the Parr power plant, was chosen as a representative stand of conifers. The last study site was located along Frees Creek adjacent to aquatic Transect G. It was composed of mixed deciduous-conifers with an open crown canopy cover and a dense shrub and herb understory.

5.7.2.2 Snap Trapping

A trapline for small mammals was utilized at four study sites (1A, 2, 3A, and 4) during the June, September, and January, 1971 and March 1972 sampling periods. Each trapline included 20 trapping stations linearly arranged at 15 meter intervals and marked with a wooden stake. Within two meters of each station marker, three snaptraps (two mouse traps and one rat trap) were set and baited with peanut butter and/or dry rolled oats. In addition, in March 1972, a single snaptrap was placed near each of the 231 pit traps (see Section 5.4) on Study Site 2. Each trap was visited on three to five successive days during each sampling period. Trapped mammals were identified as to species, sexed, weighed, measured, examined for evidence of lactation and pregnancy, catalogued, and preserved in 10 percent formalin.

5.7.2.3 Pit Trapping

In March 1972 pit traps used for collecting insects on Study Site 2 proved effective in the capture of shrews. Two hundred thirty-one pitfall traps were placed at 5 meter intervals in a 50 x 100 meter quadrat. The traps consisted of steel cans 11.8 cm high and 10.7 cm in diameter buried in the ground so that the top of the traps were at ground level. Mammals collected in the pit traps were examined and processed in the same manner as snaptrapped mammals.

5.7.2.4 Live Trapping

To capture larger mammals, such as rabbits, opossum, and raccoons, a grid of twelve live traps (Tomahawk Live Trap Company, 10x12x32 inches) was laid in each of the four major vegetational communities; loblolly pine (Site 1A), mixed deciduous-conifer upland (Site 1B), mixed deciduous-conifer lowland (adjacent to aquatic Transect G), and grassland with cultivated loblolly pine (Site 2). The traps were placed in a rectangular grid measuring 121.9 x 182.9 m (400 x 600 ft). Each trap was placed 60.9 m (200 ft) apart and baited with sardines, apple and carrot slices, and raw peanuts.

The traps were checked once each day for seven days and rebaited as necessary. Captured animals were measured, weighed, and both ears tagged with a numbered metal tag (National Band and Tag Company).

A trapping grid of 50 small mammal live traps was nested among the larger live traps at Site 1B during 17-20 November 1972. This square grid measured 61 m (200 ft) on a side, with one station every 15.24 m (50 ft). Two traps were placed at each station, one baited with rolled oats and the other with peanut butter and rolled oats.

5.7.2.5 Supplemental Collections and Observations

During the June 1971 sampling period, bats were collected at dusk with a .22 caliber rifle and a .410 gauge shotgun. The .22 shells contained #12 shot and the .410 shells contained #9 shot.

Mammals killed by vehicles, observed along the Wildlife Survey Route or seen during the course of other field work, were identified and recorded. Mammal signs such as tracks and scats were noted. Taxonomy and published distributional records are from Golley (1966).

A foot-survey was conducted along Frees Creek by a single observer in November 1972. The survey began at the Southern Railway Bridge, followed the south bank, and ended approximately 2.5 km (1.6 miles) upstream. A portion of the Broad River flood plain from Dawkins north to Terrible Creek also was examined for evidence of mammals.

A foot-survey was made during the May 1973 sampling period by two observers following Frees Creek 4.2 km (2.6 miles) from Route 99 southward to the proposed Virgil C. Summer Nuclear Station site.

5.7.2.6 Density Estimates

An estimate of the area that the grid of live traps effectively trapped is essential for estimating the density of a mammal population. To compute this area, one-half the diameter of the home range was considered the effective trapping distance from the grid perimeter and the following formula was utilized (Golley, et al. 1965):

$$2r\ (L_1+L_2) + L_1L_2 + \pi r^2 = \text{area trapped}$$

In this formula r is the radius of the home range and L_1 and L_2 represent the lengths of the two sides (in a rectangular grid).

5.7.2.7 Stomach Content Analysis

The stomach contents of the preserved mammals were removed and washed into a 1.0 mm sieve. The sieved material was washed into small petri dishes and dried at 90°C for two to three hours. All item identifications and volume percentages were determined from these dried samples using methods described by Korschagen (1962). Items were grouped according to plant, animal or miscellaneous components. Within each of these general categories, identification to the generic level was attempted by comparing samples with reference seeds, insect parts, as well as various literature sources (Delorit 1970; U.S. Forest Service 1948; Smith 1970). Percent frequency of occurrence of all items was determined for each mammal species collected during the first four sampling periods.

5.7.3 FINDINGS

A total of 17 species of wild mammals were observed or collected in the Broad River Study Area. Included in this total was one introduced species, the house mouse (Mus musculus). Game mammals observed or signs seen in the area included the white-tailed deer (Odocoileus virginianus); the gray fox (Urocyon cinereoargenteus); the gray squirrel (Sciurus carolinensis); the Eastern cottontail rabbit (Sylvilagus floridanus); and the raccoon (Procyon lotor). Ninety-six mammals of 14 species were collected by trapping in the six study sites during the five sampling periods from June 1971 to November 1972. The number of each species and percent of males collected are presented in Table 5.7.1.

Free-ranging dogs were abundant in the study area. Likewise, the domestic cat is common but it is doubtful that a "feral" population is present. Free-ranging swine have not been observed in the project vicinity, although feral swine have been reported from an adjacent county (Hanson and Karstad 1959).

5.7.3.1 Study Site 1A

The cotton mouse was the only small mammal species collected at this study site. Two were captured during both the June 1971 and March 1973 sampling periods. Live traps for medium size mammals were set during the November 1972 sampling period; however, no mammals were captured.

5.7.3.2 Study Site 1B

One white-footed mouse was caught in a grid of 50 small live traps over a three-day period. This represents only one mammal per 150 trap-nights.

5.7.3.3 Study Site 2

The relative abundance of small mammals collected by the snaptrap method along the established trapline in Study Site 2 is shown in Table 5.7.2.

Table 5.7.1 Number of each species and percent of males trapped during four survey periods.

Species	Common Name	Number Trapped	Percent Males
Didelphis marsupialis	Opossum	4	75
Sorex longirostris	Southeastern shrew	7	71
Cryptotis parva	Least shrew	3	67
Blarina brevicauda	Shorttail shrew	7	71
Procyon lotor solutus	Raccoon	1	0
Spilogale putorius	Spotted Skunk	1	?
Reithrodontomys humulis	Eastern harvest mouse	8	63
Peromyscus leucopus	White-footed mouse	1	?
Peromyscus gossypinus	Cotton mouse	35	54
Ochrotomys nuttalli	Golden mouse	3	67
Sigmodon hispidus	Cotton rat	12	33
Microtus pinetorum	Pine vole	1	?
Mus musculus	House mouse	11	36
Sylvilagus floridanus	Eastern cottontail rabbit	2	100
		96	

Table 5.7.2 Relative abundance of small mammals collected along traplines in Study Sites 1A, 2, 3A, and 4.

Study Site Animal	6/71 Survey		9/71 Survey		1/72 Survey		3/72 Survey	
	Total No. Caught	Trap-nights/ Animal*	Total No. Caught	Trap-nights/ Animal*	Total No. Caught	Trap-nights/ Animal*	Total No. Caught	Trap-nights/ Animal*
Site 1A								
Total Trapnights	300		360		240		240	
Cotton mouse	2	150	0	--	0	--	2	120
Site 2								
Total Trapnights	240		360		240		240	
Cotton rat	2	120	6	60	2	120	0	--
House mouse	4	60	7	51	0	--	0	--
Cotton mouse	0	--	1	360	3	80	3	80
Cottontail rabbit	0	--	2	180	0	--	0	--
Harvest mouse	0	--	0	--	1	240	3	80
Site 3A								
Total Trapnights	240		360		240		240	
Shorttail shrew	1	240	4	90	3	80	1	240
Cotton mouse	4	60	5	72	0	--	3	80
Cotton rat	0	--	0	--	0	--	1	240
Site 4								
Total Trapnights	180		360		240		240	
Cotton mouse	3	60	4	90	1	240	1	240
Golden mouse	2	90	1	360	0	--	0	--
Shorttail shrew	0	--	1	360	0	--	0	--
Pine vole	0	--	0	--	1	240	0	--

*Trapnights per animal caught

It should be noted that the best yields occurred during the September 1971 survey.

In addition to the established trapline, single snaptraps were placed near each of the pit traps. Ten shrew, four harvest mice, and one cotton rat were collected in pit traps or snaptraps placed near pit traps. The trapping yield on the grid was as follows: one Southeastern shrew per 231 pit trap nights; one least shrew per 539 pit trap nights; one harvest mouse per 231 snaptrap nights; one cotton rat per 924 snaptrap nights.

One spotted skunk was captured and released on Study Site 2 during the November 1972 sampling period.

5.7.3.4 Study Site 3A

The shorttail shrew, cotton mouse, and cotton rat were the small mammal species collected along the trapline on Study Site 3A (Table 5.7.2). The greatest number of mammals (nine) was collected during the September 1971 survey.

5.7.3.5 Study Site 4

The relative abundance of small mammals collected along the trapline on Study Site 4 is shown on Table 5.7.2. The greatest number of mammals (six) was collected during the September 1971 survey.

5.7.3.6 Study Site Adjacent to Aquatic Transect G

Medium size mammals were live trapped adjacent to aquatic Transect G during the November 1972 sampling period. Four opossum (2 adults) and one raccoon (adult) were captured, tagged, and released. Three of the four opossum were recaptured and were the only mammals collected in sufficient number to obtain an estimate of density.

In a trapping study in Illinois, Holmes and Sanderson (165) found that the average mean distance traveled from a central area of activity by all opossums, juvenile and adults, was 212.4 m (697 ft), i.e., radius of home range.

This mean distance was utilized to calculate the area trapped by the 121.9 x 182.9 m (400 x 600 ft) grid. The effective trapping area, therefore, would be 29.35 ha (72.6 acres) and the density of the four trapped opossum would be one per 7.3 ha (18 acres) or 36 per square mile.

5.7.3.7 Supplemental Collections and Observations

Small game mammals observed on the Wildlife Survey Route included one gray squirrel in June 1971, no game in September 1971, three gray squirrels in January 1972, and one gray squirrel in March 1972 and no game in March or May 1973. One road-killed cottontail rabbit was found in January 1972 and May 1973 and several cottontails were observed in the study area in both January and March 1972, and March and May 1973.

Three female red bats (Lasiurus borealis) were shot and collected at dusk over small ponds approximately one mile east of Study Site 3A during the June 1971 survey.

Few white-tailed deer have been seen on the Broad River Study Area. One was observed in September 1971, and two in March 1972. In November 1972, fresh tracks were observed near Site 1A and a buck was sighted along Route 16 near the Route 213 junction. One doe was seen swimming across the Broad River approxmately 13.6 km (8.5 miles) north of Parr Dam and another was observed below the Parr Dam along the Broad River. A fresh trail and single track of white-tailed deer were observed during the hike along Frees Creek in November 1972. Old bed sites were observed in an abandoned farm field along the Broad River between Dawkins and Terrible Creek. Tracks of three white-tailed deer were observed in March 1973 in an area where all merchantable timber had been removed.

One set of opossum tracks were observed near an intermittent creek located between Dawkins and Terrible Creek.

A foot survey was made during the May 1973 sampling period along Frees Creek southward from Route 99. A hard rainfall the previous day permitted easy identification of fresh mammal tracks. Within 0.52 km (one-third mile) of highway 99, fresh tracks and three white-tailed deer were observed near dense cover of shrubs and herbaceous vegetation. Along the entire 4.2 km (2.6 miles) of Frees Creek examined by the two observers, 26 sets of deer tracks (set equals one deer) were observed either crossing or paralleling the creek. Some of the 26 sets of tracks may have been made by the same deer and, therefore do not represent 26 deer but the movement of an undetermined smaller number in the vicinity of Frees Creek.

5.7.3.8 Stomach Content Items

The stomach contents of small mammals were examined to describe their food habits. The percent frequency of occurrence of stomach content items from four cotton mice collected at Site A during the June 1971 and March 1972 sampling periods, indicated that all had unidentified insect parts in their stomachs.

The percent frequency of occurrence of stomach content items of the mammal species collected from Study Sites 2, 3A, and 4 are shown in Tables 5.7.3, 5.7.4, 5.7.5, respectively.

5.7.3.9 Rare and Endangered Species

No rare or endangered mammal species were found in the Broad River Study Area, however, a mountain lion (Felis concolor) was reported to have been seen in the vicinity (W. Schrader, pers. comm.).

5.7.4 DISCUSSION

5.7.4.1 General Habitat Conditions

A variety of factors can control animal populations, i.e., food, space, weather, disease, chemical applications, etc. The major factor affecting

Table 5.7.3 Percent frequency of occurrence of stomach content items of small mammals from Study Site 2.

Species	Cotton Rat*				Cotton Mouse*		
Survey Period	6/71	9/71	1/72	3/72	9/71	1/72	3/72
No. of Animals	2	6	2	1	1	3	3
				Percent Frequency			
Vegetation							
Fungus	50	34	50	0	0	33	0
Blackberries	50	0	0	0	0	0	0
Groundcherry	50	17	0	0	0	0	0
Sorghum	0	34	0	0	0	0	0
Lespedeza	0	100	100	0	0	33	33
Dicot leaf	0	17	0	0	0	66	0
Monocot leaf	0	0	50	0	0	33	0
Unidentified	50	0	50	0	0	0	0
Animal							
Insect parts	50	50	50	100	100	100	33
Insect eggs	0	0	0	0	0	33	0
Hair	50	34	50	100	0	0	33
Nematode	50	34	50	0	0	0	0
Miscellaneous							
Sand	50	67	50	0	0	0	33
Paper	50	0	0	0	0	0	0

*Cotton rat = *Sigmodon hispidus*;
Cotton mouse = *Peromyscus gossypinus*

Table 5.7.3 (Continued)

Species	House Mouse*		Eastern Harvest Mouse*		SE Shrew*	Least Shrew*
Survey Period	6/71	9/71	1/72	3/72	3/72	3/72
No. of Animals	4	6	1	7	7	3
Vegetation						
Foxtail	50	0	0	0	0	0
Fungus	50	34	100	0	0	0
Blackberries	0	0	0	0	0	0
Groundcherry	0	0	0	0	0	0
Sorghum	0	34	0	0	0	0
Lespedeza	0	17	0	0	14	0
Dicot leaf	0	0	0	0	0	0
Monocot leaf	0	0	0	0	0	0
Unidentified	25	17	100	0	14	11
Animal						
Insect parts	50	83	100	86	57	33
Insect eggs	0	0	0	0	0	0
Hair	50	34	0	28	14	33
Nematode	50	17	0	0	0	0
Miscellaneous						
Sand	0	0	100	0	29	0
Paper	0	0	0	0	0	0

*House mouse = *Mus musculus*;
Eastern harvest mouse = *Reithrodontomys humulus*;
Southeastern shrew = *Sorex longirostris*;
Least shrew = *Cryptotis parva*

Table 5.7.4 Percent frequency of occurrence of stomach content items of small mammals from Study Site 3A.

Species	Cotton Mouse*				Shorttail Shrew*			Cotton Rat*
Survey Period	6/71	9/71	1/72	3/72	6/71	9/71	3/72	3/72
No. of Animals	4	5	3	3	1	4	1	1
	Percent Frequency							
Vegetation								
Lespedeza	0	0	33	0	0	0	0	0
Dicot leaf	0	20	33	0	0	0	0	0
Endosperm	0	0	100	0	0	0	0	0
Unidentified	50	20	66	0	0	0	0	0
Animal								
Insect parts	100	100	0	66	100	100	100	100
Hair	50	0	66	0	100	0	0	0
Nematode	0	0	0	0	0	25	0	0
Miscellaneous								
Glass	0	0	0	33	0	0	?	0

*Cotton mouse = *Peromyscus gossypinus*

Shorttail shrew = *Blarina brevicauda*

Cotton rat = *Sigmodon hispidus*

Table 5.7.5 Percent frequency of stomach content items of small mammals from Study Site 4.

Species	Cotton Mouse*				Golden Mouse*		Shorttail Shrew*	Pine Vole*
Survey Period	6/71	9/71	1/72	3/72	6/71	9/71	9/71	1/72
No. of Animals	3	4	1	1	2	1	1	1
Vegetation								
Sorghum	0	25	0	0	0	0	0	0
Lespedeza	0	0	0	100	0	0	0	0
Unidentified	33	0	100	100	50	0	0	0
Animal								
Insect	100	75	100	100	50	100	100	0
Hair	66	25	0	0	0	100	0	0

*Cotton mouse = *Peromyscus gossypinus*

Golden Mouse = *Ochrotomys nuttalli*

Shorttail shrew = *Blarina brevicauda*

Pine vole = *Microtus pinetorum*

mammalian populations in the Broad River Study Area appear to be changes in the vegetative community structure. These changes are brought about primarily by natural succession and the influence of man. Utilization of pine for pulpwood and lumber has had a strong influence on the development of soil and vegetation on the Broad River Study Area.

A closed canopy of loblolly pine at Site 1A has limited the development of adequate cover and, subsequently, the food supply of small mammals. Site 4, in contrast, has a more open canopy of primarily pine that has permitted the penetration of sunlight to the forest floor and encouraged the development of a more diverse lower and middle strata that supplies cover and food for small mammals. Despite suitable habitat the mammals are not abundant at this site.

The foregoing discussion illustrates that the selective removal of merchantable pine in the Broad River Study Area will cause changes in sunlight availability, soil moisture, and nutrient exchange resulting in an increase in lower stata vegetation and, consequently, a change in animal populations. It is recognized that such changes will be beneficial to some animal species and yet detrimental to others.

Sites where deciduous trees comprised an important part of the vegetation (1B, 3A, and near G), differences in the vegetational community structure were considerable. Moisture was one major cause of such differences.

The lack of cover for dens appeared to be the most critical limiting factor of medium-sized mammals at Site 1B. The trees at the site were not large, dbh ranging from 7.6 to 20.3 cm (3 to 8 in). Large trees with tree cavities that could be used by squirrels or raccoons were absent from this site. As the stand matures, its value to the gray squirrel and raccoon should increase.

Grasses and forbes formed a complete ground cover under an open canopy near aquatic Transect G. Food was plentiful at Sites 1B, 3A, and near Transect G. Oaks, present at all three sites are considered to be one of the most important food plants for wildlife. Opossum, raccoon, rabbits, squirrels, and deer are known to utilize parts of this tree (Martin, et al. 1951).

Site 2 was cultivated in 1967 and loblolly pine seedlings were planted. Grasses and forbes dominate the ground cover and provide protective cover and food for small mammals. Shrubs are increasing in importance and provide cover for medium-size mammals such as cottontail rabbits and browse for rabbits and white-tailed deer.

5.7.4.2 Small Mammal Populations

The diversity of mammals within each of the study sites is, in part, a function of the habitat requirements of each mammal. The diversity of vegetation between Study Sites 1A and 4, both predominately upland pine communities, is sufficient to result in an apparent change in diversity of small mammals. The lack of diversity in the flora of Site 1A is reflected by the low diversity of small mammal species and by the few individuals collected.

Study Site 4 has a more diverse mammal population as a result of a more open canopy and a greater diversity of herbaceous species. A few grasses, lespedeza, and asteraceous plants, provide a more diverse vegetative food supply, shelter, and a higher diversity of associated invertebrates.

Invertebrates represent a significant portion of the food items observed in mammal stomachs. The frequency that a particular plant part or animal is used as a diet item depends on the abundance of that plant part or animal as well as the abundance of other palatable plant or animal species. The availability of plant or animal species is seasonal and, therefore, their utilization by the mammals is seasonal.

The food and shelter requirements of numerous mammal species are satisfied by the diverse qualities of the abandoned field habitat. Study Site 2 has a high diversity of herbaceous vegetation and associated invertebrates, both of which are important food sources for the mammals collected.

Among the three forested study areas, the diversity of overstory vegetation is greatest on Study Site 3A. This is due in part to a greater slope and more moist condition; the site is often inundated by water.

Very little is known of the habitat or food requirements of the southeastern shrew. This species inhabits a variety of conditions; moist areas near swamps, woods, and open fields (Golley 1962; Gentry, Golley, and Smith 1968; Gentry, Smith, and Chelton 1971). In a study by Gentry, Golley, and Smith (1971), 92 percent of southeastern shrews were trapped in a lowland hardwood swamp habitat on the U.S. Atomic Energy Commission's Savannah River Project. Southeastern shrews from the Broad River Study Area were collected in pit traps near Study Site 2, the old field habitat.

The least shrew was similarily collected in the old field (grassland) habitat. This shrew, commonly called the old field shrew, is most often found in abandoned fields in an early stage of succession (Golley 1962; Golley, et al. 1965).

The shorttail shrew occurs most frequently in moist, deciduous woodlands (Golley 1962) such as Study Site 3A. It also has been collected in old fields and upland hardwood habitats (Gentry, Golley, and Smith 1968).

The shrews are secondary or tertiary consumers feeding primarily on a variety of insects.

The eastern harvest mouse is found in abandoned fields that are in a late herbaceous stage of succession (Golley 1962). The harvest mouse was only collected on Study Site 2, an old field (grassland).

The cotton mouse inhabits the moist river bottom woodlands that are "...often subject to periodic inundation by water" (Golley 1962). The cotton mouse has also been collected in old fields, upland pine, and lowland hardwood habitat (Golley, et al. 1965). Forty-four percent of all cotton mice collected on the Broad River Study Area were from Site 3A, moist river bottom woodlands. They were not restricted to this habitat, however, and were collected on the four study areas where trapping occurred.

The cotton rat prefers abandoned fields or roadside areas with a dense growth of vines, shrubs, or herbaceous vegetation that provides security from predators (Golley 1962). It also occurs in upland and lowland hardwood habitat (Golley, et al. 1965). Study Site 3A provided the optimum conditions based on the collection of 11 out of 12 rats were from this site.

The pine vole is common in either pine or hardwood forests in upland or lowland sites (Golley 1962). Only one specimen was collected from Study Site 4 which is predominately an upland pine forest. Distribution and abundance of the pine vole within the study area has yet to be determined. The pine vole, cotton mouse, and cotton rat are omnivorous mammals feeding on both animal and plant species.

The house mouse commonly occurs in old field communities (Gentry 1966; Golley, et al. 1965; Ramsey and Briese 1971). This mouse was collected from Study Site 2, the grassland.

The white-footed mouse occurs in or on the border of deciduous woodlands. However, they are frequently trapped in grasslands and in areas dominated by shrubby vegetation. A single individual was collected at Site 1B in November 1972.

The red bat is a migratory species which roosts in trees (Golley 1962). They frequent small ponds where their principle food, insects,

Table 5.6.3 Birds recorded by strip census and census transects in various habitats on the Broad River Study Area, May 1973.

	Strip Census			Transect		
	Pine	Grassland Site 2	Grassland Site 6	Pine Site 3B	Selectively Cut Pine Site 4	Mixed
Black Vulture	-	-	2	-	-	-
Broad-winged Hawk	-	-	-	-	1	-
Bobwhite	-	3	4	-	-	-
Mourning Dove	-	1	-	-	-	-
Yellow-billed Cuckoo	4	-	-	-	-	-
Chimney Swift	2	-	3	-	-	-
Unidentified Woodpeckers	-	-	-	-	-	2
Eastern Kingbird	-	-	4	-	-	-
Great Crested Flycatcher	1	-	-	-	-	-
Eastern Wood Pewee	1	-	-	-	-	8
Barn Swallow	-	3	1	-	-	-
Tree Swallow	2	-	-	-	-	-
Blue Jay	5	-	1	-	-	1
Fish Crow	-	-	-	-	-	3
Carolina Chickadee	-	-	-	2	-	1
Tufted Titmouse	2	-	-	-	-	3
Brown-headed Nuthatch	-	-	-	4	-	-
Carolina Wren	-	-	-	-	3	-
Mockingbird	2	2	-	-	-	-
Robin	1	-	-	-	-	2
Wood Thrush	1	-	-	-	-	-
Blue-gray Gnatcatcher	-	-	-	-	2	-
Red-eyed Vireo	-	-	-	-	-	1
Blackpoll Warbler	4	-	-	-	-	-
Pine Warbler	2	-	-	-	-	-
Prairie Warbler	5	8	1	-	1	-
Yellowthroat	-	-	3	-	-	-
Yellow-breasted Chat	-	-	3	-	-	-
Unidentified Warbler	7	-	-	-	-	2
Eastern Meadowlark	-	5	4	-	-	-

Table 5.6.3 (Continued)

	Strip Census			Transect		
	Pine	Grassland Site 2	Grassland Site 6	Pine Site 3B	Selectivity Cut Pine Site 4	Mixed
Red-winged Blackbird	-	-	9	-	-	-
Common Grackle	-	2	10	-	-	3
Brown-headed Cowbird	-	1	-	-	-	-
Summer Tanager	-	-	-	-	-	3
Cardinal	2	-	-	1	-	1
Blue Grosbeak	-	-	5	-	-	-
Indigo Bunting	-	2	7	-	-	-
American Goldfinch	-	-	1	-	-	-
Rufous-sided Towhee	1	-	-	2	2	-
Vesper Sparrow	-	1	-	-	-	-
Field Sparrow	-	3	6	-	-	-
Unidentified Sparrow	-	4	1	-	-	-
Unidentified Birds	17	4	3	2	1	17
Total Birds	59	39	68	11	10	47
Number of Species	15	11	16	4	5	10
Area censused (ha)	11.1	6.4	7.3	-	-	-
Birds per 40 hectares	216	252	378	-	-	-

Table 5.7.7 Seasonal abundance of small mammals by habitat during the first four sampling periods.

	Pine Area		Grassland		Lowland deciduous		Total	
Season	Area No. 1A & 4	Percent	Area No. 2	Percent	Area No. 3A	Percent	All Sites	Percent
Summer	7	10	6	8	5	7	18	25
Fall	6	8	14	19	9	13	29	40
Winter	2	3	6	8	3	4	11	15
Spring	3	4	6	8	5	7	14	19
Total	18	25	32	43	22	31	72	99

the level of nutrition attained by the population, plus other factors. No body measurements of small mammals from the Broad River Study Area or from Fairfield County have been recorded in the literature. However, the present study is beginning to yield baseline data concerning body measurements of local populations of small mammals.

The separation of sub-adult (sexually immature) from adult (sexually mature) is necessary if the body measurement ranges and their mean values are to be of value for comparative purposes. However, the separation of sub-adults from adults may be difficult. Table 5.7.8 lists the criteria used to separate these two groups. South Carolina and Georgia mammals apparently tend to be smaller at the time of sexual maturity than individuals of the same species in more northern parts of their ranges (Golley 1962).

Any collected mammal which was larger in either body weight and/or total length than the corresponding values in Table 5.7.8 was considered to be an adult. Means, ranges, and standard deviations of body measurements of adult mammals are in Table 5.7.9. Sample sizes were not large enough to yield data on sexual dimorphism, seasonal differences, or study site differences.

5.7.4.3 Medium-Sized Mammals

Although the major emphasis in the quarterly surveys was on small mammal populations, evidence of medium-sized mammals was recorded. Gray squirrel, gray fox, cottontail rabbit, raccoon, opossum, and skunk are present but they do not represent a significant sport resource in the Broad River Study Area. The low abundance of these mammals in the study area was verified by state personnel (Walter Schrader, pers. comm).

One spotted skunk (Spilogale putorius) was caught during the 72 trapnights. The known range of this animal in South Carolina was restricted to the western edge of the state (Golley 1966). Its capture on Study Site 2

Table 5.7.8 Minimum body weight and/or total length of mammals considered to be adults.

Species	Common Name	Body Weight,g	Total Length,mm	Source
Sorex longirostris	Southeastern shrew	3.5	76	Burt and Grossenheider, 1964
Blarina brevicauda	Shorttail shrew	12.0	92	Golley, 1962
Cryptotis parva	Least Shrew	4.0	69	Burt and Grossenheider, 1964
		3.4	64	Golley, 1962
Reithrodontomys humulis	Eastern harvest mouse	---	107	Hall and Kelson, 1959
		9.4	--	Burt and Grossenheider, 1964
		6.3	107	Golley, 1962
Peromyscus gossypinus	Cotton mouse	20.2	117	Golley, 1962
Ochrotomys nuttalli	Golden mouse	---	150	Hall and Kelson, 1959
		18.8	--	Burt and Grossenheider, 1964
		11.4	132	Golley, 1962
Sigmodon hispidus	Cotton rat	47.0	150	Sealander and Walker, 1955
		56.2	119	Golley, 1962
Microtus pinetorum	Pine vole	---	105	Hall and Kelson, 1959
		21.0	105	Burt and Grossenheider, 1964
		14.5	81	Golley, 1962
Mus musculus	House mouse	11.3	--	Burt and Grossenheider, 1964
		10.0	120	Golley, 1962
Sylvilagus floridanus	Eastern cottontail rabbit	907.0	355	Burt and Grossenheider, 1964

Table 5.7.9 Body measurements of adult mammals collected from study areas.

Measurement Statistic	Common Name of Adults Southeastern Shrew	Shorttail Shrew	Least Shrew	Harvest Mouse	Cotton Mouse	Golden Mouse	Cotton Rat	House Mouse
No. of Individuals	7	6	3	8	26	3	12	9
Total length (mm)								
Mean	82	93	70	118	160	166	227	164
Range	78-87	77-99	65-75	108-134	140-203	162-170	171-268	150-177
Std. Deviation	3.2	8.5	5.0	9.0	13.5	4.0	53.0	9.0
Tail length (mm)								
Mean	32	18	13	53	67	76	90	79
Range	28-34	16-20	11-15	50-59	50-79	69-80	67-125	75-83
Std. Deviation	2.3	1.4	2.0	3.5	6.6	6.4	17.0	2.5
Length of Hind Foot (mm)								
Mean	10	11	9.5	15	20(25)**	18	28	18
Range	9-11	11	9-10	14-16	17-23	17-20	22-31	16-19
Std. Deviation	0.4	0	0.6	1.0	1.8	1.5	2.7	0.9
Ear Length (mm)								
Mean	6	NM*	4	10	16(24)**	17	18(10)**	12.3(8)**
Range	5-7	NM	3-5	11-14	12-20	17	14-22	10-13
Std. Deviation	0.7	--	1.5	4.0	2.2	0	2.6	1.1
Body weight (g)								
Mean	3.5	10	4	8	24	18	77	21
Range	3-4	8-11	3.5-4.5	7-8.5	17-37	15-21	35-136	17-23
Std. Deviation	0.2	1.0	0.4	0.3	6.3	3.1	32.0	2.1
Sex Ratio (M:F)	2.5	2.5(7)***	2.0	1.6	1.2(35)***	2.0	0.5	0.6(11)***

*NM = Not measured
**(10) = No. of animals used for mean
***(7) = No. of animals used for ratio

will extend its recorded range approximately 64 km (40 miles) eastward. The spotted skunk has a home range of 65 ha (160 acres) or less and is omnivorous (Burt and Grossenheider 1964). The spotted skunk is a secondary or tertiary consumer eating any available small animal life. During winter and spring it depends largely on smaller mammals. The rest of the year, insects are its most important food.

The lone raccoon trapped was an adult female weighing 7,747 g (14.9 pounds) which was captured adjacent to aquatic Transect G. Raccoons are omnivorous and mainly nocturnal. Golley (1966) stated that this animal occurs abundantly throughout South Carolina. They den in hollow trees, rock crevices, or ground burrows (Burt and Grossenheider 1964). Since there is an absence of den-size trees near Transect G, it was presumed that raccoons were either ground dwellers or lived elsewhere. Raccoons may range 3.2 km (2 miles) and have a density of one per six hectares (15 acres) (considered high: Burt and Grossenheider 1964). The absence of raccoon tracks and other signs along Frees Creek, however, seem to indicate a low density.

The gray fox is a predator upon other small animals and, hence, is a secondary and often a tertiary consumer.

The cottontail rabbit may be found throughout the Broad River Study Area. The gray squirrel is found in the vicinity of hardwood forests, principally oak and hickory (Golley 1962). The rabbit and squirrel are primary consumers feeding on vegetation.

Opossum, omnivores found throughout South Carolina, are said by Golley (1966) to be most abundant in the low tangled woodlands, characteristic of stream bottoms. This preference was also noted by Llewellyn and Dale (1964).

Holmes and Sanderson (1965) estimated the opossum density in a favorable habitat in Illinois as about 300 per square mile. Sanderson (1961) found the population along a large stream in Illinois to be 230-240 opossum per square mile, as opposed to ten animals per square mile in cultivated land. The computed opossum density along Frees Creek is undoubtedly underestimated. A better estimate would involve several more weeks of trapping data.

None of the recaptured opossum were caught in the same trap. One opossum (tag no.'s 503-504) was recaptured twice. This juvenile male caught first on 17 November was caught on 20 November in a trap 136 m (447 ft) from the original capture site. The two others were recaptured in the nearest trap, approximately 60.9 m (200 feet) from where they were captured previously.

It is likely that mammals such as the cottontail rabbit, raccoon, and opossum have a low density because of unfavorable habitat. The unaccounted loss of these mammals to free roaming domestic dogs (Canis familaris) could also be significant. Many of the people living near the Broad River Study Area have a pack of hounds.

5.7.4.4 Large Mammal Populations

The white-tailed deer is presently not an abundant game mammal on the Broad River Study Area. The frequency of white-tailed deer being seen is increasing and may reflect an increase in deer in the study area. Suitable habitat is increasing in the area. The white-tailed deer is associated with edge where both shelter and browse are present. In the compact mature stands of loblolly pine and deciduous hardwood communities, little middle and lower strata vegetation occurs. Where the forests are partially open or selective cutting has increased the size and number of openings among the trees, a mixture of deciduous shrubs and saplings grow and provide both shelter and food. Important deer foods of the southeast include oak, green briar, ferns, sumac, dogwood, holly, and other woody shrubs, vines, and herbaceous vegetation.

Table 5.6.5 (Continued)

Common Name of Species Observed	Number of Individuals Counted 1968	1969	1970	1971	1972
Blue Jay	37	61	43	52	94
Common Crow	26	20	18	50	24
Carolina Chickadee	18	32	12	39	23
Tufted Titmouse	4	7	11	6	9
White-breasted Nuthatch	0	0	0	0	4
Brown-headed Nuthatch	15	2	2	3	3
Brown Creeper	2	0	1	0	0
Winter Wren	0	0	0	0	1
House Wren	0	0	1	0	0
Carolina Wren	5	12	8	27	31
Mockingbird	25	42	31	28	69
Catbird	0	0	1	0	0
Brown Thrasher	9	10	11	3	22
Robin	152	31	108	23	68
Hermit Thrush	2	2	4	5	0
Eastern Bluebird	31	4	8	12	11
Golden-crowned Kinglet	5	3	1	4	2
Ruby-crowned Kinglet	8	18	12	24	37
Water Pipit	19	0	150	25	0
Cedar Waxwing	17	0	27	17	4
Loggerhead Shrike	9	1	8	8	9
Starling	1,100	680	311	182	290
Solitary Vireo	1	0	0	0	0
Myrtle Warbler	0	13	1	4	7
Pine Warbler	3	14	1	7	0
Palm Warbler	0	0	0	0	8
English Sparrow	91	248	0	0	141
Eastern Meadowlark	118	297	180	205	147
Red-winged Blackbird	11,350	10,350	1,521	2,442	3,477
Baltimore Oriole	0	0	0	2	0
Rusty Blackbird	1	1	0	0	0
Brewer's Blackbird	0	0	40	3	40
Common Grackle	31	611	38	610	422
Brown-headed Cowbird	35	451	200	220	160
Cardinal	88	314	53	90	95
Evening Grosbeak	37	0	0	22	150
Purple Finch	2	88	0	3	17
Pine Siskin	10	24	0	0	0

Table 5.6.5 (Continued)

Common Name of Species Observed	Number of Individuals Counted 1968	1969	1970	1971	1972
American Goldfinch	46	211	103	53	87
Rufous-sided Towhee	43	130	31	47	97
Savannah Sparrow	15	17	51	506	185
Vesper Sparrow	19	1	0	0	13
Slate-colored Junco	133	57	232	5	64
Chipping Sparrow	11	6	3	2	7
Field Sparrow	59	41	71	25	145
White-crowned Sparrow	3	0	0	0	0
White-throated Sparrow	264	202	221	219	420
Fox Sparrow	1	0	5	2	2
Swamp Sparrow	3	2	0	2	6
Song Sparrow	45	64	31	37	81
Species per Year	67	66	60	66	64
Total Individuals	14,456	14,530	3,803	5,475	7,009

continued because of the limited numbers of individuals of each representative species. Statistical analysis would be most difficult to describe significant changes subsequent to environmental changes from project construction and operation. The investigations provide a baseline description of the mammals inhabiting the Broad River Study Area.

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6.0 TERRESTRIAL ECOLOGY OF THE BROAD RIVER STUDY AREA

The Broad River Study Area is located in the Piedmont Region and bordered on the south by the Coastal Plain. Vegetation of the area is typical pine-hardwood of South Carolina. Prior to white settlement in 1752, oak-hickory-pine forest prevailed which was apparently free of brushy undergrowth.

Continuous rotation-type farming since white settlement has resulted in a change from the original mixed hardwood-pine forest to pine. While oak-hickory forest would normally be climax for the area, routine removals of trees, eroded topsoils, and recurrent fires have maintained stands of pine.

Erosion has removed most of the topsoil from the Broad River Study Area. The soils which currently exist have a very low nutrient status and a pH of about 5.5. This pH level favors the growth of pine over other plant species. Erosion also has removed many of the traces of agriculture since only low concentrations of DDT were found in the soils. Cotton was the major cash crop during the period of extensive agriculture in the area and DDT was the major insecticide used for cotton boll weevil control.

Succession of plant communities in the Broad River Study Area is in a continuous state of flux with clear-cutting and agriculture disrupting the successional pattern. Plant succession of the area would normally proceed from an abandoned field through a community of herbaceous annual weedy forbs and grasses after one year. The community then becomes dominated by annuals and perennials in the second year. A transition to perennial grasses with pine seedlings occurs between 3 and 10 years after abandonment. The next 10 years result in a closed canopy of loblolly pine at the expense of a well-developed herbaceous community. The pine community will eventually give way to a stable stand of hardwood trees dominated by white and red oak which will last approximately 200 years.

Three basic habitat types currently exist in the Broad River Study Area. The first is a transitional stage from perennial grasses to loblolly pine which is a result of clear-cutting and mechanical planting of pine. The second type is a loblolly pine community. The third type is basically mixed hardwood-pine with oaks and loblolly pine being the important species.

The grassland type community was dominated by broomsedge and triple-awned grass while little bluestem occurred on more fertile soil. The vegetative cover provided habitat for millipedes, slugs, earthworms, and numerous predatory spiders and carabid beetles. The low stature of the vegetation created a microhabitat which reduced the dessicating power of the atmosphere. Thus, an environment existed in which soft-bodied invertebrates such as the slugs and earthworms could survive.

The American toad and Fowler's toad were the only two herpetofaunal species observed in the grassland area. These toad species were probably feeding upon insects which inhabit the grassland area.

Birds were more abundant in the grassland community than in any other community studied. Meadowlark, bobwhite quail, and field sparrows occupied this area during all seasons. Insects and seeds as well as good cover probably attracted these birds to the area. Bobwhite feed mostly on seeds, however, during the first few weeks of life, the young feed on insects.

Summer inhabitants of the grassland area include the barn swallow, prairie warbler, blue grosbeaks, indigo bunting and red-winged blackbird. The red-winged blackbird apparently moved into the area during nesting.

Birds of prey were not common over the grassland area. This was probably due to a low population of prey species such as rodents and herpetofauna. Vultures were common throughout the Broad River Study Area but their presence was probably due more to the number of roadkill dogs which occurred in the area than any abundance of natural prey or carrion.

The grassland area supported the greatest population of rodents with cotton rats and house mice being the most common species collected. Insects and vegetation were important food items for these rodents. Lespedeza was the most common food item found on examination of rodent stomachs.

The pine communities were dominated by loblolly pine which was an important economic plant species within the Broad River Study Area and consequently, the age of these pine communities varied considerably. Clear-cutting and fire have resulted in the development of even-aged stands with a poorly developed understory except in small open areas. Seedling to marketable pine timber in this area require 35-50 years.

Plant litter resulting from pine needles was high in lignins and resins which resist and inhibit decomposition of cellulose. The coniferous forest soils were characterized by a well-defined unincorporated, compact organic deposit resting on mineral soil. The layer was a result of slow mineralization and no mixing with the mineral soil. The soil characteristics support only limited populations of small soil organisms, most of which live at the interface of the decaying organic layer and mineral surface.

The insect fauna were not well represented in the pine community. Southern pine beetle infestations were observed in the study area, but were of minor importance.

The Pickerel frog and fence lizard were the only herpetofaunal species observed in the pine forest. While these species are principally aquatic, they do travel away from the aquatic habitat during moist seasons.

Chickadees, kinglets, bluewinged warblers, and brown-headed nuthatches were common bird species associated with pine communities. The chickadee is a multi-habitat bird species which utilizes the shrubs in the pine understory. This species feeds upon insects and seeds. Most of the other bird inhabitants of the pine community were insect eaters. Prairie and pine warblers were summer breeders in this area.

The understory of the pine community was poor habitat for rodents and other small mammals which require cover for protection. The most common mammal species found was the cotton mouse. Golden mouse, shorttail shrew and pine vole were captured in limited numbers. Sorghum and lespedeza were the most common identified plant parts in rodent stomachs. The presence of sorghum in the diet would indicate the rodents were going outside the area to feed. Insect parts also were found in stomach analyses.

While hardwood forest would be climax vegetation for the area, disturbances have kept the pine communities in a seral stage. Most of the upland hardwoods occurred as mixed hardwood-pine communities. Hardwoods occurred in small scattered stands on the uplands and predominated on the riverbottom. Important species in these communities included loblolly pine, eastern red cedar, red maple, and several oak species.

Soils of the mixed hardwood-pine community have a better developed humus layer than pine forest. Chemical composition of deciduous leaves allows for faster decomposition and mineralization of the leaf litter. Thus, the litter is incorporated with the mineral soil much faster.

While the litter layer and the plant species of the mixed hardwood-pine community were capable of supporting a more diverse population of invertebrates, these populations were not well documented for the Broad River Study Area. Spiders were the most uniformly distributed insect species in the area. The majority were found where vegetation was less dense.

The Pickerel frog and fence lizard and several turtle species were found in the mixed hardwood-pine community. The fence lizard prefers logs and trees for habitat. The Eastern box turtle, a terrestrial species, was an omnivore in the area which feeds upon seeds, fruits, berries and carrion.

The bird population within the mixed hardwood-pine community was dependent upon understory vegetation. The bobwhite quail occurred in openings in the timber which had a well-developed herbaceous understory. Other year-round residents included the Carolina wren which feeds on insects, cardinals, and white-throated sparrows which are seed eaters. Summer residents included the eastern wood pewee which is an insect eater.

The shorttail shrew, cotton mouse, and the cotton rat were the most common mammal species in the mixed hardwood-pine community. Opossum and raccoon were captured adjacent to aquatic habitats within these communities. These two mammal species probably used the woods for cover during the day and moved to the water's edge at night to feed.

While small amounts of plant material were found, insects appeared to be the most common food of small rodents captured in the mixed hardwood-pine communities.

Red bats were collected around ponds adjacent to the mixed hardwood-pine community. This bat is a migratory species which roosts in trees and frequents small ponds where insects congregate and water is available.

Migratory waterfowl utilize the Broad River and its tributaries during the fall, winter and spring. The wood duck is of particular interest because it is a major nesting duck in South Carolina. Wood ducks are abundant during the fall and spring on the tributaries and embayments created by Parr Reservoir. Breeding habitat for the wood duck appeared to be abundant on the Broad River and its tributaries while good habitat for turkey exists in the Broad River Study Area, this bird is not present in any abundance. This species requires a mixture of grasslands, mature hardwood, and mixed hardwood-pine. If clearing of trees occurs at the present rate, the carrying capacity for turkey will decrease in this area.

Adequate habitat exists to support deer in the Broad River Study Area. With proper management, the deer population can increase. The clearing practices can play a major part in increasing the deer population.

Respectively submitted,

DAMES & MOORE

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RCKA/JDK:gh

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

**"MAP OF PROJECT AREA
SHOWING VEGETATIOINAL
COMMUNITIES
AND SAMPLING LOCATIONS"**

**WITHIN THIS PACKAGE...OR
BY SEARCHING USING THE**

D-01

APPENDIX 2B

ADDENDUM TO THE BASELINE BIOTIC SURVEY
BROAD RIVER STUDY AREA
PARR, SOUTH CAROLINA
SEPTEMBER 1974
FOR SOUTH CAROLINA ELECTRIC & GAS COMPANY

Dames & Moore
Project No. 5182-059-17

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INTRODUCTION

1.0a

This addendum presents recent results of additional baseline biotic surveys of the Broad River Study Area, Parr, South Carolina, for South Carolina Electric and Gas Company (SCE&G). The purpose of these studies conducted in August 1973 and April/May 1974 was to complete the baseline surveys and supplement the Report on the Baseline Biotic Survey (Dames & Moore, 1973) (henceforth, referred to as baseline survey). As was stated in Section 1.0 of that report, this baseline information will provide the basis for vaildating predictions regarding anticipated environmental impacts resulting from construction and operation of the proposed Parr Hydroelectric Project (FPC Project No. 1894) and the proposed Virgil C. Summer Nuclear Station project (AEC Docket No. 50-395).

The format of this addendum is so designed that each section is numbered the same as its corresponding section in the baseline survey, with the exception that all addendum numbers are followed by a lower case "a". The same system is used on the tables and figures, wherever possible.

3.0a AQUATIC SURVEY

3.1a DESCRIPTION OF SAMPLING LOCATIONS

Descriptions of transect locations were given in the Baseline Biotic Survey. With the exception of Transect D, all transects remained in the same location. In April 1974, Transect D was relocated a short distance upstream from its original location and is interrupted by a sand bar (Figure 3.1.1a). The east end of the transect is approximately 945 m (3100 ft) upstream from Parr Dam and extends due west across the Broad River. The transect is 750 m (2460 ft) long and has five collecting points.

All stations that have more than one collecting point have been profiled and collecting points have been identified (Figure 3.1.2a).

3.2a PHYSICAL AND CHEMICAL CHARACTERISTICS

3.2.1a INTRODUCTION

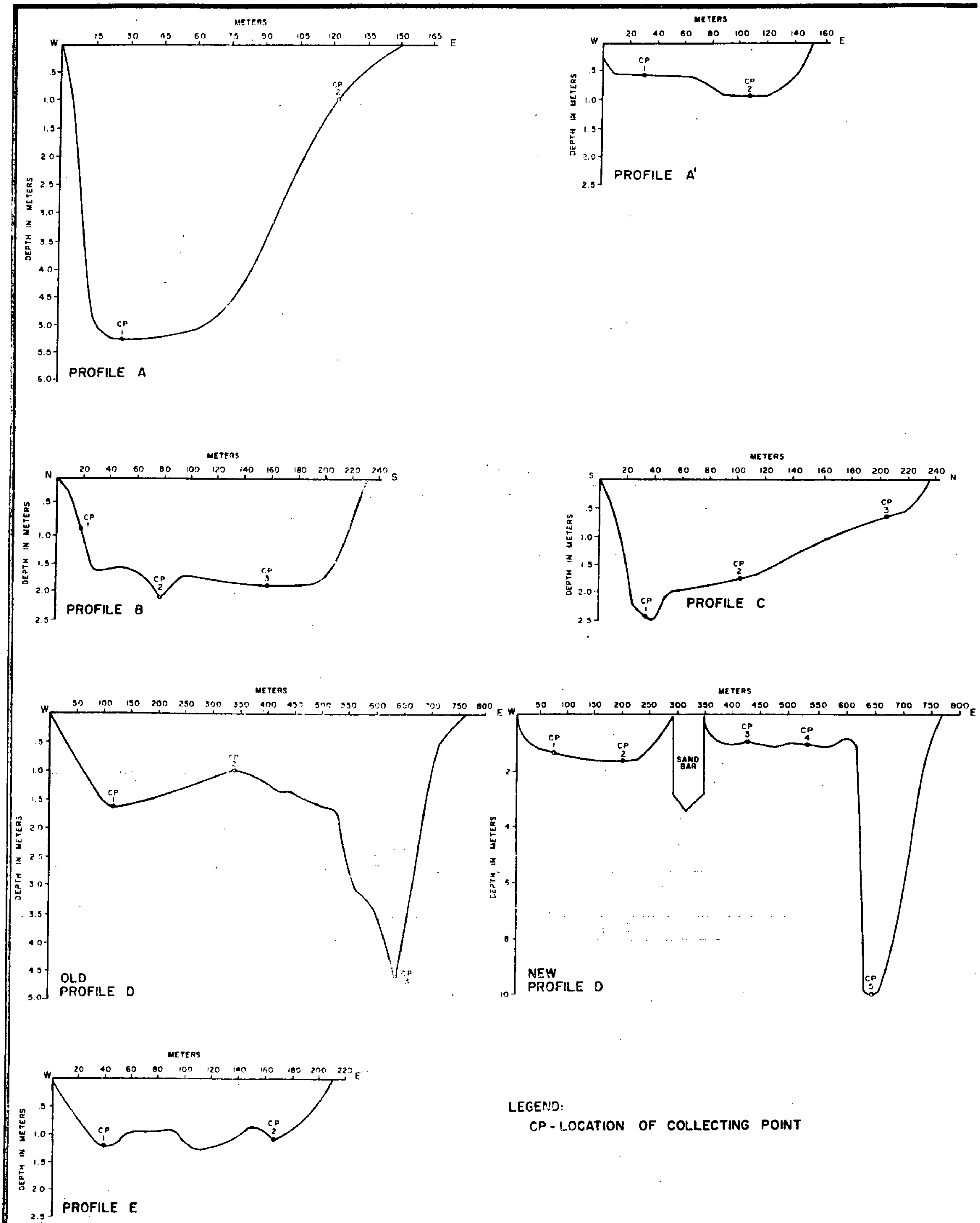
Selected physical and chemical parameters were measured at various locations in the Broad River Study Area between September 1972 and April/May 1974. The end of April and the first few days of May 1974 were arbitrarily chosen as the termination of the baseline survey and the beginning of the construction monitoring phase for the aquatic environment. Slight increases in suspended solids at several stations were considered when choosing this date. These data are useful in expanding the data base of the Baseline Biotic Survey. Some new parameters were added to this phase of the sampling program (see accompanying tables) and some sampling stations were added, relocated, or dropped from the baseline survey.

During the Baseline Biotic Survey six transects (A, B, C, D, E, and F) were selected for study of the water quality of the Broad River

CHECKED BY ____________ FILE ______________________ BY ________ DATE _____

FIGURE 3.1.1a
Location of Old and New Transect D

SOURCE: MAP [illegible] ROJECT AR' [illegible] aseline Biof [illegible] rvey) DA[illegible] MOORE



LEGEND:

CP - LOCATION OF COLLECTING POINT

FIGURE 3.1.2a
DEPTH PROFILES OF
SAMPLING TRANSECTS

DAMES & MOORE

Study Area. Sampling at Transect E was discontinued after May 1973 with the exception of fish collections. After August 1973, sampling was discontinued at Transects A and F and Transect D was moved a short distance upstream. These changes were made to streamline the sampling program and provide data for areas of greater concern.

Presently the sampling program includes samples from the deepest collecting point on Transects B, C, and D. Since Transect D is interrupted by a sand bar, collecting points have been located on both sides.

Water quality data collected by SCE&G are also considered. These analyses were conducted routinely at least once a month (but usually more often) between September 1972 and April 1974 at six collecting points. Four of these collecting points were located upstream or downstream from established transects in which case their actual location is noted in the relevant tables.

3.2.2a METHODS AND MATERIALS

Bottom sediment samples were discontinued after the May 1973 sample period. Sediments (SED) were added after September 1972 by SCE&G. This determination is made by weighing a 0.45μ filter through which a 100 ml water sample was passed. Methods for the other parameters are described in Section 3.2.2 of the baseline survey.

3.2.3a FINDINGS

3.2.3.1a Temperature

Mean seasonal water temperature from September 1972 to April 1974 ranged from 12.7 to 16.5°C (Tables 3.2.9a, 3.2.10a), at six collecting points monitored by SCE&G. The number of observations per transect varied from 20 to 318. Transect D+ had the highest and lowest temperatures of 29.7°C and 3.3°C, respectively. The average temperature for this

Table 3.2.9a Summary of chemical analysis of the Broad River Study Area (Broad River) from selected transects (September 1972 - April 1974).[1] Test results reported in mg/l unless otherwise noted.

Transect [2]	E+				D+				A-			
	Minimum	Maximum	Mean	No. of Data Points	Minimum	Maximum	Mean	No. of Data Points	Minimum	Maximum	Mean	No. of Data Points
Determination												
Total Dissolved Solids	12	25	18.5	2	7	580	107.5	20	8	865	142.2	20
Total Suspended Solids	53	55	54	2	12	1110	275.9	20	16	1170	275.4	20
Total Solids	67	78	72.5	2	49	1310	385	20	48	1750	417.6	20
Specific Conductance (μmhos/cm)	31	100	61	196	27	100	58.5	318	33	116	63	218
Total Alkalinity	19	21	20	2	13	29	21	20	13	26	20	20
Calcium Hardness	14	14	14	2	4	18	12.4	20	10	16	13	20
Magnesium Hardness	2	4	3	2	2	6	2.7	20	2	6	2.6	20
Total Hardness	16	18	17	2	12	20	15.5	20	14	20	15.6	20
Chlorides (Cl)	3.39	4.39	3.89	2	1.89	6.89	4.56	20	1.39	5.89	4.34	20
Sulfates (SO_4)	3.7	4.0	3.8	2	2.0	5.5	3.6	20	2.0	5.3	3.5	20
Nitrates (NO_3)	0.44	0.51	0.47	2	0.33	0.89	0.70	20	0.33	0.89	0.67	20
pH	6.6	7.7	7.1	185	6.4	7.6	7.0	315	6.3	8.0	7.2	207
Air Temperature (C)	9.6	33	18.7	196		33	17.6	318	0.0	29.7	16	218
Water Temperature (C)	5.0	28.6	16.5	196	3.5 ~~1.1~~	29.7	16.0	318	3.3	28.1	14.9	218
Dissolved Oxygen	4.5	13.5	7.7	196	3.8	13.2	7.7	318	5.0	14.8	8.3	218
Secchi Disc (meters)	0.25	0.25	0.25	2	0.03	0.51	0.28	20	0.03	0.46	0.23	20
Color	60	75	67	2	40	750	122	20	40	750	143	20
Chemical Oxygen Demand	0	0	0	2	0	47	15.12	15	0	65.60	19.61	16
Soluble SiO_2	17.0	18.6	17.8	2	12	23	18.6	20	12	22.5	18.0	20
SED [3]	40	6540	485	196	40	4780	450	318	60	6340	623	218

---

[1] Data from SCE&G River Sampling Program.

[2] Transect locations - E+, three-forths mile downstream from Transect E; D+, one-quarter mile downstream from Transect D; and A-, 6.1 miles upstream from Transect A.

[3] SED = mg/l of solids retained on a 0.45μ filter.

Table 3.2.10a Summary of chemical analyses of the Broad River Study Area (Frees Creek) from selected transects (September 1972 - April 1974).[1] Test results reported in mg/l unless otherwise noted.

Transect [2]	B				B-				G			
	Minimum	Maximum	Mean	No. of Data Points	Minimum	Maximum	Mean	No. of Data Points	Minimum	Maximum	Mean	No. of Data Points
Determination												
Total Dissolved Solids	6	1070	138	20	32	33	32.5	2	16	17	16.5	2
Total Suspended Solids	24	1220	402.8	20	74	79	76.5	2	65	75	70	2
Total Solids	52	1730	540.8	20	106	112	109	2	81	92	86.5	2
Specific Conductance μmhos/cm	29	108	72	175	53	103	81	20	25	126	82	206
Total Alkalinity	19	35	26	20	31	44	37	2	31	42	36	2
Calcium Hardness	12	20	16.3	20	18	20	19	2	18	22	20	2
Magnesium Hardness	2	8	4.7	20	2	10	6	2	2	8	5	2
Total Hardness	16	24	21	20	20	30	25	2	20	30	25	2
Chlorides (Cl)	2.89	5.89	4.76	20	4.89	5.89	5.39	2	4.39	5.39	4.89	2
Sulfates (SO_4)	2.0	5.0	2.9	20	1.3	2.0	1.6	2	1.7	2.3	2.0	2
Nitrates (NO_3)	0.22	0.89	0.64	20	0.51	0.51	0.51	2	0.51	0.69	0.60	2
pH	6.3	8.2	7.2	179	6.7	7.4	7.2	20	6.2	7.7	7.0	199
Air Temperature (C)	-5.5	29.7	15.4	175	0.6	23.1	13.8	20	-7.7	29.7	14.3	206
Water Temperature (C)	2.8	29.2	16.5	175	6.6	21.5	12.7	20	3.3	23.1	12.7	206
Dissolved Oxygen	4.5	11.2	7.4	175	5.8	10.4	8.2	20	4.6	16.6	9.0	188
Secchi Disc (meters)	0.03	0.46	0.20	20	0.25	0.41	0.33	2	0.46	0.46	0.46	2
Color	60	750	203	20	75	125	100	2	40	45	42	2
Chemical Oxygen Demand	0	30.8	19.0	15	9.7	11.0	10.4	2	0	114.8	57.4	2
Soluble SiO_2	18.5	26.5	22.4	20	30.0	30.5	30.2	2	32.0	34.0	33.0	2
SED [3]	72	3750	405	175	20	140	75	20	0	5440	220	206

---

[1] Date from SCE&G River Sampling Program

[2] Transect location - B-, 1 mile upstream from Transect B.

[3] SED = mg/l of solids retained on a 0.45μ filter.

transect was 16°C.

Surface and bottom temperatures were measured during August 1973 and April/May 1974 (Table 3.2.11a). A maximum vertical temperature difference of 4.2°C was noted at Transect C in April/May 1974. In August 1973, this difference was only 3.0°C at Transect C. At all other transects, 1.5°C was the maximum difference in top and bottom temperatures.

3.2.3.2a Transparency

Mean seasonal Secchi disc values measured between September 1972 and April 1974 ranged from 0.20 to 0.46 m (Tables 3.2.9a, 3.2.10a) at the six collecting points monitored by SCE&G. Minimum readings of 0.03 m were recorded at both Transects B and D+. The maximum transparency of 0.51 m also occurred at D+.

Data collected during the biological surveys indicated a maximum of 0.7 m at both Transect C and the new Transect D (east end) in April/May 1974.

3.2.3.3a Sediment

No additional data.

3.2.3.4a Sediment Chemistry

No additional data.

3.2.3.5a Dissolved Oxygen

SCE&G's monitoring of DO indicated a low of 3.8 mg/l and a high of 14.8 mg/l at Transects D+ and A-, respectively.

During August 1973 and April/May 1974, DO was measured at both the top and bottom. At the more lentic Transects C and B, vertical DO differences averaged 2.0 mg/l. Percent saturation also decreased from top to bottom. Percent saturation at Transects C and B decreased from 101 to 72 percent and 95 to 60 percent, respectively.

Table 3.2.11a Physical and chemical parameters from the Broad River Study Area during baseline surveys (August, 1973 and April/May, 1974).

Transect	A	B	B	B	B	C	C	C	D	D	D	D	D	F
Collecting point	1	2	2	2	3	1	1	1	2	2	2	3	5	-
Date	Aug.	Aug.	Apr.	Mean	Aug.	Aug.	Apr.	Mean	Aug.	Apr.	Mean	Aug.	Apr..	Aug.
Parameter														
Temperature, Air (C)	NS[1]	NS	23.0	23.0	NS	NS	22.0	22.0	NS	27.0	27.0	NS	25.0	NS
Temperature, Water (C)														
Surface	26.5	25.5	23.5	24.5	27.0	27.0	22.2	24.6	28.0	23.0	25.5	27.5	23.0	26.5
Bottom	25.0	24.5	22.0	23.3	26.5	24.0	18.0	21.0	27.5	22.5	25.0	26.5	22.2	26.5
Dissolved oxygen (mg/l)														
Surface	9.0	8.0	7.8	7.9	10.0	9.0	9.2	9.1	11.0	8.7	9.9	9.0	8.8	11.0
Bottom	NS	NS	5.2	5.2	NS	NS	6.8	6.8	NS	8.6	8.6	NS	8.6	NS
Specific conductance (μmhos/cm)														
Surface	NS	NS	81	81	NS	NS	85	85	NS	45	45	NS	70	NS
Bottom	NS	NS	80	80	NS	NS	81	81	NS	65	65	NS	100	NS
pH (surface)	7.0	7.0	7.1	7.1	7.0	7.5	7.7	7.6	7.0	7.4	7.2	7.0	7.1	7.5
Secchi disc (m)	0.55	0.3	0.3	0.3	0.15	0.7	0.5	0.6	0.3	0.7	0.5	0.5	0.5	0.6

---

[1] NS = Not Sampled

3.2.3.6a pH

Mean seasonal pH values for surface water between September 1972 and April 1974 ranged from 7.0 to 7.2 (Tables 3.2.9a, 3.2.10a), at the six collecting points monitored by SCE&G. The minimum (6.3) and maximum (8.0) pH values were recorded on the Broad River at Transect A- (Table 3.2.9a). The minimum pH on Frees Creek was 6.2 at Transect G and the maximum was 8.2 at Transect B (Table 3.2.10a).

During August 1973 and April/May 1974, pH values measured in the field ranged from 7.0-7.7 (Table 3.2.11a). These values were similar to other baseline data (Table 3.2.7).

3.2.3.7a Other Water Quality Parameters

The Broad River Study Area is characterized by soft water (below 61 mg/l total hardness) with limited buffering capacity (Tables 3.2.9a, and 3.2.10a). Phosphate determinations are only run occasionally and values are usually in trace amounts. Silica and nitrate concentrations were moderately high. Biological oxygen demand (BOD) were generally quite low. A maximum chemical oxygen demand (COD) of 114 mg/l was noted at Transect G. However, most values were below 20 mg/l.

Trace metal analyses were initiated in April 1974 (Table 3.2.12a). Copper occurred in concentrations above safe levels at all transects in Frees Creek. Becker and Thatcher (1973) have stated that concentrations above 0.02 mg/l may be chronically toxic to many aquatic organisms in soft waters. The majority of other metals were below detection limits.

3.2.4a DISCUSSION

A water temperature of 3.3°C recorded during this period is the lowest temperature reported during the baseline survey. Unusually

Table 3.2.12a Trace metal analyses of surface waters of the Broad River Study Area (24 April 1974)[1]. Test results reported in mg/l unless otherwise noted.

Transect[2]	E+	D+	A-	B	B-	G
Determination						
Sodium (Na)	5.8	6.2	3.6	6.5	8.3	7.6
Magnesium (Mg)	1.2	1.5	1.7	3.4	2.7	3.4
Aluminum (Al)	0.6	2.9	1.8	4.6	1.9	0.5
Arsenic (As)	<0.01	<0.01	0.01	0.01	0.01	0.01
Cadmium (Cd)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium, Total (Cr)	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Fluoride (F)	0.14	0.18	0.10	0.18	0.19	0.17
Iron, Total (Fe)	0.90	1.2	0.95	2.5	2.7	1.4
Lead (Pb)	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	0.06	0.06	0.05	0.28	0.82	0.02
Mercury (Hg), µg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nickel (Ni)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Tin (Sn)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Zinc (Zn)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Selenium (Se)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium (V)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Beryllium (Be)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Boron (B)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cobalt (Co)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Molybdenum (Mo)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Silver (Ag)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.03
Strontium (Sr)	0.2	0.3	<0.2	0.4	0.6	0.6
Copper (Cu)[3]	0.012	0.008	0.008	0.024	0.036	0.030

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[1] Data from SCE&G River Sampling Program; Analysis by Analytical Services Laboratory, NUS Corporation, Houston, Texas.

[2] Transect locations - E+, three-fourths mile downstream from Transect E; D+, one-quarter mile downstream from Transect D: A-, 6-1/10 miles upstream from Transect A; and B-, 1 mile upstream from Transect B.

[3] Analysis by SCE&G.

low air temperatures probably account for the newly recorded minimum. The previously reported high of 31.5°C was not approached. The abnormally high value is probably an exception that occurs only during extreme low flow and high ambient air temperatures.

In the baseline survey, vertical temperature data indicated a difference of 7°C from top to bottom at the more lentic stations. Addendum data showed a maximum difference of 4°C. High water in August 1973, probably reduced (temperature differences) stratification. The shallow nature of this reservoir lends to occasional interruption of normal seasonal stratification.

Secchi disc values were generally quite low (below 0.7 m). They compared closely to previous measurements, being lowest at the new Transect D (Collecting Point 1) and Transect B, and highest at Transect C and the new Transect D (Collecting Point 5). However, the previous low of 0.15 m was surpassed by a 0.03 reading at Transects B and D.

The DO minimum (3.8 mg/l) and maximum (14.8 mg/l) exceeded those reported in the baseline survey. However, these values are still within tolerance limits of organisms present in the study area. Vertical DO differences were also noted at Transects B and C. As noted in the baseline survey, this is characteristic of the more lentic areas. Bottom DO values were not below 50 percent saturation during either survey. Thus, benthic organisms generally had more than an adequate DO supply.

The nutrient content of waters in the study area were high enough to support algal blooms. The occasional supersaturation DO levels indicate that blooms do occur. However, as concluded in the baseline survey, turbidity may be a factor limiting the extent of these blooms.

The pH values, which were essentially quite similar at all transects on the Broad River Study Area were generally indicative of an unstressed ecosystem. The low alkalinity, however, affords little buffering capacity, therefore, the aquatic ecosystem of the Broad River Study Area is susceptible to rapid pH changes.

As stated in the Baseline Biotic Survey, occasional high COD values have been reported. Agricultural runoff in the Frees Creek area may account for the frequent high values at Transect G. BOD values are quite low, therefore, the agents contributing to high COD are not readily biodegradeable. DO values also support this conclusion as they are generally very high.

Copper is the only metal that occurred at toxic levels in the Broad River Study Area in 1974. The toxic level occurred at all three Frees Creek Transects; B, B-, and G. Previous copper analysis of sediment samples in February 1972 (Section 3.2.4) had indicated possible industrial contamination.

3.2.5a SUMMARY

The larger number of data points available for many of the water quality parameters has expanded the range of reported values in many cases. There have been no significant changes in the water quality during this portion of the baseline survey. Initial data concerning heavy metals analysis indicates that most metals analyzed are below detectable limits. Copper is one metal, however, which occurs at concentrations which could be slightly toxic to aquatic biota, particularly in Frees Creek.

3.3.a PLANKTON

3.3.1a INTRODUCTION

Phytoplankton and zooplankton populations were sampled qualitatively and quantitatively in the Broad River Study Area at specific sampling locations during August 1973 and April/May 1974. These studies were conducted to supplement existing baseline data.

3.3.2a METHODS AND MATERIALS

Field and laboratory procedures were similar to those described in Section 3.3.2 of the baseline survey. During August 1973, surface samples were collected from Transects A through F, but vertical tow plankton net samples were collected only from Transects C and D. No vertical tows were made during April/May 1974. The only samples collected were surface samples from collecting points on Transects B through D and samples for qualitative analyses from the littoral zones of Transects B and C.

Plankton biomass determinations were not included in laboratory analyses.

In April/May 1974, phytoplankton primary productivity was estimated by the ^{14}C method (Strickland and Parsons 1972). A solution of radioactive carbonate was added to duplicate light and dark bottles filled with water samples from Transects B and D. Bottles were placed at their respective stations and incubated at the depth from which the samples were collected. After approximately 4 hours of in situ incubation, water samples were fixed with 10 ml of formalin. Samples were later filtered in the laboratory and treated with hydrochloric acid to remove inorganic carbon. Liquid scintillation counting was conducted at Virginia Commonwealth University.

3.3.3a FINDINGS

3.3.3.1a Phytoplankton

3.3.3.1.1a Qualitative Analysis

A total of 127 phytoplankton taxa were collected in the Broad River Study Area in August 1973 and April/May 1974 by surface samples and vertical plankton net tows (Table 3.3.1a). The number of taxa in each major taxonomic group was: Chlorophyta, 30; Chrysophyta, 83; Cyanophyta, 8; Euglenophyta, 4 and Pyrrophyta, 2. The numbers of Chlorophyta, Euglenophyta and Pyrrophyta taxa are similar to those reported previously in the baseline survey. However, about half as many Cyanophyta taxa and almost twice as many Chrysophyta taxa occurred in the August 1973 and April/May 1974 samples as compared to previous samples from June 1971 through May 1973. Table 3.3.1a indicates 77 taxa not previously reported in the collections. These include 15 Chlorophyta, 57 Chrysophyta, two Cyanophyta, two Euglenophyta and one Pyrrophyta taxa.

A total of 102 phytoplankton taxa had been observed in the previous baseline survey. The higher number of taxa reported for August 1973 and April/May 1974 appears to reflect more detailed species analyses for genera previously collected. For example, Table 3.3.1 in the baseline report includes only two *Navicula* taxa while an additional 14 are recorded in Table 3.3.1a. Similarly Table 3.3.1a includes eight *Nitzschia* taxa, six *Synedra* taxa and three *Fragilaria* in addition to those included in Table 3.3.1.

Numbers of phytoplankton taxa per transect are summarized in Table 3.3.2a. Taxa per transect ranged from 11 to 19 in August 1973 and from 40 to 48 in April/May 1974. The general increase in taxa in April/May reflects a sharp increase in diatom taxa.

Table 3.3.1a Species list of phytoplankton present (P) in surface (S) and vertical tow (VT) plankton samples in August 1973 and April/May 1974

	August 1973		April/May 1974
Taxa	S	VT	S
Chlorophyta			
Actinastrum sp.	P	0	P
Actinastrum hantzschii*	P	0	P
Ankistrodesmus sp.	P	P	0
Ankistrodesmus falcatus	P	0	P
Chaetophora sp.*	P	0	0
Chlorococcus sp.*	0	0	P
Closterium sp.	0	0	P
Coelastrum sp.*	0	0	P
Coleochaete irregularis*	0	0	P
Cosmarium sp.	0	0	P
Crucigenia sp.*	0	0	P
Desmidium sp.*	P	0	0
Dictyosphaerium sp.*	P	0	0
Eudorina elegans	0	0	P
Gloeocystis sp.	0	0	P
Kirchneriella sp.*	0	P	0
Mougeotia sp.	P	0	P
Pediastrum duplex	P	P	0
Pediastrum duplex va. reticulatum*	P	0	0
Pediastrum tetras*	P	0	P
Scenedesmus sp.	P	P	P
Scenedesmus acuminatus*	0	0	P
Scenedesmus bijuga*	0	0	P
Scenedesmus quadricauda	0	0	P
Sphaerocystis sp.	P	P	0
Sphaerocystis schroeteri	0	0	P
Spirogyra sp.*	0	0	P
Staurastrum sp.	P	0	P
Tetraedron sp.	P	P	P
Treubaria sp.	0	0	P
Total Chlorophyta	14	6	22
Chrysophyta			
Achnanthes sp.	0	0	P
Achnanthes denticula*	0	0	P
Achnanthes lanceolata va. dubia*	0	0	P
Amphora sp.*	0	0	P
Amphora ovalis*	0	0	P

Table 3.3.1a (Continued)

Taxa	August 1973		April/May 1974
	S	VT	S
Chrysophyta (Continued)			
Amphora veneta*	0	0	P
Asterionella formosa	P	P	P
Caloneis sp.*	0	0	P
Caloneis ventricosa*	0	0	P
Cocconeis placentula*	0	0	P
Cocconeis placentula var. euglypta*	0	0	P
Cyclotella sp.	0	0	P
Cyclotella kutzingiana*	0	0	P
Cyclotella meneghiniana	0	0	P
Cyclotella stelligera	0	0	P
Cymbella sp.	0	0	P
Cymbella affinis*	0	0	P
Denticula sp.*	0	0	P
Denticula elegans*	0	0	P
Diatoma sp.*	0	0	P
Dinobryon sp.	P	P	P
Eunotia sp.	0	0	P
Fragilaria construens*	0	0	P
Fragilaria pinnata*	0	0	P
Fragilaria virescens*	P	0	0
Frustulia sp.	0	0	P
Gomphonema sp.	0	0	P
Gomphonema augur*	0	0	P
Gomphonema olivaceum*	0	0	P
Gyrosigma sp.	P	0	P
Gyrosigma acuminatum*	0	0	P
Gyrosigma kutzingiana*	0	0	P
Melosira sp.	0	P	0
Melosira ambigua*	0	0	P
Melosira distans	0	0	P
Melosira granulata	P	P	0
Melosira granulata va. angustissima*	P	P	P
Melosira italica*	P	0	0
Melosira varians	P	0	P
Navicula sp.	P	P	P
Navicula aikenensis*	0	0	P
Navicula auriculata	0	0	P
Navicula cryptocephala*	0	0	P
Navicula exigua*	0	0	P
Navicula exigua var. capitata*	P	0	0
Navicula gastrum*	0	0	P

Table 3.3.1a (Continued)

Taxa	August 1973		April/May 1974
	S	VT	S
Chrysophyta (Continued)			
Navicula gysingensis*	0	0	P
Navicula hungarica var. capitata*	0	0	P
Navicula muralis*	0	0	P
Navicula mutica var. undulata*	0	0	P
Navicula pupula var. rectangularis*	0	0	P
Navicula pusilla*	0	0	P
Navicula tripunctata*	0	0	P
Navicula viridula var. linearis*	0	0	P
Nitzschia sp.	0	0	P
Nitzschia acicularis	0	0	P
Nitzschia amphibia*	0	0	P
Nitzschia filiformis*	0	0	P
Nitzschia holsatica*	0	0	P
Nitzschia lorenziana*	0	0	P
Nitzschia microcephala*	0	0	P
Nitzschia palea	0	0	P
Nitzschia paradoxa*	0	0	P
Nitzschia sigmoidea*	0	0	P
Nitzschia tryblionella*	0	0	P
Pinnularia biceps*	0	0	P
Stauroneis sp.	P	0	P
Stephanodiscus sp.	0	0	P
Stephanodiscus astrea*	0	0	P
Stephanodiscus invisitatus*	0	0	P
Stephanodiscus niagarae*	P	0	0
Surirella sp.	0	0	P
Synedra sp.	P	P	P
Synedra actinastroides*	P	0	0
Synedra delicatissima*	0	0	P
Synedra fasciculata var. truncata*	P	0	0
Synedra rumpens*	P	P	0
Synedra rumpens var. familiaris*	0	0	P
Synedra ulna	P	P	P
Synedra vaucheriae*	0	0	P
Tabellaria sp.	0	0	P
Tabellaria fenestrata	P	P	0
Terpsinoe sp.*	P	P	0
Total Chrysophyta	19	11	72

Table 3.3.1a (Continued)

Taxa	August 1973 S	 VT	April/May 1974 S
Cyanophyta			
Anabaena sp.	P	P	P
Calothrix sp.*	0	0	P
Lyngbya sp.*	P	0	0
Merismopedia sp.	P	P	P
Microcystis sp.	0	0	P
Oscillatoria sp.	P	0	0
Phormidium	0	0	P
Spirulina sp.	P	0	0
Total Cyanophyta	5	2	5
Euglenophyta			
Euglena sp.	P	P	0
*Euglena acus**	0	0	P
*Phacus torta**	P	P	0
Trachelomonas sp.	0	0	P
Total Euglenophyta	2	2	2
Pyrrophyta			
Ceratium hirundinella	0	0	P
Glenodinium sp.*	0	0	P
Total Pyrrophyta	0	0	2
TOTAL TAXA	40	21	103

*Not reported in previous baseline collections

Table 3.3.2a Total phytoplankton species by phyla collected at transects in the Broad River Study Area in August 1973* and April/May 1974**

	A	B	C		D		E	F
			S	VT	S	VT		
August 1973								
Chlorophyta	4	3	5	5	3	2	6	10
Chrysophyta	11	5	8	7	6	8	7	6
Cyanophyta	0	2	1	1	1	2	5	0
Euglenophyta	1	1	1	2	1	0	1	0
Total/Depth			15	15	11	12		
Total/Transect	16	11	13		19		19	16

	B			BL			C			CL			D				
April/May 1974	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	4	5
Chlorophyta	8	5	5	4	8	3	3	2	2	2	1	4	5	2	6	2	1
Chrysophyta	21	18	20	21	23	17	18	26	20	15	21	20	17	15	13	16	22
Cyanophyta	1	0	0	2	1	0	1	0	0	0	1	0	0	0	1	0	1
Euglenophyta	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0
Pyrrophyta	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0
Total/Station	30	24	25	28	34	21	22	29	22	17	24	24	23	17	20	18	24
Total/Transect		47			48			45			40				45		

*Only one surface sample was collected per transect, except at Transects C and D where surface (S) and vertical tows (VT) were made.

**Three collecting points were sampled at Transects B, BL, C, and CL and five at Transect D. Transects A, E, and F were not sampled. BL and CL represen the littoral zones of Transects B and C, respectively.

Of those taxa listed in Section 3.3.3.1.1 of the baseline report as common in the Broad River Study Area, Pleurosigma and Chroococcus were not present in the August 1973 or April/May 1974 samples and Oscillatoria and Microcystis were relatively scarce.

3.3.3.1.2a Quantitative Analysis

Laboratory analyses revealed that very low phytoplankton populations characterized the Broad River Study Area during August 1973. Densities averaged 47 phytoplankters per liter and ranged from 32 per liter at Transect B to approximately 51 per liter at Transects A and F. These are the lowest densities which have been recorded in the study area.

None of the diatoms listed in Table 3.3.3 of the Baseline Biotic Survey were predominant in the August 1973 samples. Although Table 3.3.3a lists the most numerous taxa, it can be seen readily that none were found in abundance. The greatest density of any taxon was 25 Ankistrodesmus per liter occurring at Transect F.

Much higher phytoplankton populations characterized the study area during April/May 1974. Densities averaged 1480 phytoplankters per liter and ranged from 240 per liter at Collecting Point 5 of Transect C to 5977 at Collecting Point 3 of Transect B. These densities are within the range of those previously reported in the study area during spring. Highest densities consistently occurred at Transect B while lowest densities generally occurred at Transect D.

With the exception of Melosira granulata var. angustissima, which was the most abundant species, the predominant taxa in the April/May 1974 samples (Table 3.3.3a) differed from those in the previous baseline survey (Table 3.3.3). However, as in previous collections, all were chrysophytes.

Table 3.3.3a. Mean density (number/liter) of major phytoplankton taxa in the Broad River Study Area from Transects A through F in August 1973 and Transects B through D in April/May 1974.

			C		D			
	A	B	S	VT	S	VT	E	F
August 1973								
Ankistrodesmus sp.	0	6	13	10	12	0	0	0
Ankistrodesmus falcatus	0	0	0	0	0	0	0	25
Pediastrum duplex	3	1	0	1	4	13	4	0
Anabaena sp.	0	3	2	9	2	2	2	0
Phacus torta	0	2	7	1	2	0	7	0
Desmidium sp.	0	0	0	0	13	0	3	3

	B			C			D				
	1	2	3	1	2	3	1	2	3	4	5
April/May 1974											
Melosira granulata var. *angustissima*	2278	804	2917	37	106	60	0	31	0	0	8
Dinobryon sp.	405	0	870	65	54	43	0	0	0	0	0
Nitzschia acicularis	172	138	510	57	109	48	16	24	43	12	0
Melosira ambigua	555	432	51	0	37	5	0	12	0	2	12
Cyclotella sp.	234	60	434	2	6	3	14	0	8	2	8

As with phytoplankton densities, primary productivity was higher at Transect B than at Transect D. ^{14}C assimilation values were 51.6 and 27.8 mgC/m^3/hr at Transects B and D, respectively.

3.3.3.2a Zooplankton

3.3.3.2.1a Qualitative Analysis

A total of 28 zooplankton taxa were collected in the Broad River Study Area in August 1973 and April/May 1974 by surface samples and vertical plankton net tows (Table 3.3.4a). The number of taxa in each major taxonomic group was: Protozoa, 1; Rotifera, 20; Copepoda, 1; and Cladocera, 6. These numbers are similar to those reported previously in the baseline survey. Table 3.3.4a includes seven rotifer taxa and one cladoceran taxa not previously reported in the baseline survey. These include four additional species of genera previously observed as well as four additional genera.

Of those taxa listed in Section 3.3.3.2.1 of the baseline report as common in the Broad River Study Area, all occurred in the August 1973 and April/May 1974 samples, except Cyclops sp. which only occurred at Transect C in August.

Taxa per transect ranged from 1 to 9 in August 1973 and from 6 to 15 in April/May 1974. During both sampling periods, Transects B and C had the highest number of taxa. As in the previous baseline survey, few taxa were collected from Transects E and F in August 1973.

3.3.3.2.2a Quantitative Analysis

Laboratory analyses revealed that low zooplankton populations characterized the Broad River Study Area during August 1973. Densities averaged 31 zooplankters per liter and ranged from 2 per liter at Transect E to 94 per liter at Transect C. These low densities are within the range

Table 3.3.4a Species list of zooplankton present (P) in surface (S) and vertical tow (VT) plankton samples in August 1973 and April/May 1974.

	August 1973		April/May 1974
Taxa	S	VT	S
Rotifera			
Asplanchna sp.	P	0	0
*Asplanchna priodonta**	0	0	P
Brachionus spp.	P	0	P
Brachionus bidentata	0	0	P
Conochilus sp.	P	P	P
Chromogaster sp.*	0	0	P
Filinia sp.	P	0	0
Filinia longiseta	0	0	P
Gastropus sp.	P	0	P
Keratella cochlearis	P	P	P
*Keratella quadrata**	0	0	P
Lecane sp.	P	0	0
Lepadella sp.	0	0	P
Notholca sp.	0	0	P
Platyias sp.*	P	P	P
*Platyias polyacanthus**	0	0	P
Ploesoma sp.	0	0	P
Polyarthra sp.	P	P	P
Synchaeta sp.	0	0	P
Trichocerca sp.	P	P	P
Total Rotifera	10	5	17
Copepoda			
Cyclops sp.	0	P	0
Calanoid copepod	0	0	P
Cyclopoid copepod	0	0	P
Nauplii	P	P	P
Total Copepoda	1	2	3
Cladocera			
Alona sp.	0	0	P
Bosmina longirostris	0	0	P
Chydorus sphaericus	0	0	P
Daphnia sp.	0	P	0
Diaphanosoma sp.*	0	0	P
Scapholeberis kingi	0	0	P
Total Cladocera	0	1	5

*Not reported in previous baseline collections.

Table 3.3.4a (Continued)

Taxa	August 1973		April/May 1974
	S	VT	S
Protozoa			
Astrameba radiosa	P	0	0
Total Protozoa	1	0	0
Total Taxa	12	8	25

of densities reported previously in the baseline survey. Although rotifers were the dominant taxonomic group in most samples, their numbers were rather low compared to most aquatic systems. Rotifers ranged from 1 per liter at Transects D and E to 72 per liter at Transect C. According to Pennak (1953), most plankton communities average 40 to 500 rotifers per liter.

Much higher zooplankton populations occurred in the study area during April/May 1974. Densities averaged 338 zooplankters per liter, but sample densities had a wide range. Zero zooplankters were reported for Collecting Point 5 of Transect D while 1505 per liter were reported for Collecting Point 3 of Transect B. In general, densities at all Transect B stations were much higher than those at Transects C and D.

As in previous baseline studies, rotifers were the predominant taxonomic group. Copepods were more numerous than cladocerans, but neither group was abundant. In contrast to previously reported findings, a single rotifer genus, Conochilus, was dominant in both the August 1973 and April/May 1974 samples. It comprised as much as 79 percent of the Transect F sample in August and 91 percent of the Collecting Point 1 sample at Transect B in April/May.

It was previously stated in Section 3.3.3.2.2 of the baseline survey, that mean zooplankton densities generally did not exceed 50 per liter, but several exceptions to this occurred in August 1973 and April/May 1974. The sample period, transects having a density greater than 50 per liter and the dominant rotifer taxa follow: August at B (51/liter), Conochilus; August at C - vertical tow (94/liter), Conochilus and Platyias; August at F (56/liter), Conochilus; April/May at Collecting Points 1-3 at Transect B (1231, 776, and 1505/liter, respectively), Conochilus and Keratella cochlearis; and April/May at Collecting Points 1 and 3 at Transect C (72 and 62/liter, respectively), Conochilus and Keratella cochlearis.

3.3.4a DISCUSSION

3.3.4.1a Phytoplankton

In contrast to the previous baseline survey, the August 1973 phytoplankton collections were numerically dominated by chlorophytes. As in previous studies, the April/May 1974 collections were qualitatively and quantitatively dominated by chrysophytes. The composition of the phytoplankton in the Broad River Study Area reflects seasonal variation in light and temperature. According to Williams (1966), in temperate climates during the cooler months, phytoplankton communities largely consist of diatoms, but increasing temperatures encourage the development of green and blue-green algae, which attain their maximum development during the warmer months. Although blue-green algae were generally sparse in both August 1973 and April/May 1974, like the green algae, they were more diversified and numerous in August 1973.

As mentioned in Section 3.3.3.1.2a, the August 1973 phytoplankton densities are the lowest of any which have been reported for the study area. Although the principal phytoplankton taxa are listed in Table 3.3.3a, because their numbers for August are relatively low, a discussion of their ecological significance would not be meaningful. On the other hand, principal taxa were sufficiently abundant in the April/May 1974 collections to warrant consideration of their ecological significance (Table 3.3.3a). Melosira granulata, the most abundant species in the April/May 1974 samples has been a dominant plankter in the previous baseline survey. According to Hutchinson (1967), this species is indicative of nutrient enrichment. In Palmer's (1963) list of the 60 most pollution tolerant algal species in order of decreasing emphasis, Melosira granulata is ranked 59th and Nitzschia acicularis is 18th. Melosira ambigua is not listed. In a similar list of the 52 most pollution tolerant genera, Nitzschia is ranked sixth; Cyclotella, 15th; and Melosira, 19th (Palmer, 1963). The genus Dinobryon is not included in the list.

It was mentioned in Section 3.3.3.1.1a that several different species of Navicula and Nitzschia occurred in the April/May 1974 samples. Because these are typically benthic genera (Hynes, 1972), their abundance reflects the high spring water levels characterizing the study area during April/May. Hynes (1972) states that when water levels are high, numbers of benthic algae increase disproportionately to true plankters.

Transect B, near the mouth of Frees Creek, appears to provide a more suitable habitat for phytoplankton than other sampling transects, although its Secchi disc readings of light penetration were consistently low. Damann (1951) found substantially higher phytoplankton populations in 19 Missouri River tributaries than in the main channel of the river and suggested the difference might be attributed to the more stable substrates and lower current velicities as well as lower turbidity levels characterizing the tributaries.

Examination of water quality data from August 1973 and April/May 1974 gives no indication that plankton are nutrient-limited. According to Chu (1942), algae are likely to suffer a nutrient deficiency when nitrogen concentrations are less than 0.2 mg/l. This level was exceeded in all water samples collected in the study area in August 1973 and April/May 1974.

Values for ^{14}C assimilation were moderately high. Samsel (1974) reported similar values for a eutrophic pond. Highest primary productivity coincided with highest algae density, reflecting the fact that standing crop affects ^{14}C assimilation, though apparently no direct correlation exists (Tunzi and Porcella, 1974). Section 3.3.4.1 of the baseline survey discusses factors which may limit primary productivity in the Broad River Study Area.

3.3.4.2a Zooplankton

Zooplankton composition and densities in the Broad River Study Area during August 1973 were similar to those discussed in the baseline survey. Exceptionally high zooplankton densities reported for the April/May 1974 samples are probably related to the increased spring phytoplankton densities. Hynes (1972) observes that when diatom numbers increase, rotifers, the principal river zooplankters, become more common. This may indicate either a trophic effect or that similar conditions favor both types of organisms.

As with phytoplankton, highest and lowest zooplankton densities occurred at Transects B and D, respectively. Williams (1966), comparing phytoplankton and rotifer data from the national water quality network samples, found that stations with high phytoplankton populations generally had high rotifer populations. The opposite relationship also occurred.

According to Edmondson (1959), the colonial sessile rotifer Conochilus may accumulate in great numbers under suitable light and trophic conditions. However, specific ecological factors stimulating its great abundance, particularly at Transect B in April/May 1974, have not been determined.

3.3.5a SUMMARY

3.3.5.1a Phytoplankton

A total of 127 phytoplankton taxa were collected in the Broad River Study Area in August 1973 and April/May 1974. Seventy-seven of these taxa were not previously reported in the baseline survey. These include 15 Chlorophyta, 57 Chrysophyta, two Cyanophyta, two Euglenophyta and one Pyrrophyta taxa. This higher number of taxa compared to previous studies not only reflects more detailed species analyses for genera previously collected, but also an increase in benthic algae corresponding to high water levels in April/May 1974.

Phytoplankton populations in August 1973 were the lowest reported in the study area. The April/May 1974 populations, however, were within the range of those previously reported. In contrast to previous samples, the August 1973 collections were dominated by chlorophytes while the April/May 1974 collections were qualitatively and quantitatively dominated by diatoms.

With the exception of *Melosira granulata* var. *angustissima*, the predominant taxa in the August 1973 and April/May 1974 collections differed from those in the previous baseline survey.

Primary productivity in the study area in April/May 1974 was moderately high.

3.3.5.2a Zooplankton

A total of 28 zooplankton taxa were collected in the Broad River Study Area in August 1973 and April/May 1974. Although this number of taxa is similar to that previously reported for the baseline survey, it includes seven rotifer taxa and one cladoceran taxa not previously reported.

Low densities, averaging 31 zooplankters per liter, characterized the August 1973 samples. Much higher densities, averaging 338 zooplankters per liter, occurred during April/May 1974. As in the previous baseline survey, zooplankton abundance appeared to be directly related to phytoplankton abundance.

In contrast to previous findings, the colonial rotifer <u>Conochilus</u> was dominant in the August 1973 and April/May 1974 collections. Ecological factors stimulating its dominance were not determined.

3.4a VASCULAR HYDROPHYTES

A shoreline survey of the Broad River Study Area during the fall of 1973 resulted in the collection and identification of four previously unidentified species (Table 3.4.1a). Collection techniques and identification were the same as those used in previous surveys. Identification was facilitated because the plants bore the proper reproductive structures necessary for positive identification.

Bentgrass (_Agrostis_ _stolonifera_) was found growing along the banks of the Broad River. Deer will graze the young shoots of this species during the spring. The other three species belong to the sedge family. All three species; sedge (_Cyperus_ _acuminatus_), beak rush (_Rhynchospora_ sp.) and wool grass (_Scirpus_ _cyperinus_) are emergent hydrophytes and were found growing along the banks of Frees Creek. The nutlets of all three species are desirable food sources for waterfowl.

Table 3.4.1a Vascular hydrophytes found during a shoreline survey of the Broad River Study Area in the fall of 1973.

Family Scientific Name Common Name	Growth Form	Location
Gramineae		
Agrostis stolonifera		
Bent Grass	Emergent	Broad River
Cyperaceae		
Cyperus acuminatus		
Sedge	Emergent	Frees Creek
Rhynchospora sp.		
Beak Rush	Emergent	Frees Creek
Scirpus cyperinus		
Wool Grass	Emergent	Frees Creek

3.5a BENTHOS

3.5.1a INTRODUCTION

Benthic macroinvertebrate populations were examined qualitatively and quantitatively at specific collecting points in the Broad River Study Area in August 1973 and April/May 1974. The purpose of these studies was to amplify the baseline survey.

3.5.2a METHODS AND MATERIALS

Sampling methods and materials remained the same as those described in Section 3.5.2 of the baseline survey with the following exceptions. After the August 1973 sampling period, the number of Eckman dredge samples was reduced from five to three at each collecting point, since the larger number of samples did not significantly reduce the variability of organisms collected. Biomass analyses were discontinued after August 1973.

3.5.3a FINDINGS

3.5.3.1a Insects

3.5.3.1.1a Qualitative Analysis

Five new insect species were identified, three to genus, and two to subfamily. This increased the total insect taxa collected for the baseline survey from 66 to 71 (Table 3.5.1a). Of the new taxa collected, four were dipterans and one was an ephemeropteran. A change in nomenclature reclassified Sialis sp. as a Megaloptera rather than a Neuroptera.

Nine and 20 insect taxa were identified, respectively, in the August and April/May sampling periods (Table 3.5.1a). These values are within the range determined during the baseline survey.

The seasonal range of total insect species from individual

Table 3.5.1a Species list of benthic macroinvertebrates present (P) at sample periods in August 1973 and April/May 1974 on the Broad River Study Area.

Taxa	August 1973	April/May 1974
Insecta		
Diptera		
Ceratopogonidae		
Palpomyia sp.	0	P
Unidentified*	P	P
Chironomidae		
Cladotanytarsus sp.	0	P
Clinotanypus sp.	0	P
Chironomus sp.	0	P
Coelotanypus sp.	0	P
Cricotopus sp.	0	P
Cryptochironomus sp.	0	P
Dicrotendipes sp.	0	P
Metriocnemus sp.	0	P
Paracladopelma sp.	0	P
Polypedilum sp.	0	P
Procladius sp.	0	P
Tanypus sp.	0	P
Chironominae	P	0
Tanypodinae	P	0
Culicidae		
Chaoborus punctipennis	P	P
Diptera Total	4	15
Ephemeroptera		
Caenidae		
Caenis sp.	P	0
Ephemeridae		
Hexagenia limbata	P	P
Ephemeroptera Total	2	1
Hemiptera		
Corixidae		
Unidentified*	0	P
Hemiptera Total	0	1
Megaloptera		
Sialidae		
Sialis sp.	P	P
Megaloptera Total	1	1

Table 3.5.1a (Continued)

Taxa	August 1973	April/May 1974
Odonata		
Gomphidae		
Gomphus sp.	0	P
Unidentified*	P	0
Odonata Total	1	1
Trichoptera		
Psychomiidae		
Phylocentropus sp.	P	0
Trichoptera Total	1	0
Insecta Total	9	19
Archnoidea		
Hydracarina		
Pionidae		
Piona sp.	0	P
Uniocolidae		
Huitfeldtia rectipes?	0	P
Unicola sp.	0	P
Unidentified*	0	P
Archnoidea Total	0	4
Nematoda		
Dorylaimidae		
Laimydurus sp.?	0	P
Unidentified*	P	P
Nematoda Total	1	2
Nemertea		
Prostoma rubrum	P	P
Nemertea Total	1	1
Hirudinea		
Glossophoniidae		
Batrachobdella sp.	0	P
Unidentified*	0	P
Hirudinea Total	0	2

Table 3.5.1a (Continued)

Taxa	August 1973	April/May 1974
Oligochaeta		
Lumbriculidae		
Unidentified*	0	P
Naididae		
Arcteonais lomondi	0	P
Dero obtusa	0	P
Dero digitata	0	P
Dero nivea	0	P
Dero sp.	P	0
Nais elinguis	0	P
Slavina appendiculata	0	P
Specaria josinae	0	P
Stylaria lacustris	0	P
Tubificidae		
Aulodrilus limnobius	0	P
Aulodrilus pigueti	0	P
Branchiura sowerbyi	P	P
Ilyodrilus templetoni	0	P
Limnodrilus hoffmeisteri	0	P
Peloscolex multisetosus	0	P
Immature sp.1	0	P
Immature sp.2	0	P
Unidentified*	P	0
Oligochaeta Total	3	17
Mollusca		
Pelecypoda		
Corbiculidae		
Corbicula manilensis	P	P
Sphaeriidae		
Pisidium sp.	0	P
Sphaerium striatinum	0	P
Sphaerium sp.	0	P
Unidentified*	P	P
Mollusca Total	2	5
Taxa Total	16	50

*Species unknown, may be more than one species but considered here as one.

transects was as follows: B, 6-7; C, 13; and D, 6-8 (Tables 3.5.2a, 3.5.3a). This extends the range at Transect B from 10-17 taxa to 6-17 taxa and Transect D from 8-17 taxa to 6-17 taxa.

Nine insect species were considered ubiquitous to the Broad River Study Area during the baseline survey; however, in the August 1973 and the April/May 1974 surveys two chironomids, Ablabesmia sp. and Tanytarsus sp., were not collected. Only three (Chaoborus punctipennis, Hexagenia limbata and Sialis sp.) of the nine ubiquitous species were present during both surveys. Although it is likely that on any sampling date most of the nine "ubiquitous species" will be collected, it should be understood that under certain circumstances (e.g. just after emergence) even the most common species might be omitted from a collection.

3.5.3.1.2a Quantitative Analysis

The orders Diptera and Ephemeroptera (mayflies) continued to be numerically predominant in the Broad River Study Area during all seasons (Tables 3.5.2a, 3.5.3a). The chironomid larvae and phantom midges continued to be the most abundant dipteran and Hexagenia limbata continued to be the most abundant mayfly. The density of insects were comparable with previous data for the Broad River Study Area. Both the August 1973 and the April/May 1974 data had mean insect densities of about 1100/m^2, characteristic of baseline data for spring and late summer.

Seasonal density changes in the numerically predominant taxa (Diptera and mayflies) were more clearly identified; data shows that densities for both groups were relatively low in April/May, but that by August they were much higher. This coincides with past trends since density peaks for Diptera and mayflies occurred in November and September, respectively (Tables 3.5.2 to 3.5.7).

Table 3.5.2a Total insect species by order and mean number per square meter (in parentheses) on transects in the Broad River Study Area in August 1973

	B	D
Insecta		
Diptera	3 (1813)	3 (173)
Ephemeroptera	1 (5)	2 (43)
Megaloptera	1 (62)	0 (0)
Odonata	0 (0)	1 (9)
Trichoptera	1 (9)	0 (0)
Total Taxa	6 (1889)	6 (325)

Table 3.5.3a Total insect species by order and mean number per square meter (in parentheses) on transects in the Broad River Study Area in April/May 1974.

	B	C	D
Insecta			
Diptera	6 (859)	11 (1363)	6 (445)
Ephemeroptera	0 (0)	1 (128)	1 (437)
Hemiptera	0 (0)	1 (5)	0 (0)
Odonata	0 (0)	0 (0)	1 (5)
Megaloptera	1 (10)	0 (0)	0 (0)
Total Taxa	7 (869)	13 (1496)	8 (887)

3.5.3.2a Other Benthic Macroinvertebrates

3.5.3.2.1a Qualitative Analysis

In addition to the insects, the oligochaetes and molluscs comprised the other important benthic fauna of the Broad River Study Area (Table 3.5.1a). The species composition of the oligochaetes was examined in more detail in August 1973 and April/May 1974. During these surveys, a total of 20 different taxa were recognized of which Branchiura sowerbyi was the only species definitely common to the prior surveys. The predominant species of molluscs included the pelecypods, Corbicula manilensis and Sphaerium spp. No gastropods were collected during either survey period. Other major taxa represented in the August 1973 and April/May 1974 collections (Table 3.5.1a) included: Arachnoidea, Hirudinea (leeches), Nematoda (roundworms) and Nemertea (Proboscis worms); however, the densities of these taxa were relatively low.

3.5.3.2.2a Quantitative Analysis

The density of oligochaetes continued to vary by sample period and transect (Figure 3.5.1a). These data reflect trends similar to other baseline data since mean oligochaete densities at Transects B, C, and D were usually greater than 400/m^2 and exceeded 1000/m^2 on several occasions. Branchiura sowerbyi usually comprised a major proportion of the total oligochaete numbers.

The density and species composition of pelecypod molluscs was similar to other baseline data. Corbicula manilensis and Sphaerium spp. continued to have low densities except at Transect D where densities usually ranged from about 400 to 2600/m^2. During April/May 1974, the density of clams of the family Sphaeriidae (at Transect D) exceeded 3000/m^2, more than 1200/m^2 greater than previously reported for the Broad River Study Area (Tables 3.5.8, 3.5.8a).

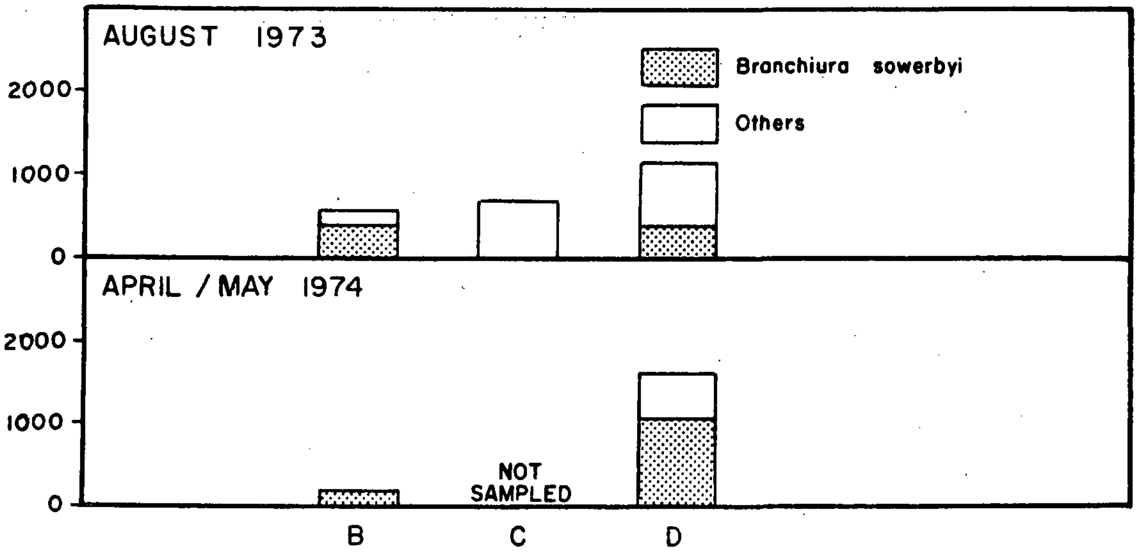

Figure 3.5.1a Mean number of oligochaetes (Branchiura sowerbyi and other species) per square meter on Transects B through D in the Broad River Study Area in August 1973 and April/May 1974

Table 3.5.8a Quantitative comparison (number per square meter) of pelecypod families Sphaeriidae and Corbiculidae at ten collecting points along three transects in the Broad River Study Area between August 1973 and April/May 1974.

		B			C				D*		
	1	2	3	1	2	3	1	2	3	4	5
August 1973											
Sphaeriidae											
<u>Sphaerium</u> spp.	0	NS**	0	NS	NS	NS	0	NS	36	NS	NS
Corbiculidae											
<u>Corbicula</u> <u>manilensis</u>	9	NS	0	NS	NS	NS	711	NS	2018	NS	NS
April/May 1974											
Sphaeriidae											
<u>Sphaerium</u> spp.	0	15	0	15	30	400	NS	NS	430	578	NS
<u>Pisidium</u> sp.	0	0	0	0	0	0	NS	NS	2633	0	NS
Corbiculidae											
<u>Corbicula</u> <u>manilensis</u>	0	0	0	0	0	0	NS	NS	356	1393	NS

*This transect was relocated in April 1974 (Figure 3.1-2a)

**NS = not sampled

3.5.3.3a Biomass

Benthos standing crop was determined (reported as ash-free dry weight biomass) from shallow and deep collecting points of Transects B and D in August 1973 (Table 3.5.9a). The total biomass at Transect B was much lower than at Transect D. There was not much difference between shallow and deep collections at Transect B as reported earlier; however, values of 0.158 and 0.600 grams per square meter were lower than any earlier reports. At Transect D, the biomass of the deep collection was more than three times greater than the shallow collection. This falls within the earlier reported range for which the biomass was 2 to 5 times greater from the deep collections than the shallow ones.

Insects and oligochaetes accounted for about 86 percent of the biomass at Transect B. The oligochaetes accounted for most of the biomass in the shallow area and the insects accounted for most of the biomass in the deep area. At Transect D, the mollusc, Corbicula manilensis was the major component of the biomass in both the shallow (97 percent) and deep (99 percent) areas. The total biomass reported for this period (August 1973) was more than twice as great as earlier reported values (Table 3.5.10) for both shallow (91.385 g/m^2) and deep (337.348 g/m^2) collections.

3.5.4a DISCUSSION

Most of the species of benthic organisms previously identified (Section 3.5.4) as faculative or pollution tolerant were present in August 1973 and/or April/May 1974. Two species of aquatic oligochaetes, Branchiura sowerbyi, and Limnodrilus hoffmeisteri (present during the baseline survey, Tables 3.5.1, 3.5.1a) are also considered as pollution tolerant organisms (Mason, et al., 1971). Two species of Diptera,

Table 3.5.9a Ash-free dry weight biomass in grams per square meter of benthic organisms in quantitative samples at two stations on Transects B and D in the Broad River Study Area in August 1973.

	B-1 (Shallow)	B-3 (Deep)	D-1 (Shallow)	D-3 (Deep)
Insecta				
Diptera				
Chironomidae	0.047	0.048	0.013	0.013
Others	0.001	0.098	0.001	-
Ephemeroptera				
Ephemeridae	0.030	-	0.074	0.004
Others	-	-	-	0.002
Megaloptera	0.101	-	-	-
Odonata	-	-	0.171	0.163
Trichoptera	0.027	-	-	-
Oligochaeta				
Tubificidae	0.288	0.012	2.059	0.762
Others	-	-	-	0.001
Nematoda	0.001	-	-	-
Mollusca				
Corbiculidae	0.105	-	89.067	336.400
Sphaeriidae	-	-	-	0.002
Others	-	-	-	0.001
TOTAL	0.600	0.158	91.385	337.348

Ablabesmia sp. and Tanytarsus sp., which were considered ubiquitous to the study area (Section 3.5.4) and which are also considered pollution sensitive were not collected in August 1973 or April/May 1974. The absence of these organisms could indicate recent environmental stress; however, the continued presence of Hexagenia limbata (a pollution sensitive species) refutes this premise. This new information on indicator species does not change conclusions drawn during previous baseline work.

Seasonal differences in the number of taxa and density continued to be observed (Tables 3.5.2a, 3.5.3a, 3.5.8a). These differences are generally similar to previously collected data for a given station during the same season. The high density of clams of the family Sphaeriidae at Transect D in April/May 1974 was one exception to the above generality. This high density (more than 3000/m^2) may be due in part to the relocation of Transect D and related changes in habitat types.

The relatively consistent characteristics of the biomass values at Transect B (mean biomass was 2.247 g/m^2 at the shallow and 2.244 g/m^2 at the deep collecting points) provides data which may be used in the future to determine changes in benthic productivity (Tables 3.5.9, 3.5.9a). Although the mean biomass values at the shallow and deep collecting points on Transect D were not similar (45.981 g/m^2 at the shallow and 165.461 g/m^2 at the deep collecting points), they were relatively constant throughout the survey (Tables 3.5.10, 3.5.9a). Thus, they too provide data which may be used to determine future changes in benthic productivity.

3.5.5a SUMMARY

3.5.5.1a Insects

A total of 71 insect taxa were collected during the baseline survey (June 1971 - April/May 1974). The seasonal range of total insect taxa from individual transects was as follows: A′, 7-11; A, 1-15; B, 6-17; C, 10-16; D, 6-17; E, 0-21; and F, 0-16. Chaoborus punctipennis, Hexagenia limbata and Sialis sp. were the only insect species which may be considered ubiquitous to the Broad River Study Area for the entire baseline survey.

The mean density of insects from individual transects varied by sample period and ranged from a minimum of $0/m^2$ to a maximum of $3845/m^2$. The greatest overall mean density of insects occurred in June 1971 (489 to $3763/m^2$) and November 1972 (1630 to $3845/m^2$).

3.5.5.2a Other Benthic Macroinvertebrates

The oligochaetes and molluscs were the numerically predominant taxa in this category. The species composition of the oligochaetes was examined in more detail in August 1973 and April/May 1974, revealing at least 20 different taxa. Branchiura sowerbyi continued to be the most numerically abundant oligochaete. The predominant molluscs continued to be Corbicula manilensis and Sphaerium spp. During April/May 1974 the density of clams of the family Sphaeriidae (at Transect D) exceeded $3000/m^2$, more than $1200/m^2$ greater than previously reported for the Broad River Study Area.

3.5.5.3a Biomass

Biomass standing crop determinations were relatively consistent at given collecting points. The minimum biomass values for Transect B were observed in August 1973 as were the maximum values for Transect D. These data should be useful for determining future changes in benthic productivity.

3.6a FISH

3.6.1a INTRODUCTION

The addendum contains two additional fisheries investigations not contained in the baseline survey, August 1973 and April/May 1974. The purpose and objectives of these investigations are described in Section 3.6.1 of the baseline report.

3.6.2a METHODS AND MATERIALS

3.6.2.1a Collection

Collection methods are the same as those reported in Section 3.6.2.1 of the baseline survey. However, in 1974 the sampling effort was increased in the littoral area by the addition of seining and back-pack shocking for larval and juvenile fish at three collection points on Transects B, C, and D. The areas of fish collection were in conjunction with areas where littoral plankton was collected and also within areas covered with the boat electroshocker, but inaccessible due to vegetative overgrowth and shallow depth. Back-pack shocking was done for 15 minutes at each collecting point in order to adequately sample the entire area. In addition, three seine hauls were randomly taken in corresponding collecting points outside the vegetative cover.

3.6.2.2a Age and Growth

Described in Section 3.6.2.2 of the baseline report.

3.6.2.3a Length-Weight Relationships

Described in Section 3.6.2.3 of the baseline report.

3.6.2.4a Condition Factor

Described in Section 3.6.2.4 of the baseline report.

3.6.2.5a Sex Ratio and Gonadal Condition

Described in Section 3.6.2.5 of the baseline report.

3.6.2.6a Standing Crop Estimate

The rationale and objectives of annual rotenone sampling appears in Section 3.6.2.6 of the baseline report. Baseline samples in Cannon and Frees Creeks were taken on 11-13 November 1972, and 27-29 August 1973.

The location of the cove sample at Transect B was 128 m upstream from the trestle on the north side of Frees Creek and the location of the Transect C cove sample was 1026 m downstream from the bridge on the north side.

3.6.2.7a Food Habits

Described in Section 3.6.2.7 of the baseline report.

3.6.3a FINDINGS AND DISCUSSION

3.6.3.1a Species Composition and Relative Abundance

Table 3.6.2a is modeled after Table 3.6.2 in the baseline report, with additional data from the August 1973 and April/May 1974 samplings. Dominance of the five most abundant species was relatively unchanged (76.4 versus 76.9 percent) by the additional data. Gizzard shad (Dorosoma cepedianum) was the only species which had increased dominance; however, the decline in white crappie (Pomoxis annularis) almost equaled the gizzard shad increase. The other three dominant species changed little. The increased shocking efficiency below the dam (Transect E) may account for changes in dominance as reflected by gizzard shad and white crappie since more gizzard shad were collected below the dam than previously reported.

Two additional samples contributed five new species: mosquitofish

Table 3.6.2a Species composition and relative abundance of all fishes collected from the Broad River Study Area between March 1971 and April/May 1974.

Common Name	Scientific Name	No.	Percent
Bluegill	*Lepomis macrochirus*	1830	34.12
Gizzard shad	*Dorosoma cepedianum*	1041	19.41
White crappie	*Pomoxis annularis*	565	10.54
Redear sunfish	*Lepomis microlophus*	458	8.54
Largemouth bass	*Micropterus salmoides*	206	3.84
Longnose gar	*Lepisosteus osseus*	137	2.55
Carp	*Cyprinus carpio*	122	2.27
River carpsucker	*Carpiodes carpio*	117	2.18
Shorthead redhorse	*Moxostoma macrolepidotum*	105	1.96
Black crappie	*Pomoxis nigromaculatus*	82	1.52
Flat bullhead	*Ictalurus platycephalus*	78	1.45
Channel catfish	*I. punctatus*	70	1.31
Warmouth	*Lepomis gulosus*	64	1.19
Quillback	*Carpiodes cyprinus*	64	1.19
White catfish	*Ictalurus catus*	61	1.14
Pumpkinseed	*Lepomis gibbosus*	56	1.04
Golden shiner	*Notemigonus crysoleucas*	53	0.99
Silver redhorse	*Moxostoma anisurum*	40	0.75
Mosquitofish	*Gambusia affinis*	34	0.63
Redbreast sunfish	*Lepomis auritus*	27	0.50
Silvery minnow	*Hybognathus nuchalis*	19	0.35
Snail bullhead	*Ictalurus brunneus*	17	0.32
White sucker	*Catostomus commersoni*	13	0.24
Brown bullhead	*Ictalurus nebulosus*	12	0.22
White bass	*Morone chrysops*	12	0.22
American eel	*Anguilla rostrata*	11	0.21
Yellow bullhead	*Ictalurus natalis*	10	0.19
Green sunfish	*Lepomis cyanellus*	10	0.19
Spotted sucker	*Minytrema melanops*	9	0.17
Satinfin shiner	*Notropis analostanus*	8	0.15
Unidentified shiner	*Notropis* spp.	6	0.11
Hybrid sunfish	*Lepomis* sp.	6	0.11
Longear sunfish	*L. megalotis*	5	0.09
Smallfin redhorse	*Moxostoma robustum*	2	0.04
Striped jumprock	*M. rupiscartes*	2	0.04

Table 3.6.2 (continued)

Common Name	Scientific Name	No.	Percent
Creek chubsucker	*Erimyzon oblongus*	2	0.04
Black bullhead	*Ictalurus melas*	2	0.04
Tadpole madtom	*Noturus gyrinus*	2	0.04
Spotted gar	*Lepisosteus oculatus*	1	0.02
Speckled madtom	*Noturus leptocanthus*	1	0.02
Chub	*Hybopsis* spp.	1	0.02
Pallid shiner	*Notropis amnis*	1	0.02
Yellow perch	*Perca flavescens*	1	0.02
Swamp darter	*Etheostoma fusiforme*	1	0.02
Johnny darter	*E. nigrun*	1	0.02
Total No.		5363	
Total Species		45 minimum	

(Gambusia affinis), snail bullhead (Ictalurus brunneus), smallfin redhorse (Moxostoma robustum), striped jumprock (M. rupiscartes), and johnny darter (Etheostoma nigrum). All of these species, with the exception of the mosquitofish, were collected only at non-reservoir Transects E or F.

The following annotated list of species contains the new species reported and data which differs from that reported in Section 3.6.3.1 of the baseline survey. Additional data including the percentage each species comprises of the total are included in Table 3.6.2a.

Lepisosteidae - Gar family

Lepisosteus osseus - Abundance of longnose gar increased from ninth to sixth during the two additional surveys. Their large numbers at Transects B and E in April/May 1974 accounted for their increase.

Cyprinidae - Minnow family

Carpiodes carpio - River carpsucker decreased in rank from sixth to seventh. Few river carpsucker were taken probably because spawning activity had ceased as the gonadal condition average was 5.5.

Carpiodes cyprinus - The quillback rank increased from 20th to 14th. In April/May 1974, 47 quillback were collected at Transect E, near the dam. As stated in the baseline survey in Section 3.6.3.1, spawning migrations probably concentrate fish at the base of the dam in the spring. Gonadal condition of quillbacks collected in April/May 1974 averaged 5.0, which indicates active spawning condition (Nikolsky, 1963).

Moxostoma robustum - Prior to the August 1973 sampling period, all redhorse specimens collected were identified only to genus. With subsequent sampling, identification to species was possible. The smallfin redhorse (Moxostoma robustum) and striped jumprock (Moxostoma rupiscartes) collected at Transect E in April/May 1974 represent two species not recorded previously in the baseline collections.

Ictaluridae - Freshwater catfish family

Ictalurus brunneus - Another addition to the species list is the snail bullhead collected at Transects E and F. Prior to 1970, this species was synonymous with I. platycephalus, the flat bullhead (Bailey et al., 1970).

Ictalurus catus - The ranking of white catfish decreased to 15th from 11th.

Ictalurus nebulosus - The rank of brown bullhead increased from 28th to 24th. To date, specimens have been collected from all transects except F.

Ictalurus platycephalus - A decline from 8th to 11th was observed for the flat bullhead. This species was not collected in the two additional surveys, which accounts for its overall decline in the abundance ranking.

Centrarchidae - Sunfish family

Lepomis gibbosus - The pumpkinseed's ranking decreased from 13th to 16th. In April/May 1974, a single specimen was collected at Transect E, representing the first pumpkinseed collected at a non-reservoir transect.

Lepomis gulosus - Warmouth increased in rank from 14th to 13th.

Percidae - Perch Family

Etheostoma nigrum - In April/May 1974, a single specimen of johnny darter was collected, representing an additional darter species.

3.6.3.2a Age and Growth

A gradual increase in back-calculated growth rate for the age I bluegill occurred from 1966 through 1972 (Table 3.5.3a). However, subsequent age groups did not have the same gradual increase. The maximum growth rate for age group II occurred in 1967, while for age groups III through V, it was in 1968.

This growth increase for age I bluegills indicates an increase in stability of the littoral area, which promoted higher zooplankton densities. Since bluegills depend on zooplankton longer than the other four species for which growth was calculated, this might explain the growth increase for bluegills compared to the other species. Even with an increase in growth rate, the bluegill, as well as gizzard shad, and largemouth bass, had slower growth rates than other area lakes (Stevens, 1959). The opposite was true for age I white crappie and all age classes of redear sunfish.

3.6.3.3a Length-Weight Relationship

Data for both the November 1972 and April/May 1974 surveys appear in Table 3.6.4a. Most variation is due to small samples used in the regression analysis. However, Ricker (1970) stated that coefficient a varies seasonally with the time of day and between one habitat and another, but coefficient b is more stable and only changes at maturity or as a result of major environmental changes.

Coefficient b generally increased in August 1973 over values in November 1972 at Transect C for the five most abundant species: bluegill, gizzard shad, white crappie, redear, and largemouth bass. The remaining Transects, B, D, and E, had decreased b values. This indicates that habitat was more favorable in November 1972 than August 1973. The

Table 3.6.3a Mean back calculated total lengths and average growth increments of selected fishes from all Parr Reservoir transects (B, C, D), March 1971 - August 1973.

		Total Length (mm) at Annulus						
Year Class	n*	1	2	3	4	5	6	7
				Bluegill				
1972	44	64						
1971	115	56	88					
1970	117	57	92	126				
1969	85	53	86	115	146			
1968	54	56	87	115	141	143		
1967	12	65	97	130	155	-		
1966	8	29	69	106	134	154	172	
Mean Length		54	87	118	144	149	172	
Mean Increment		54	34	32	27	11	18	
				White Crappie				
1972	5	60						
1971	41	73	139					
1970	59	71	129	181				
1969	44	58	125	165				
1968	23	74	128	174	210			
1967	6	52	97	137	198	235		
1966	7	47	102	150	204	237	271	
Mean Length		62	120	161	204	236	271	
Mean Increment		62	57	45	47	35	34	
				Gizzard Shad				
1972	3	181						
1971	95	116	193					
1970	44	121	177	196				
1969	30	94	160	203				
1968	23	106	177	201	276			
1967	14	125	173	198	232	286		
1966	4	130	218	240	275	318	348	
1965	1	150	195	260	290	330	360	397
Mean Length		128	185	216	268	311	354	397
Mean Increment		128	57	33	44	46	30	37

Table 3.6.3a (Continued)

		Total Length (mm) at Annulus						
Year Class	n*	1	2	3	4	5	6	7
				Redear				
1972	9	81						
1971	21	62	118					
1970	23	65	111	148				
1969	17	60	111	147	197			
1968	18	54	119	146	177			
1967	6	61	119	162	185	194		
1966	2	84	109	148	173	195	209	
1965	6	54	77	120	150	188	208	222
1964	4	54	80	124	167	196	221	241
Mean Length		64	106	142	175	193	214	232
Mean Increment		64	41	38	34	24	20	17
				Largemouth Bass				
1972	1	103						
1971	13	98	143					
1970	11	120	145	237				
1969	10	97	181	270	250			
1968	5	161	215	275	-			
1967	5	116	175	233	285	354		
1966	6	99	186	257	300	353	399	
1965	1	55	107	141	180	212	241	255
1964	1	40	80	148	235	323	375	405
Mean Length		99	154	223	250	289	338	330
Mean Increment		99	56	68	29	39	42	22

*Number of fishes examined.

Table 3.6.4a Regression equations of length-weight relationships for fishes collected from the Broad River Study Area, November 1972 and August 1973.

	November, 1972		August, 1973	
Species	Transect	Equation	Transect	Equation
Bluegill	B	$W=3.136x10^{-6}L^{3.336}$	B	$W=9.970x10^{-6}L^{3.099}$
	B (cove)	-	B (cove)	$W=6.626x10^{-6}L^{3.175}$
	C	$W=1.705x10^{-5}L^{2.950}$	C	$W=5.624x10^{-6}L^{3.223}$
	C	$W=9.899x10^{-4}L^{2.168}$	C (cove)	$W=7.888x10^{-6}L^{3.148}$
	D	$W=4.719x10^{-7}L^{3.719}$	D	$W=4.025x10^{-6}L^{3.286}$
	E	$W=1.135x10^{-7}L^{3.960}$	E	$W=5.803x10^{-7}L^{3.694}$
Gizzard Shad	B	$W=2.984x10^{-6}L^{3.211}$	B	$W=7.991x10^{-6}L^{3.021}$
	B (cove)	-	B (cove)	$W=1.166x10^{-4}L^{2.529}$
	C	$W=7.674x10^{-5}L^{2.584}$	C	$W=1.277x10^{-6}L^{3.401}$
	C (cove)	-	C (cove)	$W=3.082x10^{-6}L^{3.207}$
	D	$W=1.315x10^{-5}L^{2.946}$	D	$W=1.564x10^{-5}L^{2.889}$
	E	$W=8.128x10^{-6}L^{3.063}$	E	-
	F	$W=1.774x10^{-4}L^{2.462}$	F	-

Table 3.6.4a (Continued)

	November, 1972		August, 1973	
Species	Transect	Equation	Transect	Equation
White Crappie	B	$W=4.602x10^{-6}L^{3.173}$	B	$W=1.650.10^{-5}L^{2.958}$
	B (cove)	-	B (cove)	$W=1.349x10^{-6}L^{3.450}$
	C	$W=4.459x10^{-6}L^{3.180}$	C	$W=7.549x10^{-6}L^{3.036}$
	D	-	D	$W=4.351x10^{-7}L^{3.603}$
Redear	B	$W=6.232x10^{-6}L^{3.203}$	B	$W=2.48x10^{-5}L^{2.899}$
	B (cove)	-	B (cove)	$W=1.865x10^{-5}L^{2.943}$
	C	$W=2.088x10^{-5}L^{2.936}$	C	$W=2.772x10^{-5}L^{3.401}$
	C (cove)	-	C (cove)	$W=1.448x10^{-6}L^{3.507}$
	D	$W=1.053x10^{-5}L^{3.558}$	D	$W=8.198x10^{-6}L^{3.107}$
	E	-	E	$W=6.178x10^{-7}L^{3.626}$
Largemouth Bass	B	$W=4.352x10^{-6}L^{3.188}$	B	$W=4.454x10^{-5}L^{2.752}$
	B (cove)	-	B (cove)	$W=3.089x10^{-5}L^{2.820}$
	C	$W=1.286x10^{-5}L^{2.958}$	C	$W=7.405x10^{-7}L^{3.477}$
	C (cove)	-	C (cove)	$W=6.314x10^{-6}L^{3.117}$

Table 3.6.4a (Continued)

	November, 1972		August, 1973	
Species	Transect	Equation	Transect	Equation
Largemouth Bass (con't.)	D	$W=2.503\times10^{-6}L^{3.305}$	D	-
	E	$W=2.138\times10^{-9}L^{4.474}$	E	$W=1.225\times10^{-3}L^{2.273}$
Carp	E	$W=2.193\times10^{-4}L^{2.563}$	E	$W=1.093\times10^{-6}L^{3.336}$
Longnose Gar	B	$W=4.331\times10^{-7}L^{3.240}$	B	$W=1.344\times10^{-10}L^{5.455}$
	E	-	E	$W=3.163\times10^{-5}L^{3.665}$
Black Crappie	C	$W=1.320\times10^{-7}L^{3.907}$	C	-
			D	$W=6.63\times10^{-6}L^{3.122}$
	E	$W=3.042\times10^{-6}L^{3.279}$	E	-
Silver Redhorse	E	$W=7.127\times10^{-7}L^{3.472}$	E	-
Shorthead Redhorse	E	$W=3.496\times10^{-6}L^{3.198}$	E	$W=2.444\times10^{-4}L^{2.478}$
	F	-	F	$W=1.015\times10^{-5}L^{3.016}$
Channel Catfish	E	$W=7.294\times10^{-8}L^{3.822}$	E	$W=3.113\times10^{-5}L^{2.784}$

Table 3.6.4a (Continued)

	November, 1972		August, 1973	
Species	Transect	Equation	Transect	Equation
White Catfish	B	$W=1.615\times10^{-6}L^{3.348}$	B	-
	B (cove)	-	B (cove)	$W=6.475\times10^{-5}L^{2.538}$
	C	$W=5.052\times10^{-6}L^{3.131}$	C	-
			C (cove)	$W=3.194\times10^{-5}L^{2.769}$
	D	-	D	$W=1.101\times10^{-5}L^{2.986}$
Pumpkinseed	B	$W=2.430\times10^{-6}L^{3.410}$	B	-
	C	$W=3.048\times10^{-4}L^{2.393}$	C	-
Warmouth	B	$W=8.060\times10^{-6}L^{3.165}$	B	$W=1.085\times10^{-6}L^{3.572}$
	B (cove)	-	B (cove)	$W=2.763\times10^{-8}L^{4.288}$
	C	$W=1.977\times10^{-5}L^{2.974}$	C	$W=3.713\times10^{-6}L^{3.327}$
	C (cove)	-	C (cove)	$W=5.899\times10^{-6}L^{3.240}$
Quillback Carpsucker	E	$W=7.779\times10^{-5}L^{2.685}$	E	-
Golden Shiner	B	$W=7.126\times10^{-6}L^{3.033}$	B	-
	B (cove)	-	B (cove)	$W=7.914\times10^{-6}L^{3.054}$
	C (cove)	-	C (cove)	$W=7.494\times10^{-7}L^{3.486}$

Table 3.6.4a (Continued)

	November, 1972		August, 1973	
Species	Transect	Equation	Transect	Equation
River Carpsucker	E	-	E	$W=5.99x10^{-6}L^{3.136}$
Yellow Bullhead	C (Cove)	-	C (cove)	$W=2.409x10^{-5}L^{2.836}$
Snail Bullhead	E	-	E	$W=9.526x10^{-6}L^{3.014}$
	F	-	F	$W=1.015x10^{-5}L^{3.016}$
Noturus Spp.	C (Cove)	-	C (cove)	$W=3.884x10^{-4}L^{2.145}$
Swamp Darter	C (Cove)	-	C (cove)	$W=8.844x10^{-2}L^{0.606}$

reason for the change is unclear, but it may be attributed to smaller specimens collected in August, which have lower b values.

3.6.3.4a Condition Factor

The additional data from August 1973 and April/May 1974 resulted in a change in condition factor for three species, longnose gar, pumpkinseed, and white bass (Table 3.6.5a). The longnose gar k factor increased from 0.2 to 0.3. The previous small sample and a large specimen collected at Transect E accounted for the increase. Pumpkinseed condition factor also increased, from 1.8 to 1.9. Several large adults at Transect C in April/May 1974 accounted for the increase. White bass was the only species whose k declined. The decline from 1.5 to 1.4 is attributed to several rather small individuals being collected at Transect E in April/May 1974.

3.6.3.5a Sex Ratio

Table 3.6.6a contains combined sex ratios from November 1972 through April/May 1974. Several species still had insufficient numbers for an accurate estimate; however, sufficient data were collected to accurately predict the male:female ratio of bluegills, showing an increase from 1:1.6 to 1:1.7 for that species.

3.6.3.6a Gonadal Conditions

All gonadal condition data through April/May 1974 are presented, with mean surface water temperature, in Table 3.6.7a. In August 1973, all species except river carpsucker which were in a maturing state (3.0), were in the nesting stage (2.0).

Fishes collected in April/May 1974 had a mean gonadal condition of 4.7. The average for the previous spring survey was 4.5. This increase in spawning condition can be explained by the warmer water in April/May 1974.

Table 3.6.5a Mean condition factors for all important species collected from the Broad River Study Area between March 1971 and April/May 1974

Species	Total Number	Condition Factor
Bluegill	1105	1.8
Gizzard shad	667	0.9
White crappie	126	1.3
Redear sunfish	315	1.8
Largemouth bass	131	1.3
River carpsucker	72	1.2
Carp	80	1.4
Flat bullhead	41	1.2
Longnose gar	92	0.3
Black crappie	69	1.2
Redhorse	4	1.1
Channel catfish	37	0.8
White catfish	34	1.1
Pumpkinseed	22	1.9
Warmouth	46	1.9
Golden shiner	24	1.0
Shorthead redhorse	67	1.2
Silver redhorse	24	1.2
Silvery minnow	18	1.1
Redbreast sunfish	27	1.9
Quillback	52	1.3
Yellow bullhead	3	0.7
American eel	6	0.2
White bass	5	1.4
Unidentified shiners	2	1.0
Brown bullhead	7	1.4
Hybrid sunfish	2	1.9
Longear sunfish	2	2.1
Creek chubsucker	2	1.1
Black bullhead	2	1.5
Spotted gar	1	0.2
Tadpole madtom	1	0.6
Yellow perch	1	1.1
Swamp darter	1	0.6
Snail bullhead	17	1.1
Noturus spp.	1	1.0
Robust redhorse	1	1.1
Striped jumprock	1	1.1
Johnny darter	1	0.9

Table 3.6.6a Sex ratios of fishes collected from the Broad River Study Area, November 1972; February, May and August 1973; and April/May 1974.

Species	Male	Female	Ratio
Bluegill	231	452	1:2
Redear sunfish	115	142	1:1.2
Warmouth	21	28	1:1.3
Pumpkinseed	7	16	1:2.3
Redbreast sunfish	4	8	1:2.0
Hybrid sunfish	1	1	1:1.0
White crappie	58	58	1:1
Black crappie	35	28	1:0.8
Largemouth bass	61	60	1:1
Gizzard shad	182	154	1:0.8
Carp	46	21	1:0.5
Shorthead redhorse	26	32	1:1.2
Silver redhorse	10	8	1:0.8
Redhorse	3	1	1:0.3
River carpsucker	50	18	1:0.4
Golden shiner	2	1	1:0.5
Creek chubsucker	1	0	1:0
Brown bullhead	0	1	0:1.0
Black bullhead	0	2	0:2.0
Flat bullhead	10	13	1:1.3
Channel catfish	4	14	1:3.5
White catfish	3	10	1:3.3
Snail bullhead	1	0	1:0
Quillback	25	21	1:0.8
Mosquitofish	14	10	1:0.7

Table 3.6.7a Mean gonadal condition of mature female fishes collected in the Broad River Study Area, February, May and August 1973 and April/May 1974.

	February		May		August		April/May	
Species	n*	Average Condition	n	Average Condition	n	Average Condition	n	Average Condition
Bluegill	123	2.0	89	4.3	66	2.1	73	3.8
Redear sunfish	42	2.2	27	4.2	13	2.1	29	4.4
Pumpkinseed	4	2.3	-	-	1	3.0	3	4.7
Warmouth	2	2.0	7	4.1	3	2.0	4	4.0
Redbreast sunfish	-	-	5	4.6	1	2.0	2	5.0
Hybrid sunfish	1	2.0	-	-	-	-	-	-
White crappie	11	2.6	3	4.6	6	2.0	4	4.0
Black crappie	-	-	2	2.0	3	2.0	2	4.5
Largemouth bass	15	2.5	8	3.1	6	2.0	9	3.7
Gizzard shad	46	3.1	23	4.0	2	2.0	17	4.2
Golden shiner	1	3.0	-	-	-	-	-	-
Carp	6	3.5	5	4.2	4	2.0	4	5.3
Silver redhorse	6	4.0	3	6.0	-	-	-	-
Shorthead redhorse	5	4.4	6	6.0	6	2.0	6	5.8
River carpsucker	4	3.5	7	4.1	2	3.0	4	5.5
Quillback	-	-	1	6.0	-	-	21	5.0
White catfish	2	3.0	1	6.0	3	2.7	-	-
Channel catfish	1	2.0	4	3.0	1	2.0	2	6.0
Brown bullhead	1	3.0	-	-	-	-	-	-
Black bullhead	-	-	2	5.0	-	-	-	-
Flat bullhead	5	3.4	8	5.4	-	-	-	-
Silvery minnow	-	-	-	-	1	2.0	-	-
Mosquitofish	-	-	-	-	-	-	10	**
Temperature (C)***	9.8		20.0		26.7		22.6	

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*Number of fishes examined

**All females had mature embryos

***Mean surface water temperature from all lake transects

Sunfish, crappie, largemouth bass, and gizzard shad were approaching spawning condition, but had not spawned when the April/May 1974 sample was collected. Members of the sucker family either were spawning or had spawned because their condition ranged from 5.0 to 5.8. The only species of catfish checked, the channel catfish, had already spawned. Because only two specimens were collected, these data could be misleading, since this species normally does not spawn until early summer.

3.6.3.7a Standing Crop Estimate

An estimate of standing crop was not possible in August 1973. No fish were recaptured from the cove sample at Transect C and the number of recaptures from Transect B, six (representing five species), was no greater than the number assumed recaptured when no actual recapture occurs. A reliable standing crop estimate cannot be based solely on assumed recaptures.

3.6.3.8a Food Habits

Additional food habit data collected in August 1973 and April/May 1974 are presented below only if enough specimens were collected to add validity or differ from observations made in the baseline survey, Section 3.6.3.8.

Bluegill

Trends stated in the baseline report were confirmed by 191 stomach analyses from the August 1973 and April/May 1974 surveys.

Gizzard Shad

Thirty-three specimens confirmed use of plankton and unidentified organic matter (UOM). However, during the August 1973 survey, chironomids were quite prominent as a food source.

White Crappie

Fish were the main contents of three additional stomachs which were analyzed in August 1973 and April/May 1974.

Redear Sunfish

Stomach analyses of 53 specimens revealed differences between transects and seasons which deviated from the baseline survey. Corbicula manilensis, the asiatic clam, was more prevalent in the diet at Transect C during the summer period, while the spring diet for all size groups was dominated by chironomids. Differences in benthic availability probably account for dietary changes in use of Corbicula versus Sphaerium at Transect C.

Largemouth Bass

Many of the 36 stomachs analyzed contained more benthic fauna than reported in the baseline survey, particularly in the small size groups. Also, several specimens collected at Transect E contained fish in addition to Decapoda.

River Carpsucker

The 10 stomachs analyzed contained UOM almost exclusively. This substantiates the data in the baseline survey.

Black Crappie

Analyses of nine additional stomachs were correlated closely with those reported in the baseline survey.

Channel Catfish

The six additional specimens collected at Transect E in April/May 1974 contained 65 percent algae by volume, differing significantly from the UOM and benthic diet reported in the baseline survey. These fish were all in the 301 to 600 mm size range. Because the algae were not identified, their source is uncertain.

White Catfish

Eight additional stomachs were analyzed, confirming previous reported food habits.

Pumpkinseed

Three stomachs, analyzed from Transect C in April/May 1974, confirmed use of benthos as a food source and indicated that during the spring, *Sphaerium* sp. dominated as a food component.

Warmouth

Variation between Transects B and C was noted in 14 specimens collected in August 1973 although two size groups, 51-100 and 101-150 mm, depended on benthos at both transects. However, at Transect B, *Hexagenia* sp. (burrowing mayfly) dominated, while at Transect C, Pelecypoda dominated. The larger size groups, 151-200 and 201-251 mm, collected in April/May 1974, depended more on crayfish and fish, as reported for this size group in the baseline survey.

Golden Shiner

One specimen, collected in August 1973 at Transect C, contained only UOM.

Shorthead Redhorse

Twenty-four additional stomachs analyzed confirmed food habits reported in the baseline survey.

Redbreast Sunfish

In April/May 1974, nine additional stomachs were analyzed. At Transect C, Isopoda dominated food for the specimens below 100 mm and Pelecypoda for specimens larger than 100 mm. This differs from food habits of specimens at Transect E where insects (Chironomidae and Odonata) dominated.

White Bass

In April/May 1974, three specimens were collected at Transect E. One specimen's (101-150 mm) stomach was empty; one (151-200 mm) contained UOM; and one (301-600 mm) contained unidentified fish remains. These data correspond to food habits of the two specimens reported in the baseline survey.

Snail Bullhead

In the 17 specimens analyzed, aquatic plants dominated food components of almost all size groups above 100 mm. At Transect F, in August 1973, plant material was identified as Podostemum sp., an aquatic species.

Brown Bullhead

Of the seven brown bullheads collected in April/May 1974, two at Transect B had empty stomachs. A trend noted in the other specimens was that the small size group depended on benthos, particularly Hexagenia sp., while with increasing size, fish became a more important food source.

Quillback

Six stomachs analyzed from Transect E in April/May 1974 contained over 95 percent UOM. Three specimens were in the 251-300 mm category and three in the 301-500 mm category.

Silvery Minnow

One silvery minnow in the 51-100 mm category collected at Transect E in August 1973, contained largely UOM.

Mosquitofish

Stomach analyses of 19 specimens collected in the littoral area at Transect B and D, indicated that zooplankton (Daphnia) and UOM comprised most of the diet.

Johnny Darter

One specimen collected at Transect C in the littoral area during the April/May 1974 survey, contained primarily chironomids and zooplankton.

3.6.3.9a Parasites

Studies of fish parasites were not included in August 1973 or April/May 1974.

3.6.4a SUMMARY

Fish collections in August 1973 and April/May 1974 yielded five additional species: mosquitofish, snail bullhead, smallfin redhorse, striped jumprock, and johnny darter. This increases the total number of species collected throughout the baseline survey to 45 species, representing ten families.

The additional data obtained in August 1973 and April/May 1974 supported previous findings on age and growth, length-weight relationships, sex ratios, and gonadal condition. However, slight deviations in food habits were noted for redear, largemouth bass, and channel catfish. Because of limited recaptures, no data on fish standing crop were obtained. Studies of fish parasites were not included in the August 1973 or April/May 1974 surveys.

5.0a TERRESTRIAL SURVEY

5.1a DESCRIPTION OF SAMPLING LOCATIONS

Described in Section 5.1 in the baseline survey.

5.3a VEGETATION

5.3.2a METHODS AND MATERIALS

Earlier studies were conducted in 1971 to inventory and quantitatively describe woody vegetation which currently exists in the area based on stands considered representative of the Broad River plant community. Site 1 was divided after the initial survey to include two representative habitat types; IA, representative of planted pine forests and IB, representative of hardwood forests. Another survey in the fall of 1973 was conducted to quantify Site IB.

Increment cores were collected from trees at all sites in an attempt to age the stands and to determine what stresses, such as fire and drought, have been imposed upon these communities.

5.3.2a

Quantitative analyses of perennial woody vegetation on Site 1B were the same as those employed during the previous study (Section 5.3.2).

Stand age was estimated by counting annual rings on cores extracted from trees in each community. Cores were extracted at approximately 30 cm (12 in) from the base of the tree with an increment borer and were packaged in plastic straws, and shipped to the Dames & Moore Environmental Services Laboratory, Cincinnati, Ohio. Each core was prepared for dating in the laboratory by mounting the core on a wood holder, carefully observing that the core was mounted in a position to vertically expose the vascular structures. Once mounted, the core was sanded and stained with acidic phloroglucinal (Jensen 1962). The stain was used to accentuate the annual growth ring which facilitates counting the rings for age and characterizing any signatures of cyclic or unique occurrences which could provide insight into the vegetational history of these sites.

5.3.3a FINDINGS AND DISCUSSION

5.3.3.1a Floristic Composition

Study Site IB was represented by 16 tree species and a density of 533 trees/ha (1317/acre). Each tree had a mean area of 18.8 m^2. Sweetgum was the most important species on the site while white oak and loblolly pine were considered subdominant (Table 5.3.1a). The high importance value for red maple indicated that the stand was tending toward maturity and loblolly was declining.

Climax vegetation of the area is potentially oak-hickory. The number of oak and hickory species present in the area indicated that succession had progressed to the deciduous phase. It also should be pointed out that selective cutting was taking place in the area during the sampling period. The more mature loblolly pine and hardwoods had been removed thus making the data somewhat biased. The harvest also accounts for the lower tree density when compared with the other study sites.

5.3.3.2a Dendrochronology

Annual growth rings formed by trees provide a chronological record of the developmental history on a particular site. During a growing season, individual trees form wood by cellular growth thereby increasing the diameter. The yearly growth generally occurs in two phases, a spring wood phase and a summer phase. The spring wood phase is initiated at the beginning of the growing season and the wood is characteristically very porous, of low density, and exhibits a light color. The summer wood phase commences as the growing season progresses and the wood is less porous, more dense, and much

Table 5.3.1a Relative frequencies, densities, dominances and importance values of tree species (2.5 cm or greater dbh) growing on Site 1B of the Broad River Study Area, August 1973.

Species	Relative Frequency	Relative Frequency	Relative Frequency	Importance Value*
Sweet Gum	17.48	25.63	26.71	69.82
White Oak	13.99	12.50	25.04	51.53
Loblolly Pine	13.29	15.63	11.11	40.03
Red Maple	10.49	9.38	9.30	29.17
Dogwood	12.24	11.88	4.85	28.97
Black Cherry	3.50	2.50	10.65	16.65
Shagbark Hickory	4.55	3.75	1.74	10.04
Black Jack Oak	4.55	3.13	1.87	9.55
Sugarberry	2.80	2.50	1.89	7.19
Red Oak	2.80	2.50	1.41	6.71
Laurel Oak	1.75	1.88	0.93	4.56
Water Oak	1.75	1.25	1.21	4.21
Pignut Hickory	1.75	1.25	0.93	3.93
Eastern Red Cedar	1.75	1.25	0.41	3.41
Virginia Pine	1.75	1.25	0.31	3.31
Winged Elm	1.05	0.63	0.16	1.84
	100.04	100.04	100.01	300.09

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*Importance value is the sum of values for relative frequency, density and dominance.

darker than the spring wood. The seasonal variation in wood density and color provide the foundation for age determination (Douglas 1946; Fritts 1958).

Annual rings also provide evidence of stresses to which a tree has responded. Stresses include fire, water and temperature variation (Schulman 1953). These stresses are reflected in varying widths of the annual rings. The annual rings will be very narrow in years of stress reflecting the lack of growth induced by reduced water availability. Correspondingly, in years of optimum moisture and temperature, the rings will be wide, reflecting a good growth rate. By analyzing these wide and narrow annual ring signatures, a index to the type condition may be obtained.

Study Site 1A was predominantly loblolly pine. Estimated ages ranged from 14 to 35 years (Table 5.3.2a). Variability of age to diameter class would indicate highly variable growing conditions. For example, the tree in the 7.5 cm diameter class had an age of 22 years which would indicate very slow growth when compared to the 14 year old tree sampled in the 22.5 cm diameter class. A white oak was estimated at the same age as the oldest pine which would indicate this species became established at the same time the pines were planted. Sweetgum became established approximately 20 years B.P. (before present). This species is one of the early deciduous species to become established during successional processes. Two periods of subdued growth were indicated by narrow annual growth rings. These were for the periods 1959-1961 and 1965 to present. The subdued growth was probably due to moisture stress.

Study Site 1B was currently being selectively cut for the higher grade timber; both coniferous and deciduous. Where possible, the annual rings were read on some of the cut stumps. Two periods of white oak establishment were noted. The first period was approximately 95 years B.P. and the second period was approximately 50 years B.P. These observations are in agreement

Table 5.3.2a Distribution and mean age*, by midpoint of diameter size classes, of tree species growing on the Broad River Study Area, 1973.

Study Site	Midpoint of Diameter Classes						
Species	7.5	12.5	17.5	22.5	27.5	32.5	>32.5
1-A							
Loblolly Pine	22	17	20	14	27	35	
Sweet Gum			20	**			
Flowering Dogwood	22						
White Oak		35					
1-B							
Sweet Gum	9.5		25	54			62+
White Oak			47	35	100+		100+
Loblolly Pine	32		30			18	
Red Maple			92				
Flowering Dogwood			40	57			
Black Cherry		25					
Shagbark Hickory		32.5					
Water Oak				41			
Eastern Red Cedar			54	50			
Yellow Poplar		37					
3-A							
Loblolly Pine			36		34	42	48
Eastern Red Cedar	27						
Red Maple	**						
Hop Hornbeam		62					
White Oak					71		
Red Oak			54	52		27+	73+
Shagbark Hickory			69	59			
Basswood	30						
Flowering Dogwood		69+		76			
Elm sp.					61+		
Pignut Hickory	29	35					
4							
Loblolly	30	28	27	39	41	43	37
Eastern Red Cedar			60				
White Oak			**	59			
Red Maple				52			
Shagbark Hickory		62					
Virginia Pine		60	36		51		

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*Ages estimated from cores collected at 15 to 45 cm above ground line.

**Core collected but age undetermined.

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ındation for age determination (Douglas 1946; Fritts 1958).
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their ages would indicate timbering harvest on this area has been on a selective basis. This is evident by the number of deciduous species older than loblolly pine (Table 5.3.2a). White and red oak and shagbark hickory are the oldest trees in the stand.

Study Site 4 also was dominated by loblolly pine. The age distribution of this species ranged from approximately 25 to 45 years. The even age of this species would indicate that the pine has become established within the last 50 years. The age of white oak, red maple, and shagbark hickory would indicate that pine was the only species selectively removed within the past 50 years (Table 5.3.2a). The absence of older trees would indicate that the area had been selectively cut between 75 and 100 years B.P. This site also supported a number of mature Virginia pines. Virginia pine was one of the original dominant coniferous species in the area.

The drought of the 1930's was evident in the narrow rings that occurred between 1931 through 1934. Another group of narrow bands occurred between 1941 through 1945. This was followed by a period of wide bands from 1946 to 1948.

Man has played an important role in the development of the vegetation patterns of the Broad River Study Area. It is apparent that his activities have created a development of vegetation which is inconsistent with the natural successional pattern for the area. Continued activity by man in the area also makes it difficult to attribute ring signatures to natural phenomena or man-induced stresses.

5.3.3.3a Present Stresses

A recent stress imposed upon the vegetative community of the Broad River Study Area was invasion by the pine bark beetle. This insect attacks and kills pine trees. This invasion which became apparent in 1971 was attributed to the lack of any sustained freezing temperatures in the area during the winters of 1971 and 1972 (Lynn, M.H. Pers. Comm.).

5.3.4a SUMMARY

Human activities in the Broad River Study Area have resulted in the development of vegetation inconsistent with natural successional patterns. Continued human activity in the area has made the interpretation of ring signatures difficult.

Study Sites 1A, 3A and 4 were predominantly loblolly pine. Variability of age to diameter class indicated highly variable growing conditions at Site 1A. Moisture stress probably caused periods of subdued growth from 1959-1961 and 1965 to the present. Analyses of various species and their ages on Site 3A indicated that timbering harvest in the area has been selective. At Site 4, the age of white oak, red maple and shagbark hickory indicated that pine was the only species selectively removed within the past 50 years. Narrow growth rings occurring between 1931 and 1934 reflected the drought of the 1930's. Sweet gum was the most important tree species on Study Site 1B while white oak and loblolly pine were considered subdominant. During the present study, higher grade coniferous and deciduous timber was being selectively cut at Site 1B. Most trees in the higher diameter classes have been selectively removed.

An invasion by the pine back beetle has recently stressed the vegetative community of the Broad River Study Area.

5.6a BIRDS

5.6.1a INTRODUCTION

The following data on avian populations in the Broad River Study Area include information from five survey periods between August 1973 and September 1974. This material supplements the Baseline Biotic Survey, Broad River Study Area, Parr, South Carolina, March 1971 to May 1973, and completes two years of quarterly baseline collections.

5.6.2a METHODS AND MATERIALS

5.6.2.1a Survey Periods

Avian surveys were conducted during the months of August of 1973 and January, April, June, and September of 1974. The different census techniques utilized during each of these periods are listed in Table 5.6.1a. Methods were generally the same as those described in Section 5.6.2 of the Baseline Biotic Survey, except as noted below.

5.6.2.2a Strip Census

Census methods were altered somewhat for the different survey periods in order to gather additional information. One such change was the addition of two sites near the proposed nuclear power plant for avian strip censuses. These sites were established to provide information on environmental changes occurring in this area due to construction activities. The methods utilized in these areas are described in the Baseline Biotic Survey.

5.6.2.3a Auto Survey

Auto surveys were conducted during the August 1973 and January 1974 survey periods. The routes and methods used in the auto surveys are the same as previously reported in Section 5.6.2.2 of the Baseline Biotic Survey.

Table 5.6.1a Census techniques employed during sampling periods August 1973 - September 1974.

August 1973	January 1974	March 1974	June 1974	September 1974
Auto Survey	Auto Survey			
Strip Census	Strip Census	Strip Census	Strip Census	Strip Census
Waterfowl Survey	Waterfowl Survey		Waterfowl Survey	

The auto surveys were discontinued after the survey of January 1974 because it was felt that sufficient baseline data had been assembled. The auto surveys will be reinstituted after Monticello Impoundment has been filled to determine any construction effects and attempt to establish new baseline conditions prior to operation.

5.6.2.4a Waterfowl Survey

See Section 5.6.2.5 of the Baseline Biotic Survey for methods. The survey was run in August of 1973 and in January and June of 1974.

5.6.2.5a Additional Sources of Information

During the April, June, and September 1974 surveys, three areas were examined qualitatively for suitability as wildlife habitat. These areas were the ponds and surrounding deciduous forest at Dawkins and Terrible Creek and approximately 731 m (800 yds) along Frees Creek south from County Road 99.

5.6.3a FINDINGS

A total of 90 species of birds were observed during the five survey periods (Table 5.6.2a). Of the 90 species recorded, 44 were permanent residents, 21 were winter residents, 23 were summer residents, and two species were considered transients.

5.6.3.1a Auto Surveys

The number of birds recorded per stop per day on each of the four auto survey routes are presented in Figure 5.6.1a. When combined with previous reported baseline data, a complete picture of the abundance of birds on all four survey routes is provided for each season of the year. The fall and winter surveys were conducted during the morning since it was found during the baseline study that this was the most productive period of the day for a survey of this nature.

Table 5.6.2a Birds observed on the Broad River Study Area during five survey periods during 1973-1974.

Family	Scientific Name	Common Name	8-73	1-74	4-74	6-74	9-74	Status*
Ardeidae	*Casmerodius albus*	Common Egret	X	0	0	0	0	P
	Bubulcus ibis	Cattle Egret	X	0	X	0	0	T
	Ardea herodias	Great Blue Heron	X	X	X	0	0	P
	Butorides virescens	Green Heron	X	0	X	0	0	P
Anatidae	*Anas platyrhynchos*	Mallard	0	X	X	0	0	W
	Anas acuta	Pintail	0	X	0	0	0	W
	Anas discors	Blue-winged Teal	X	0	0	0	0	W
	Aix sponsa	Wood Duck	X	X	X	0	0	P
	Aythya collaris	Ring-necked Duck	0	X	0	0	0	W
	Bucephala albeola	Buffle-head	0	X	0	0	0	W
	Mareca americana	Baldpate	0	X	0	0	0	W
	Anas strepera	Gadwell	0	X	0	0	0	W
Cathartidae	*Cathartes aura*	Turkey Vulture	X	X	0	0	X	P
	Coragyps atratus	Black Vulture	X	X	0	0	X	P
Accipitridae	*Circus cyaneus*	Marsh Hawk	X	X	0	0	X	P
	Buteo jamaicensis	Red-tailed Hawk	X	X	0	0	X	P
Falconidae	*Falco sparverius*	Sparrow Hawk	0	X	0	0	X	P
Phasianidae	*Colinus virginianus*	Bobwhite	X	X	0	X	0	P
Charadriidae	*Charadrius vociferus*	Killdeer	0	X	0	0	X	T
Scolopacidae	*Actitis macularia*	Spotted Sandpiper	X	0	0	0	0	S
Columbidae	*Zenaidura macroura*	Mourning Dove	X	X	0	0	0	P
Cuculidae	*Coccyzus americanus*	Yellow-billed Cuckoo	X	0	0	X	X	S
Caorimulgidae	*Caprimulgus carolinensis*	Chuck-will's-widow	0	0	X	0	0	S
	Caprimulgus vociferus	Whip-poor-will	0	0	X	0	0	S
Apodidae	*Chaetura pelagica*	Chimney Swift	X	0	0	0	0	S
Trochilidae	*Archilochus colubris*	Ruby-throated Hummingbird	X	0	0	0	0	P

Table 5.6.2a (Continued)

Family	Scientific Name	Common Name	8-73	1-74	4-74	6-74	9-74	Status*
Turdidae	*Turdus migratorius*	Robin	X	X	0	0	X	P
	Hylocichla mustelina	Wood Thrush	0	0	X	X	0	S
	Hylocichla guttata	Hermit Thrush	0	X	0	0	0	W
	Sialis sialis	Eastern Bluebird	X	X	0	0	X	P
Sylviidae	*Polioptila caerulea*	Blue-gray Gnatcatcher	X	0	X	X	0	S
	Regulus satrapa	Golden-crowned Kinglet	0	X	0	0	0	W
	Regulus calendula	Ruby-crowned Kinglet	0	X	X	0	X	W
Laniidae	*Lanius ludovicianus*	Loggerhead Shrike	X	X	0	0	X	P
Sturnidae	*Sturnus vulgaris*	Starling	X	X	0	0	X	P
Vireonidae	*Vireo flavifrons*	Yellow-throated Vireo	0	0	X	0	0	S
	Vireo olivaceus	Red-eyed Vireo	X	0	0	X	X	S
	Vireo griseus	White-eyed Vireo	X	0	X	0	0	S
Parulidae	*Parula americana*	Paula Warbler	0	0	X	X	0	S
	Dendroica coronata	Myrtle Warbler	0	X	X	0	X	W
	Dendroica dominica	Yellow-throated Warbler	X	0	0	0	0	P
	Dendroica pinus	Pine Warbler	X	X	X	X	X	P
	Dendroica discolor	Prairie Warbler	0	0	X	X	X	S
	Geothlypis trichas	Yellowthroat	X	0	X	X	0	P
	Wilsonia citrina	Hooded Warbler	X	0	X	0	0	S
Ploceidae	*Passer domesticus*	English Sparrow	X	X	0	0	X	P
Icteridae	*Sturnella magna*	Eastern Meadowlark	X	X	0	0	X	P
	Agelaius phoeniceus	Red-winged Blackbird	0	X	0	0	X	P
	Molothrus ater	Brown-headed Cowbird	0	0	X	0	0	P
	Icterus spurius	Orchard Oriole	0	0	0	X	0	S
Thraupidae	*Piranga rubra*	Summer Tanager	X	0	X	X	X	S
Fringillidae	*Richmondena cardinalis*	Cardinal	X	X	X	X	X	P
	Guiraca caerulea	Blue Grosbeak	X	0	0	0	0	S
	Passerina cyanea	Indigo Bunting	X	0	0	X	0	S
	Carpodacus purpureus	Purple Finch	X	X	0	0	0	W
	Spinus tristis	American Goldfinch	X	X	0	0	X	P

Table 5.6.2a (Continued)

Family	Scientific Name	Common Name	8-73	1-74	4-74	6-74	9-74	Status*
Alcedinidae	Megaceryle alcyon	Belted Kingfisher	X	X	X	0	X	P
Picidae	Colaptes auratus	Yellow-Shafted Flicker	X	X	0	X	X	P
	Dryocopus pileatus	Pileated Woodpecker	0	0	0	0	0	P
	Centurus carolinus	Red-bellied Woodpecker	X	X	X	X	X	P
	Sphrapicus varius	Yellow-bellied Sapsucker	0	X	0	0	0	W
	Dendrocopos villosus	Hairy Woodpecker	0	X	X	X	0	P
	Dendrocopos pubescens	Downy Woodpecker	X	X	X	X	X	P
	Melanerpes erythrocephalus	Red-headed Woodpecker	0	0	0	0	X	P
Tyrannidae	Tyrannus tyrannus	Eastern Kingbird	X	0	0	0	0	S
	Myiarchus crinitus	Great Crested Flycatcher	X	0	0	X	0	S
	Sayornis phoebe	Eastern Phoebe	0	X	0	0	X	W
	Contopus virens	Eastern Wood Pewee	X	0	0	X	0	S
	Empidonax virescens	Acadian Flycatcher	0	0	0	X	X	S
Hirundinidae	Hirundo rustica	Barn Swallow	X	0	0	0	0	S
Corvidae	Cyanocitta cristata	Blue Jay	X	X	X	X	X	P
	Corvus brachyrhynchos	Common Crow	X	X	0	X	X	P
	Corvus ossifragus	Fish Crow	X	0	0	0	0	P
Paridae	Parus carolinensis	Carolina Chickadee	X	X	X	X	X	P
	Parus bicolor	Tufted Titmouse	X	X	X	X	X	P
Sittidae	Sitta pusilla	Brown-headed Nuthatch	X	X	X	X	X	P
Certhiidae	Certhia familiaris	Brown Creeper	0	0	0	0	X	W
Troglodytidae	Thryothorus ludovicianus	Carolina Wren	X	X	X	X	X	P
Mimidae	Mimus polyglottos	Mockingbird	X	X	0	X	X	P
	Dumetella carolinensis	Catbird	X	0	X	0	0	P
	Toxostoma rufum	Brown Thrasher	0	X	0	X	X	P

Table 5.6.2a (Continued)

Family	Scientific Name	Common Name	8-73	1-74	4-74	6-74	9-74	Status*
Fringillidae (continued)	*Spinus pinus*	Pine Siskin	0	X	0	0	X	W
	Pipilo erythrophthalmus	Rufous-sided Towhee	X	X	X	X	X	P
	Junco hyemalis	Slate-colored Junco	0	X	0	0	X	W
	Spizella pusilla	Field Sparrow	X	X	0	0	X	P
	Zonotrichia leucophrys	White-crowned Sparrow	0	X	0	0	0	W
	Zonotrichia albicollis	White-throated Sparrow	0	X	0	0	X	W
	Melospiza melodia	Song Sparrow	X	X	0	0	X	W
	Aimophila aestivalis	Bachman's Sparrow	0	0	X	0	0	S
	Passerella iliaca	Fox Sparrow	0	X	0	0	0	W
Total Species Per Survey Period			55	54	33	29	44	

Totals: 33 Families; 90 Species

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*P-Permanent Resident; S-Summer Resident; W-Winter Resident; T-Transient

X-Present

0-Not Present

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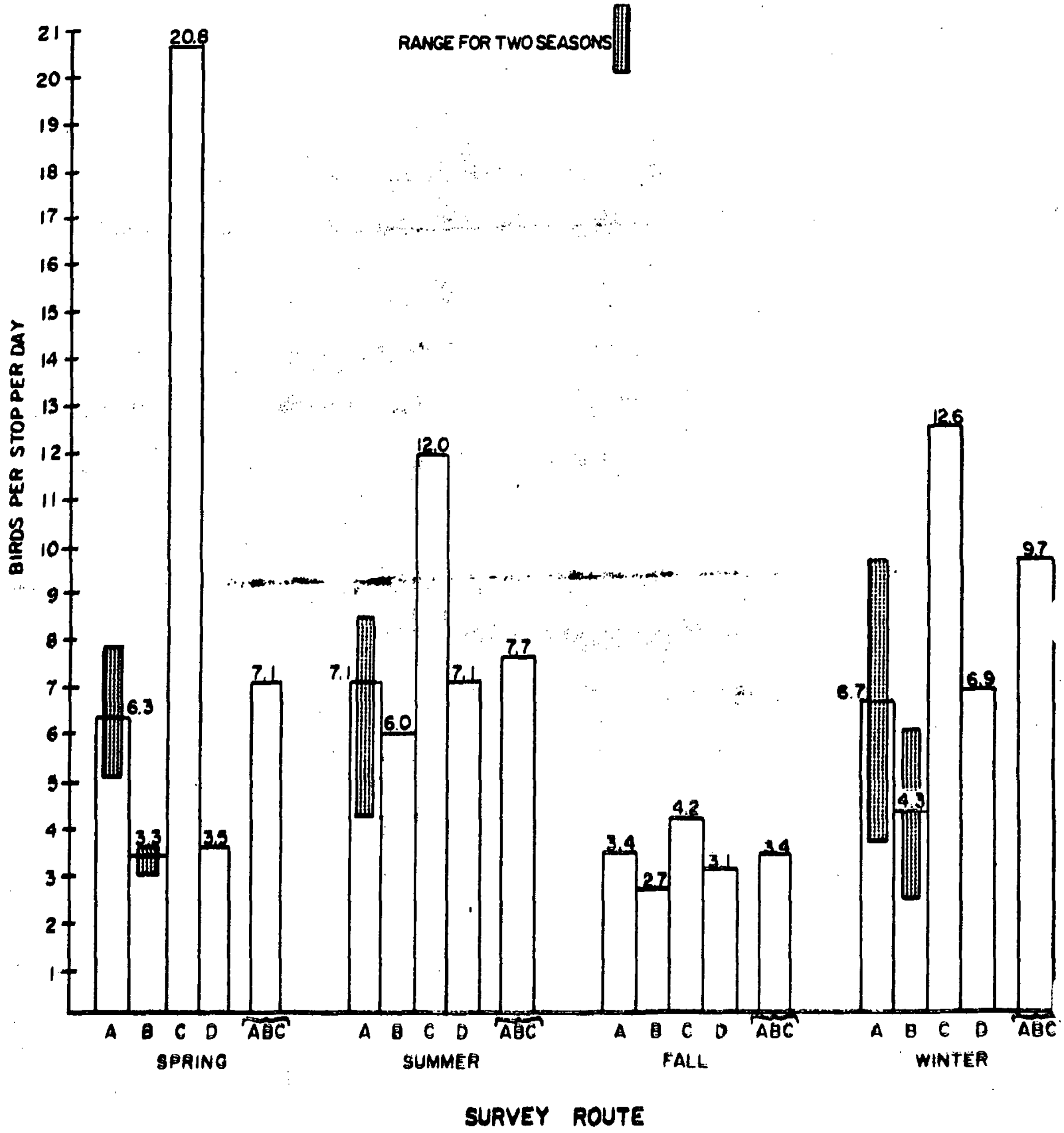

Figure 5.6.1a Average number of birds recorded on each auto survey route

The variability of the abundance of birds observed along each survey route is a result of the variety of habitats found at each stop. Not only do the different habitats contain different numbers and species of birds, but certain habitats, such as grasslands, provide better visibility over large areas which aids in observation of birds.

5.6.3.2a Indicator Species

Section 5.6.3.1.3 in the Baseline Biotic Survey presented the criteria for selecting indicator species and listed nine species as potential indicators of environmental change. During the auto census, it was found that four of these species occurred in sufficient abundance to qualify them as indicator species. Four additional species which occurred along the auto survey routes were found to be acceptable as indicators. These eight species are the following:

Mockingbird
Loggerhead Shrike
Eastern Meadowlark
Mourning Dove
Cardinal
Pine Warbler
Rufous-sided Towhee
Carolina Chickadee

The mean and range of the combined totals of indicator species observed along the test and the control auto routes during each season are presented in Figure 5.6.2a. These data will be compared later with data obtained from surveys of cleared and cut areas associated with the pumped storage facility.

5.6.3.3a Strip Census

The variety and number of birds per 100 acres (40 hectares) recorded by the strip census method in pine, cut pine, deciduous, and mixed habitat types are shown on Table 5.6.3a. As in the Baseline Biotic Survey, data collected from similar sites, such as pine, were combined to provide a better idea of avian abundance in these habitat types. Data from Areas 1C and 5B were combined as pine habitats; Areas 1B and 5C were

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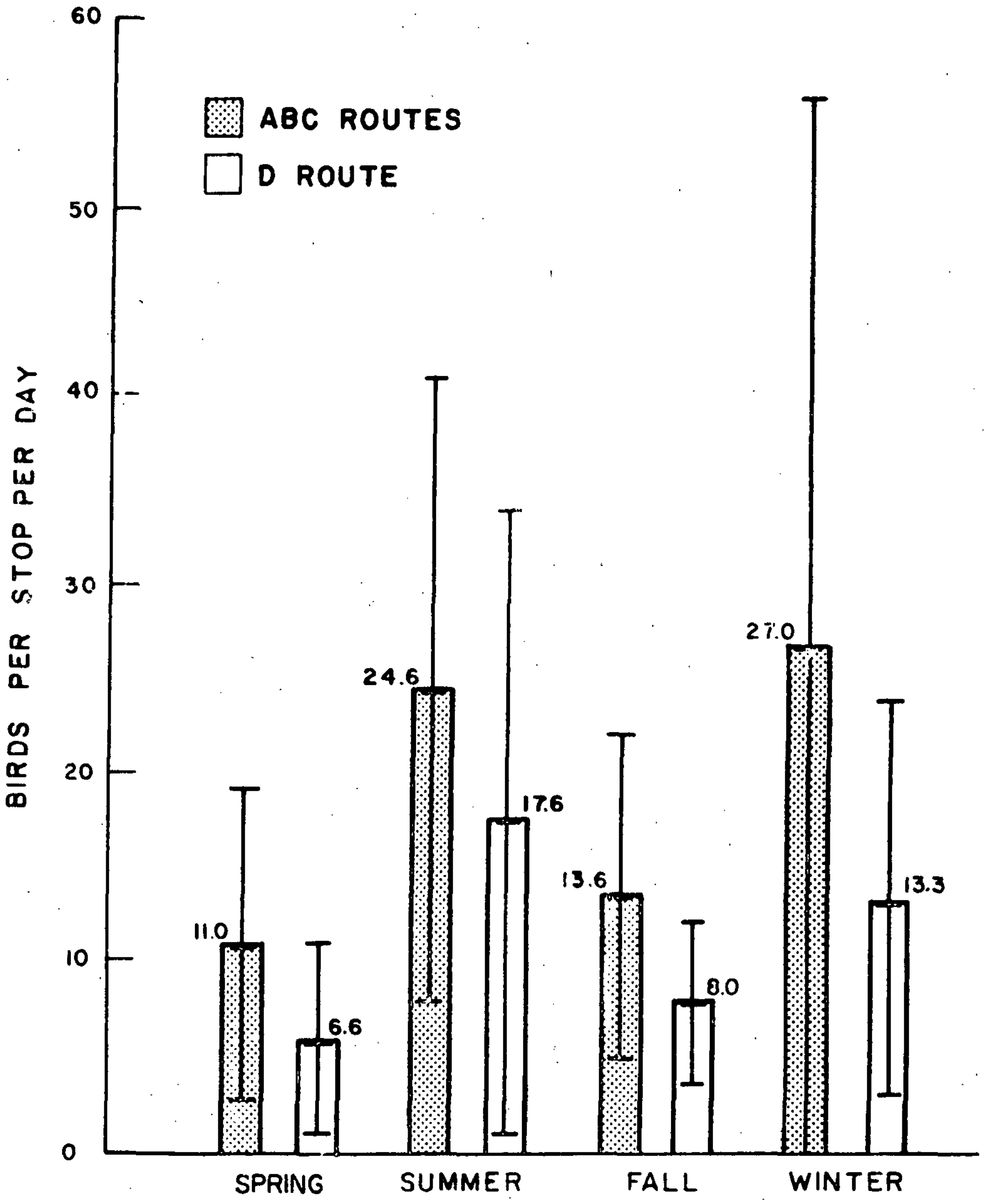

Figure 5.6.2a Mean and range recorded of total indicator species during auto surveys

Table 5.6.3a Results of avian strip censuses in different habitats, Fall 1973 to Fall 1974.

	PINE					SELECTIVELY CUT PINE					DECIDUOUS					PINE AND DECIDUOUS				
	Fall	Winter	Spr.	Summer	Fall	Fall	Winter	Spr.	Summer	Fall	Fall	Winter	Spr.	Summer	Fall	Fall	Winter	Spr.	Summer	Fall
Bobwhite		12		1			13					8								
Mourning Dove																	2			
Yellow-billed Cuckoo	1			1							2			3	2	1				
Chuck will's-widow																		2		
Whip-poor-will								1												
Ruby-throated Hummingbird											1									
Common Flicker							3			1				1						
Red-bellied Woodpecker			2	4				1		1		2			1					
Yellow-bellied Sapsucker		1															1			
Hairy Woodpecker							1	1	1			1								
Downy Woodpecker				2	1					1	1		10	1						
Great Crested Flycatcher				5																
Acadian Flycatcher										1				7	2					
Eastern Wood Peewee				1										3						
Blue Jay	7		1	6	12		1	1	3	5			2		1					5
Crow		2		1																
Carolina Chickadee	13	3	5	7	3		2	7	7	5	11	16	5	4	4		1		3	1
Tufted Titmouse	1		1						2	6	1			1			2			
Brown-headed Nuthatch	5		4	16	6		1	4	11	16	1	11		2		1				
Carolina Wren		2	2	9		1		1	1	2	4	3	14		8					
Mockingbird				1																
Catbird								1												
Brown Thrasher				3										1						
Robin							40													
Wood Thrush			1	1																3
Hermit Thrush		2					3					1								
Blue-gray Gnatcatcher			5					2	11				14	3						
Golden-crowned kinglet												19								
Ruby-crowned Kinglet			2				1					2	14							
Kinglet sp.							3					6								
White-eyed Vireo			1										3		1					
Yellow-throated Vireo													3							
Red-eyed Vireo				2					1				1	4						
Parula Warbler													11	1						
Myrtle Warbler			17					2					6		3					
Pine Warbler	6	2	12	4	4		1	1	6		10									
Prairie Warbler			4	2				12	6	1			2							
Yellowthroat			1					1	2				11	2						
Hooded Warbler											6		1							
Warbler sp.			3																	
Orchard Oriole				1															1	
Cowbird								1												
Summer Tanager			3	2	1	1		1	6	3			1	3					2	
Cardinal	3			5	4		7	7	7		4	4	5	4	4	1		2		4

Table 5.6.3a (Continued)

	PINE					SELECTIVELY CUT PINE					DECIDUOUS					PINE AND DECIDUOUS				
	Fall	Winter	Spr.	Summer	Fall	Fall	Winter	Spr.	Summer	Fall	Fall	Winter	Spr.	Summer	Fall	Fall	Winter	Spr.	Summer	Fall
Indigo Bunting				1										2						
Purple Finch							2													
American Goldfinch												5								
Rufous-sided Towhee			2	7		5	2	1	6	1		5	3		1					
Bachman's Sparrow													4							
White-throated Sparrow												15								
Fox Sparrow							6													
Song Sparrow												4								
Unidentified	12		5	6	3	1	2		2	1	18	6	20		1					
Total Species	9	7	18	23	8	4	16	17	15	13	11	16	10	16	11	3	4	2	4	4
Total Birds	48	24	71	63	34	8	33	45	72	44	59	108	130	42	23	3	6	4	6	13

both deciduous habitats; Areas 4 and 7 were selectively cut pine habitats and Area 3B was a mixed stand. Loblolly pine were selectively removed from Area 4 in March of 1972, and Area 7 was selectively cut during the summer of 1973. Area 1B was referred to as "mixed" habitat in the Baseline Biotic Survey since one portion was covered with pine and the other with hardwoods. In May 1973, the pine portion was clear-cut so this area is now considered deciduous habitat. Twenty-nine species of birds were observed by strip census in the pine habitat, 29 in selectively cut pine habitat, 36 in deciduous habitat, and 21 in the mixed (pine and deciduous) stand.

5.6.3.4a Waterfowl Survey

Waterfowl and shorebirds were surveyed along the Broad River between the Enoree River and Parr Reservoir during August 1973 and January and June 1974. Fourteen waterfowl species, eight duck and six shorebird species, were observed in the area (Table 5.6.4a). Waterfowl occurrences in each of the survey sections along the Broad River are compared in Figure 5.6.3a.

The Wood Duck was the most commonly observed duck having been observed in 82.4 percent of the surveys. The Great Blue Heron and the Belted Kingfisher were the most common shorebirds occurring 82.4 and 100 percent of the time, respectively. These three species are listed as indicator species in the Baseline Biotic Survey and will be important during interpretation of impacts.

5.6.3.5a Additional Findings

5.6.3.5.1a Qualitative Assessment of Habitats

Dawkins and Terrible Creek

A brief description of the habitat surrounding these two areas is presented in Section 5.6.3.4 of the Baseline Biotic Survey. Ponds at

Table 5.6.4a Maximum waterfowl and shorebirds seen any one day along the boat survey route during three study periods.

	Broad & Enoree River north of Blair, S.C.			Broad River from Blair South to Hellers Creek			Hellers Creek			Broad River from Hellers to Frees Creek			Frees Creek			Cannons Creek			Parr Reservoir		
	1973	1974		1973	1974		1973	1974		1973	1974		1973	1974		1973	1974		1973	1974	
Common Name	Aug*	Jan*	June	Aug*	Jan*	June	Aug*	Jan*	June	Aug*	Jan*	June	Aug*	Jan*	June*	Aug	Jan*	June	Aug	Jan*	June
Great Blue Heron		1		3	1			2	1	2	1		2	3	4	2	5		2	2	
Common Egret										1											
Cattle Egret										1					1						
Green Heron	2								1	2			3		3	2		2	3		
Mallard		8													10					3	
Gadwall					2																
American Widgeon		2																			
Pintail																				2	
Blue-winged Teal							1														
Wood Duck	5	16		1	6		5	1		7			6		16	6	2	3	5	5	
Ringneck								2						2			1			2	
Bufflehead																				12	
Unidentified Duck		8							3				1							16	
Spotted Sandpiper	5			5			1			4								3			
Belted Kingfisher	1	1		2	3		2	1	3	1	2		3	4	4	3	4	1	3	2	
Minimum # species	4	5		4	4		4	4	4	6	2		5	3	6	4	4	3	5	7	
# ducks	5	34		1	8		6	3	3	7			7	2	26	6	3	3	5	40	
# shorebirds	8	2		10	4		3	3	5	7	3		12	7	12	7	11	3	11	4	

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*Two Day Observation

SIONS

FILE

DATE

BY

CHECKED

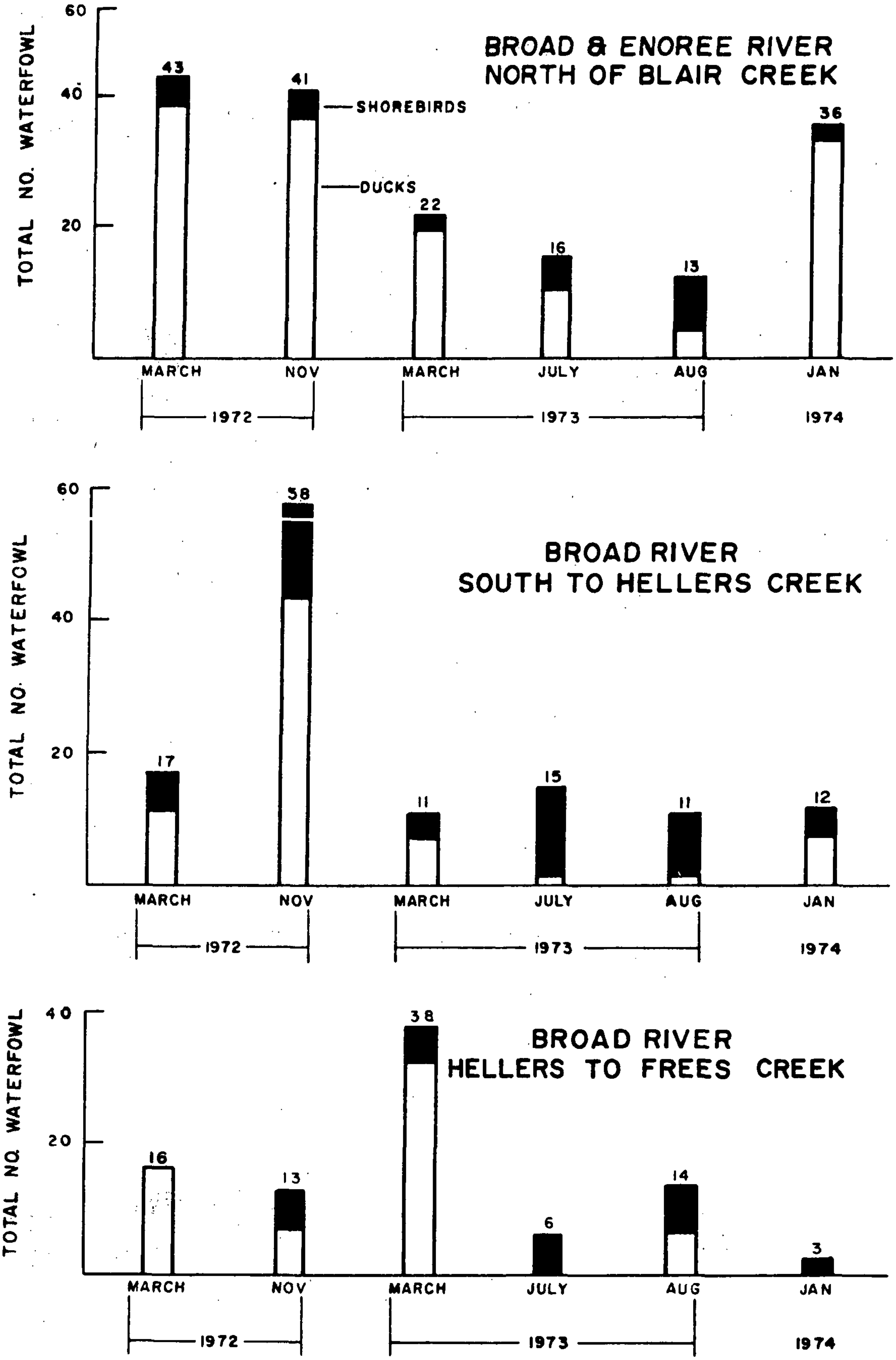

Figure 5.6.3a Results of waterfowl surveys on seven sections of the Broad River

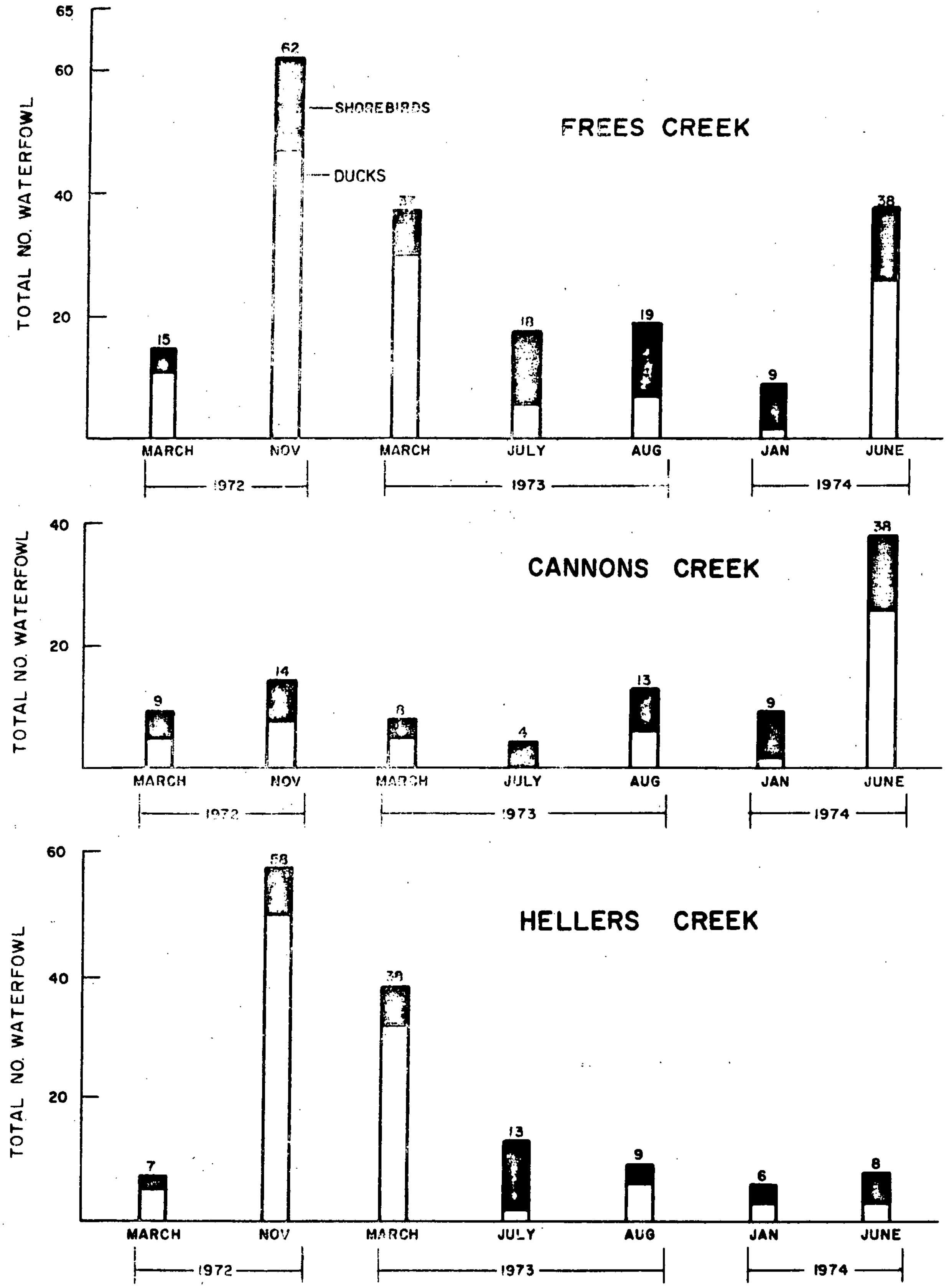

Figure 5.6.3a (continued)

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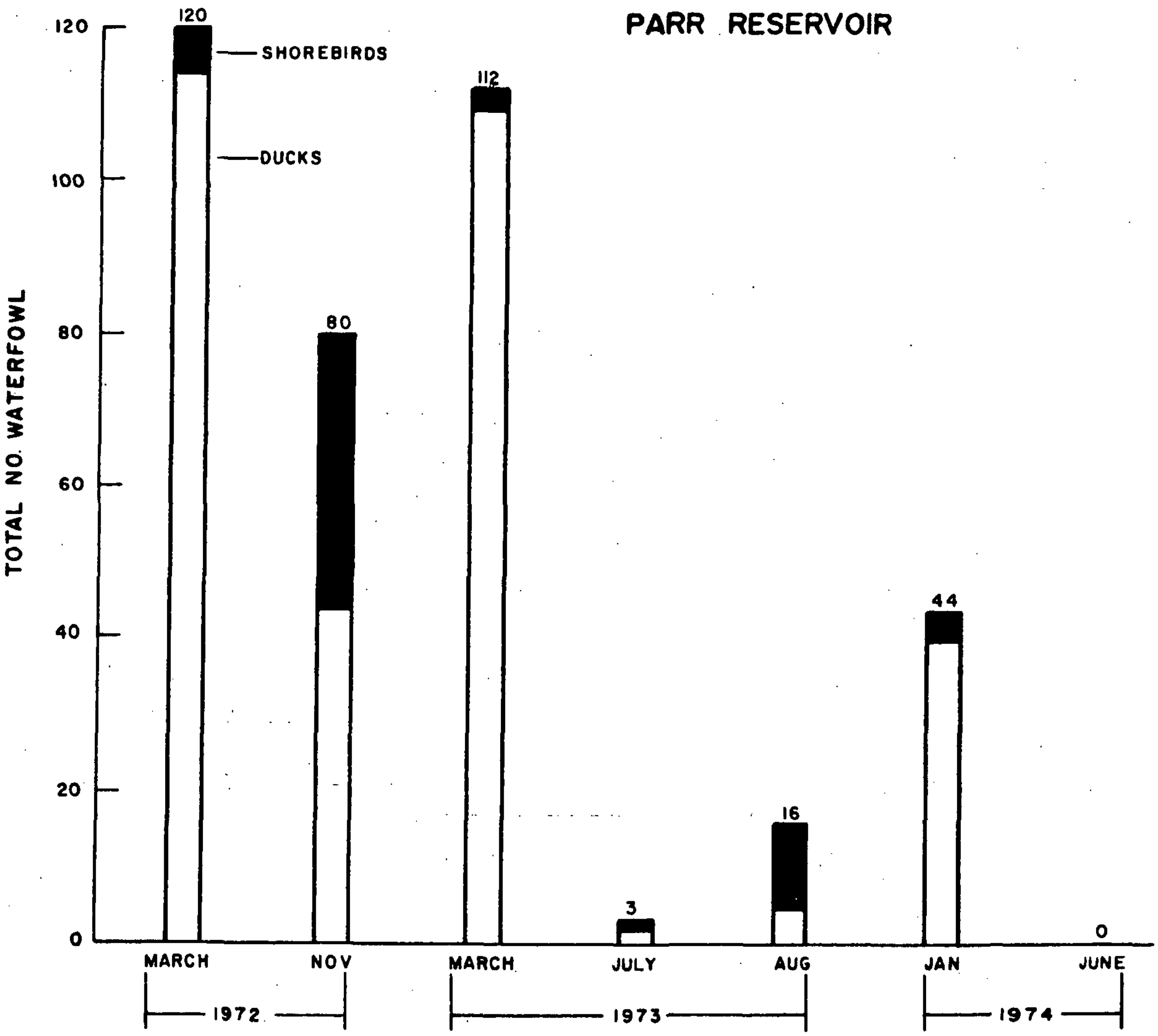

Figure 5.6.3a (continued)

Dawkins Creek, located approximately 6.5 miles north-northwest of Parr, South Carolina, are surrounded by a border of emergent macrophytes and/or overhanging shrubs. The deciduous forest is mature and the soils are often saturated from frequent flooding. The ponds at Terrible Creek are approximately 8.25 miles north-northwest of Parr. Bordered by mature timber and shrubs, the Terrible Creek ponds contain little emergent vegetation. The growth of smartweeds noted in the Baseline Biotic Survey were not as extensive in September 1974 as in November 1972.

Both Dawkins and Terrible Creek provide abundant tree cover, however, although deer tracks were noted in these areas, this habitat provides little in the way of food sources. Where the elevation rises to upland sites, forbs, shrubs, and other plants increase in abundance and serve as a food supply.

Wild turkey prefer habitat of deciduous forests on the river flood plain. Their tracks were noted during each visit to the ponds at Terrible Creek. Six turkey had traveled through the bottomlands near Terrible Creek in January 1974, and between two and four sets of tracks were observed in April, June, and September 1974. A brief description of habitat requirements for turkey is presented in Section 5.6.4.3.2 of the Baseline Biotic Survey.

Central Frees Creek

A portion of the Frees Creek Watershed was examined to assess its value to wildlife species. The area covered during each survey period included approximately 274 m (300 yds) south of County Road 99. Disturbances by clearing for wood harvest or farming have occurred in the area during the last two decades, and during the summer months these clearings supported dense herbaceous vegetation and shrubs. A portion of the area examined, however, still remains in mature timber of deciduous trees and loblolly pine.

Evidence of whitetail deer, raccoon, cottontail rabbit, and opossum were noted in the area during one or more survey periods. Food for these species was abundant and the distribution of abandoned sites and mature timber provides habitat suitable for the above game mammals as well as game birds and non-game wildlife. The overall value of the watershed prior to 1973 is considered to be moderate to high.

Since 1973, considerable timber harvest has occurred. Some harvest had begun prior to 1973. One to two years following harvest of timber resources, increases in the growth of honeysuckle, greenbriar, and a variety of herbaceous plants were noted. Deciduous tree seedlings were also sprouting in the disturbed soils. Whitetail deer, cottontail rabbit, and bobwhite should respond favorably to these changes, while the turkey and squirrel will find them unfavorable. The value of the environs for wildlife, although low to moderate following a timber harvest, will increase as vegetation grows to fill the void.

5.6.4a DISCUSSION

It is possible to make some comparisons of bird densities in certain areas of the study area between years. Auto route A was run in January 1972 and again in January 1974. During January 1972, 3.7 birds per stop per day were observed while in January 1974, 9.7 birds per stop per day were seen. This same route was run in September 1971, and again in August 1973, and at both times 3.4 birds per stop per day were counted. One explanation for the difference at one season and similarity in another may be the weather. The average temperature for the three survey days in January 1972 was 43.8°F. While the temperature in January 1974 was 57.3°F.

The milder temperature in 1974 may have been responsible for more birds being active and therefore available for observation. The average temperatures for the two fall surveys were 75.4°F for September 1971 and 78.7°F in August 1973. These similar temperatures may have been at least partially responsible for the similar density of birds observed at these two seasons.

The aggregate baseline data can now be used for comparisons with data from continuing monitoring programs to determine what changes may be taking place on the study area due to natural or man-made disturbances. This method will also be used to determine the changes in bird populations after the reservoir is filled with water. Thus the present information reported in the auto survey will be valuable as a baseline to determine the changes in bird populations brought about by the clearing of a large section of land and its subsequent inundation. Control and impact areas have been established in each of the major habitat types around the study area to further monitor the environmental changes in the area. Data gathered from the impact areas which are placed in or near areas of expected major disturbance will be compared to data from the control sites and data already reported in the Baseline Biotic Survey. Indicator species designated in the baseline report and addendum will be important in future assessments of environmental quality.

The establishment of the upper impoundment and the expansion of Parr Reservoir for use as a lower reservoir for the pumped storage facility is expected to have a great impact on waterfowl usage in the area. A great quantity of waterfowl habitat will be added and substantial changes will be made to the terrestrial habitat presently in existence. Therefore, the waterfowl data presented in this and the baseline report is important for determining the effects of these changes on this area's bird life.

5.6.5a SUMMARY

The purpose of this addendum has been to add pertinent, supplementary information to the Baseline Biotic Survey. The data reported herein cover the establishment of two strip census sites in the vicinity of the nuclear power plant for monitoring environmental changes in this area. Auto surveys conducted in the fall and winter seasons have been combined with previously reported baseline data to give a complete four season picture of bird abundance over the study area. Once extensive clearing has been accomplished in the Monticello Impoundment area, the auto survey data will be useful as a comparison to post-clearing bird surveys. Additional information was gathered on waterfowl occurrence in the Broad River and Parr Reservoir areas. This will be useful for monitoring changes due to clearing and construction activities in these areas at a latter date.

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APPENDIX 2C

INTERIM REPORT ON CONSTRUCTION MONITORING
BROAD RIVER STUDY AREA
PARR, SOUTH CAROLINA
SEPTEMBER 1974
FOR SOUTH CAROLINA ELECTRIC & GAS COMPANY

Dames & Moore
Project No. 5182-059-17

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1.0 INTRODUCTION

This report presents the results of a biological survey which occurred after construction had commenced on the Virgil C. Summer Nuclear Power Station and Fairfield Pumped Storage Project. The purpose of this report is to identify environmental impacts resulting from that construction. Contained within are the results and discussion of one aquatic field survey, four terrestrial field surveys, and several water quality samples taken by South Carolina Electric & Gas (SCE&G). Terrestrial impacts of construction have included the displacement of birds and mammals from the site. However, little change in water quality, and no change in aquatic life has been detected.

2.0 AQUATIC SURVEY

2.1 DESCRIPTION OF SAMPLING LOCATIONS

Refer to Sections 3.1 and 3.1a of the Baseline Biotic Survey.

2.2 PHYSICAL AND CHEMICAL CHARACTERISTICS

2.2.1 INTRODUCTION

The objectives of this portion of the survey were to determine if there were any construction effects on the aquatic ecosystem as reflected by changes in physical and chemical water quality characteristics. In order to evaluate possible changes in the data from the baseline survey (June 1971 to April/May 1974), they were compared with data collected during the initial phase of the construction period (May-September 1974). During this phase of the program, data from the September 1974 biological field survey were used in conjunction with data from SCE&G's Broad River Study Ares sampling program.

2.2.2 METHODS AND MATERIALS

Refer to Sections 3.2.2 and 3.2.2a of the Baseline Biotic Survey.

2.2.3 FINDINGS

2.2.3.1 Temperature

Mean surface water temperatures from May-September 1974 ranged from 18.7 to 24.8°C (Tables 2.2.1 and 2.2.2), at six collection points monitored by SCE&G. Maximum temperatures observed equaled or exceeded values reported during the baseline survey at most stations. Transects E+, B, and B- had temperature which exceeded earlier reported maximums by 0.6, 1.6, and 1.6°C, respectively.

Surface and bottom water temperatures measured during the biological field survey (September 1974) had greater differences than reported during the baseline survey at Transects C and D.

Table 2.2.1 Summary of chemical analysis of the Broad River Study Area (Frees Creek) from selected stations (May 1974-September 1974)[1]. Test results reported in mg/l unless otherwise noted.

Transect[2]	B				B-				G			
	Minimum	Maximum	Mean	No. of Data Points	Minimum	Maximum	Mean	No. of Data Points	Minimum	Maximum	Mean	No. of Data Points
Determination												
Total Dissolved Solids	37	82	55	5	20	55	34	4	4	30	11	5
Total Suspended Solids	37	130	72	5	20	175	106	4	10	41	23	5
Total Solids	165	430	200.7	5	40	230	137	4	20	45	43.8	5
Specific Conductance (μmhos/cm)	58	90	77	52	92	110	101	4	60	108	95	59
Total Alkalinity	28	40	32.8	5	43	47	44.8	4	38	48	43.6	5
Calcium Hardness	16	18	17.2	5	22	24	23.5	4	22	24	23.6	5
Magnesium Hardness	2	8	4.4	5	8	12	10	4	8	10	9.2	5
Total Hardness	20	24	21.6	5	32	36	33.5	4	30	45	35	5
Chlorides (Cl)	6.19	8.30	7.73	5	7.60	8.30	8.12	4	7.60	8.30	8.16	5
Sulfates (SO_4)	1.87	3.12	2.62	5	2.08	2.91	2.44	4	2.08	3.54	3.25	5
Nitrates (NO_3)	.35	.35	.35	5	.35	.35	.35	4	.35	.35	.35	5
Carbonates (HCO_3)	28	40	32	5	43	47	44	4	38	48	43	5
pH	6.6	7.4	6.9	52	6.7	7.2	7.0	4	6.7	7.1	6.9	59
Air Temperature (C)	10.5	28.6	23.1	52	25.8	29.7	27.0	4	11.0	34.1	23.1	59
Water Temperature (C)	18.2	30.8	24.8	52	19.8	23.1	21.5	4	12.7	23.1	18.7	59
Dissolved Oxygen	5.3	7.9	6.5	52	7.4	8.9	8.0	4	6.0	8.8	7.1	59
Secchi Disc (meters)	0.05	0.15	0.1	5	0.08	0.25	0.15	4	0.46	0.46	0.46	5
Color	100	350	235	5	50	275	143	4	25	50	39	5
Chemical Oxygen Demand	0	34.8	15.8	3	0	6.0	3.0	2	0	46	30	3
Soluble SiO_2	19.0	26.0	23.1	5	29	35.6	31.8	4	30.0	43	37.2	5
SED[3]	200	1790	442	52	40	650	260	4	10	90	21	59

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[1] Data from SCE&G River Sampling Program.

[2] Transect B- is 1 mi upstream from Transect B.

[3] SED = mg/l of solids retained on a 0.45μ filter.

Table 2.2.2 Summary of chemical analysis of the Broad River Study Area (Broad River) from selected stations (May 1974-September 1974)[1]. Test results reported in mg/l unless otherwise noted.

Transect[2]	E+				D+				A-			
	Minimum	Maximum	Mean	No. of Data Points	Minimum	Maximum	Mean	No. of Data Points	Minimum	Maximum	Mean	No. of Data Points
Determination												
Total Dissolved Solids	1	54	18.3	7	12	34	21	4	22	74	53	4
Total Suspended Solids	58	156	106	5	76	178	116	5	61	226	143.6	5
Total Solids	80	210	132	5	92	230	143.8	5	83	300	186	5
Specific Conductance	52	78	63	59	47	77	62	59	50	78	65	59
Total Alkalinity	20	24	21.2	5	19	23	20.4	5	19	24	21.4	5
Calcium Hardness	10	10	10	5	10	10	10	5	10	10	10	5
Magnesium Hardness	4	4	4	5	4	4	4	5	4	4	4	5
Total Hardness	14	14	14	5	14	14	14	5	14	14	14	5
Chlorides (Cl)	7.60	8.30	8.16	5	7.60	8.30	8.16	5	6.19	8.30	7.73	5
Sulfates (SO_4)	2.89	3.64	3.01	5	2.29	3.33	2.95	5	2.91	3.74	3.34	5
Nitrates (NO_3)	.35	.35	.35	5	.35	.35	.35	5	.35	.35	.35	5
Carbonates (HCO_3)	20	24	21	5	19	23	20	5	19	24	21	5
pH	6.8	6.9	6.9	59	6.8	7.0	6.9	59	6.9	7.2	7.0	59
Air Temperature (C)	9.9	31.9	25.3	59	16.5	32.5	23.1	59	13.8	29.7	24.2	59
Water Temperature (C)	18.2	29.2	24.2	59	18.2	27.0	20.0	59	17.1	26.4	23.1	59
Dissolved Oxygen	5.9	8.8	6.7	59	5.9	8.0	6.5	59	6.2	8.5	6.9	59
Secchi Disc (meters)	0.1	0.25	0.18	5	0.1	0.2	0.15	5	0.08	0.25	0.18	5
Color	45	100	71	5	45	100	71	5	50	75	67	5
Chemical Oxygen Demand	0	20.0	8.6	3	2	17.3	10.4	3	18.4	72.4	42.2	5
Soluble SiO_2	18.0	22.0	20.7	5	18.0	22.0	20.5	5	17.0	21.5	20.3	5
SED[3]	80	480	196	59	60	810	206	59	70	650	209	59

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[1] Data from SCE&G River Sampling Program.

[2] Transect locations - E+, 0.75 mi downstream from Transect E; D+, 0.25 mi downstream from Transect D, and A-, 6.1 mi upstream from Transect A.

[3] SED = mg/l of solids retained on a 0.45μ filter.

2.2.3.2 Transparency

Mean monthly Secchi disc readings from May-September 1974 ranged from 0.1 to 0.46 m (Tables 2.2.1, 2.2.2). The lowest readings reported from the biological survey and SCE&G were at Transect B. However, the low of 0.05 m at Transect B was slightly higher than the low of 0.03 m reported in the baseline survey for both Transects B and D. A new low of 0.2 m was reported during the September biological surveys which surpassed the previous low of 0.3 m (baseline survey).

2.2.3.3 Dissolved Oxygen

Dissolved oxygen extremes reported by SCE&G for monthly samples from May-September 1974 were 5.3 mg/l to 8.9 mg/l. The low values of 5.3 mg/l at Transect B were higher than the 3.8 mg/l reported for Transect D during the 1973 summer sampling.

Deviations in vertical DO readings ranged from 0 at Transect D to 9.2 mg/l at Transect C. This maximum deviation was greater than the 5 mg/l difference reported in the baseline report at Transect B.

2.2.3.4 pH

Mean surface water pH from May-September 1974 ranged from 6.8 to 7.0 (Tables 2.2.1, 2.2.2), at six collecting points monitored by SCE&G. Minimum and maximum pH values recorded at each transect were within minimum (6.6) and maximum (7.4) values reported for the baseline survey.

The pH of surface water during the biological field survey (September 1974) ranged from 7.0 to 8.0 (Table 2.2.3). A pH of 8.0 reported at Transect C exceeds a maximum value of 7.7 reported for this transect during the baseline survey.

2.2.3.5 Other Water Quality Parameters

The maximum total hardness on the Broad River was 14 mg/l and

Table 2.2.3 Physical and chemical parameters from the Broad River Study Area during biological field surveys (September 1974).

Transect	B	C	D	D
Collecting Point	2	1	2	5
Date	Sept.	Sept.	Sept.	Sept.
Parameter				
Temperature, Air (C)	25.0	30.0	35.0	34.0
Temperature, Water (C)				
Surface	24.0	30.0	25.0	25.0
Bottom	21.0	21.5	22.0	23.0
Dissolved oxygen (mg/l)				
Surface	9.3	12.2	8.2	7.6
Bottom	6.8	3.0	8.2	7.6
Specific Conductance (µmhos/cm)				
Surface	73	70	70	70
Bottom	82	55	70	70
pH (Surface)	7.0	8.0	7.0	7.0
Secchi disc (M)	0.1	0.2	0.5	0.5
Turbidity (JTU)	83	43	16	17

45 mg/l on Frees Creek (Tables 2.2.1, 2.2.2). This low total hardness is indicative of a low buffering capacity. COD was generally low; mean values ranged from 42.2 mg/l at Transect A- to 3.0 mg/l at Transect B-. Specific conductance was also relatively low, with maximums of 78 and 110 μmhos/cm on the Broad River and Frees Creek, respectively. Specific conductance during the biological field survey ranged from 55 to 82 μmhos/cm (Table 2.2.3). Nutrients were generally high, particularly nitrates (NO_3) which averaged 0.35 mg/l at all transects (Tables 2.2.1, 2.2.2).

Heavy metal analyses were conducted monthly at each transect (Tables 2.2.4, 2.2.5) from May-September 1974. Copper was the only metal occurring in concentrations which might be toxic. Copper in concentrations above 0.02 mg/l is known to be chronically toxic to many aquatic organisms (Becker and Thatcher, 1973) and was found to be above this level at all transects on Frees Creek. The maximum reported concentration of 0.55 mg/l was at Transect B- during the May sampling period. The maximum concentration of copper on the Broad River never exceeded 0.016 mg/l and was usually much lower.

2.2.4 DISCUSSION

Several transects (E+, B and B-) had surface water temperatures which exceeded those reported during the baseline survey. These higher temperatures are attributed to warmer air temperatures rather than any effect due to construction. The warmer weather and resulting higher surface temperatures probably account for the large differences between surface and bottom temperatures particularly at Transects C and D.

Secchi disc data indicated that the transparency of Frees Creek has been reduced. However, occasional high flows during the baseline survey have caused some lower Secchi disc readings. The mean Secchi disc values

Table 2.2.4 Trace metal analysis of surface waters of the Broad River (22 May 1974 through 11 September 1974)[1]. Test results reported in mg/l unless otherwise noted.

Transect[2]	E+						D+						A-					
Sample Date[3]	a	b	c	d	e	Mean[4]	a	b	c	d	e	Mean	a	b	c	d	e	Mean
Determination																		
Sodium (Na)	10.3	6.0	8.8	8.9	8.7	8.5	10.3	8.0	8.4	18.0	8.8	10.7	8.7	12.0	8.3	7.5	6.0	8.5
Magnesium (Mg)	1.4	1.4	1.6	2.5	1.2	1.6	2.4	1.7	1.4	2.9	1.0	1.9	1.4	1.6	1.0	0.2	1.2	1.1
Aluminum (Al)	2.6	3.7	3.0	1.2	3.3	2.8	3.4	6.6	5.5	1.2	2.7	3.9	2.6	4.5	3.5	1.4	2.0	2.8
Arsenic (As)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01
Cadmium (Cd)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01
Chromium, Total (Cr)	<0.02	<0.03	<0.02	<0.03	<0.03	<0.03	<0.02	<0.03	<0.02	<0.03	<0.03	<0.03	<0.02	<0.03	<0.02	<0.03	<0.03	<0.03
Fluoride (F)	0.17	0.13	0.2	0.1	0.1	0.14	0.16	0.13	0.2	0.1	0.2	0.16	0.11	0.07	0.2	0.1	<0.1	0.1
Iron, Total (Fe)	0.97	1.5	2.0	3.2	3.2	2.2	0.99	2.5	2.6	3.1	2.8	2.4	1.1	1.9	2.0	1.5	2.2	1.7
Lead (Pb)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	0.05	<0.02	0.06	0.09	0.16	0.09	0.04	0.03	0.07	0.07	0.16	0.37	0.05	<0.02	0.06	0.04	0.08	0.06
Mercury (Hg), μg/l	8.5	<0.2	<0.2	<0.2	1.4	5.0	10.0	0.6	<0.2	<0.2	<0.2	5.3	0.4	0.2	0.2	<0.2	0.4	0.3
Nickel (Ni)	<0.02	<0.05	<0.02	<0.02	<0.02	<0.03	<0.02	<0.05	<0.02	<0.02	<0.02	<0.03	<0.02	<0.05	<0.02	<0.02	<0.02	<0.03
Tin (Sn)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Zinc (Zn)	<0.02	<0.02	0.04	0.10	0.06	0.07	0.03	<0.02	<0.02	0.05	0.06	0.05	0.03	0.11	0.13	0.05	0.06	0.08
Selenium (Se)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium (V)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01
Beryllium (Be)	<0.02	<0.02	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.01	<0.02	<0.02
Boron (B)	<0.1	0.1	<0.1	0.2	<0.1	0.2	<0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1
Cobalt (Co)	<0.02	<0.02	<0.02	<0.05	<0.05	<0.03	<0.02	<0.02	<0.02	<0.05	<0.05	<0.03	<0.02	<0.02	<0.02	<0.05	<0.05	<0.03
Molybdenum (Mo)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Silver (Ag)	<0.05	<0.02	<0.02	<0.02	<0.21	<0.09	<0.05	<0.02	<0.03	<0.02	<0.02	<0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Strontium (Sr)	0.1	<0.2	<0.2	<0.2	<0.2	0.1	0.1	<0.2	<0.02	<0.2	<0.2	0.1	0.1	<0.2	<0.2	<0.2	<0.2	0.1
Copper (Cu)[5]	0.007	0.012	0.010	0.014	0.008	0.010	0.009	0.010	0.010	0.014	0.010	0.011	0.010	0.010	0.012	0.016	0.012	0.012

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[1] Data from SCE&G River Sampling Program; analysis by Analytical Services Laboratory, NUS Corporation, Houston, Texas.

[2] Transect locations - E+, three-fourths mile downstream from Transect E; D+, one-quarter mile downstream from Transect D; and A-, 6.1 miles upstream from Transect A.

[3] Sample dates; a - May 22, 1974; b - June 19, 1974; c - July 17, 1974; d - August 21, 1974; e - September 18, 1974

[4] Means do not include values that are below detectable limits (e.g. <0.1) unless all values for a given determination are below detectible limits.

[5] Analysis by SCE&G.

Table 2.2.5 Trace metal analysis of surface waters of Frees Creek (22 May 1974 through 11 September 1974).[1] Test results reported in mg/l unless otherwise noted.

Transect[2]	B						B-						G					
Sample Date[3]	a	b	c	d	e	Mean[4]	a	b	c	d	e	Mean	a	b	c	d	e	Mean
Determination																		
Sodium (Na)	11.3	8.0	7.6	8.2	7.6	8.5	12.5	10.0	9.8	10.9	ND[5]	10.6	13.0	10.0	10.3	10.0	9.4	10.5
Magnesium (Mg)	3.4	2.4	1.8	2.2	1.7	2.3	4.1	4.1	3.1	3.4	ND	3.7	3.8	3.6	2.9	3.1	1.6	3.0
Aluminum (Al)	9.5	7.9	4.9	1.6	6.1	6.0	6.8	3.5	1.8	1.0	ND	3.3	0.9	6.5	0.8	0.1	<0.1	2.1
Arsenic (As)	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	ND	0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.02
Cadmium (Cd)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	ND	<0.01	<0.01	0.01	0.01	<0.01	<0.01	0.01
Chromium, Total (Cr)	<0.02	<0.03	<0.02	<0.03	<0.03	<0.03	<0.01	<0.03	<0.02	<0.03	ND	<0.02	<0.02	<0.03	<0.02	<0.03	<0.03	0.03
Fluoride (F)	0.17	0.15	0.2	0.1	0.1	0.14	0.22	0.16	0.20	0.20	ND	0.19	0.21	0.12	0.2	0.1	0.1	0.15
Iron, Total (Fe)	3.1	4.3	3.3	2.4	0.7	2.8	4.1	4.0	3.2	3.6	ND	3.7	1.5	1.4	1.8	1.4	1.5	1.5
Lead (Pb)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	ND	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	0.16	0.12	0.30	0.12	0.19	0.18	0.46	0.39	0.70	0.57	ND	0.53	0.17	0.05	0.16	0.12	0.22	0.14
Mercury (Hg), µg/l	10.3	<0.2	<0.2	<0.2	<0.2	10.3	4.2	1.0	<0.2	<0.2	ND	2.6	0.2	0.5	<0.2	<0.2	0.5	0.5
Nickel (Ni)	<0.02	<0.05	<0.02	<0.02	<0.02	<0.03	<0.02	<0.05	<0.02	<0.02	ND	<0.02	<0.02	<0.05	<0.02	<0.02	<0.02	<0.03
Tin (Sn)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	ND	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Zinc (Zn)	<0.02	<0.02	<0.02	0.05	0.04	0.05	<0.02	0.09	0.04	0.01	ND	0.05	<0.02	<0.02	0.04	0.06	0.02	0.04
Selenium (Se)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	ND	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium (V)	<0.01	<0.01	<0.0ol	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	ND	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Beryllium (Be)	<0.02	<0.02	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.01	ND	<0.02	<0.02	<0.02	<0.02	<0.01	<0.01	<0.02
Boron (B)	<0.1	<0.1	<0.1	0.1	<0.1	0.1	<0.1	<0.1	<0.1	0.1	ND	0.1	<0.1	<0.02	<0.1	<0.1	<0.1	<0.02
Cobalt (Co)	<0.02	<0.02	<0.02	<0.05	<0.05	<0.03	<0.02	<0.02	<0.02	<0.05	ND	<0.03	<0.02	<0.3	<0.02	<0.05	<0.05	<0.09
Molybdenum (Mo)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	ND	<0.3	<0.3	<0.02	<0.3	<0.3	<0.3	<0.24
Silver (Ag)	0.05	<0.02	<0.09	<0.02	<0.02	0.05	0.03	<0.02	<0.02	<0.02	ND	0.03	0.01	<0.2	<0.02	<0.02	<0.02	0.01
Strontium (Sr)	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	ND	0.3	0.3	<0.1	<0.2	<0.2	<0.2	0.3
Copper (Cu)[6]	0.036	0.030	0.018	0.025	0.032	0.028	0.055	0.044	0.036	0.028	ND	0.041	0.032	0.026	0.032	0.024	0.028	0.028

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[1] Data from SCE&G River Sampling Program; analysis by Analytical Services Laboratory, NUS Corporation, Houston, Texas

[2] Transect location - B-, 1 mile upstream from Transect B.

[3] Sample dates; a - May 22, 1974; b - June 19, 1974; c - July 17, 1974; d - August 21, 1974; e - September 18, 1974.

[4] Means do not include values that are below detectable limits (e.g. <0.1) unless all values for a given determination are below detectable limits.

[5] ND = No data.

[6] Analysis by SCE&G.

for Frees Creek were much higher during the baseline survey. If Transect B- is considered as a control station with regards to construction effects, then a mean reduction of 0.05 m has occurred. Additional support for this conclusion is afforded by comparing the difference in values for the maximum reading at Transect B and the reading at Transect C, which is 0.05 m also. A 0.05 m reduction in the mean Secchi disc reading results in a decreased photic zone. Thus, a slight decrease in total photosynthesis (primary productivity) can be expected.

Surface DO values are normally above 4.0 mg/l and approach 100 percent saturation. During the late summer, plankton blooms may cause supersaturation. The lowest surface DO reported in the baseline was 3.8 mg/l reported from Transect D+.

During construction monitoring (May-September 1974) surface DO was not reported below 5.3 mg/l. The low was observed at Transect B. An increase in allochthonous material (including silt from construction) probably accounted for the reduction in DO. However, because this reduction is not below 4.0 mg/l or 50 percent saturation, it probably had little effect on aquatic life.

Vertical differences in DO greater than reported in the baseline were noted at Transect C. This increase is not related to construction effects but does indicate that subminimal bottom DO can result when thermal stratification occurs.

The pH values were all within acceptable limits for the existence of typical aquatic communities of the region. The high pH reported at Transect C may be due to a plankton bloom; however, it is unlikely that it is related to any effects of construction.

Chemical parameters (analyzed by SCE&G) confirmed the Sawyer and

McCarty (1967) classification of South Carolina's surface water as usually being soft (total hardness <75 ppm). Broad River transects had lower total hardness than Frees Creek.

Specific conductance is also quite low. During construction, monitoring values were below maximums reported in the baseline survey. As with total hardness, specific conductance was highest in Frees Creek. In Frees Creek, specific conductance was higher at the more upstream stations which confirms observations for total hardness. Generally, soft waters support less plankton biomass than corresponding hard waters. However, in the case of Parr Reservoir, turbidity is probably the major factor which suppresses plankton blooms. Minimum variations between transects indicate construction has not significantly affected nutrient loading of Parr Reservoir.

Copper seems to be the only metal reported in concentrations that approach 50 percent of levels known to be acutely toxic to most aquatic organisms. These high levels of copper occurred at all Frees Creek transects during the baseline as they did during the initial construction monitoring. Therefore, construction is not the cause of these high values. The reported copper levels, although not directly toxic, may have a chronic effect on the more intolerant aquatic species.

2.2.5 SUMMARY

Stable water conditions prior to the September 1974 biological sampling survey resulted in greater thermal stratification than previously reported. This stratification is directly related to increased differences in top and bottom DO values. A subminimal DO value of 3.0 mg/l was noted at Transect C.

Secchi disc readings, primarily affected by suspended solids, and DO were the only parameters that reflected the effects of construction.

A comparison of mean Secchi disc values (between baseline and construction data) indicate a 0.05 m reduction in transparency. Surface DO was also lower at Transect B than the others. This probably reflects increased allochthonous material. Heavy metal data indicate there is a possibility that chronic toxicity levels of copper occur in Frees Creek; however, this potential problem is not related to construction effects since levels were high prior to construction and also occur at the upstream Transect G.

2.3 PLANKTON

2.3.1 INTRODUCTION

Plankton collected in the study area in September 1974 was analyzed to determine if construction activities beginning the previous May had any detectable effects on the structure of the phytoplankton and zooplankton communities. Possible effects were evaluated by comparing the September 1974 data with data collected during the baseline survey.

2.3.2 METHODS AND MATERIALS

Field and laboratory procedures are similar to those previously described in Section 3.3.2 of the baseline survey and 3.3.2a of the addendum. As in the April/May 1974 collection, the only samples collected were surface samples from collecting points on Transects B through D and samples for qualitative analyses from the littoral zones of Transects B and C. Samples for estimates of primary productivity were incubated approximately 0.5 m below the surface at Transects B and D and also about 0.5 mi upstream from Transect D.

2.3.3 FINDINGS

2.3.3.1 Phytoplankton

2.3.3.1.1 Qualitative Analysis

A total of 260 phytoplankton taxa were collected in the Broad River Study Area in September 1974 (Table 2.3.1). The number of taxa in each major group was Chlorophyta, 48; Chrysophyta, 199; Cyanophyta, 6; Euglenophyta, 5; and Pyrrophyta, 2. These numbers are similar to those reported during the baseline survey except that a much higher number of diatom taxa occurred in the September 1974 samples. Table 2.3.1 indicates 173 taxa not collected during the baseline surveys. These include 24 Chlorophyta, 148 Chrysophyta, and one Euglenophyta taxa.

Table 2.3.1 Species list of phytoplankton in surface plankton samples in September 1974.

Chlorophyta
- _Actinastrum hantzschii_
- _Ankistrodesmus convolutus_*
- _Ankistrodesmus falcatus_
- _Arthrodesmus_ sp.
- _Carteria_ sp.*
- _Chlamydomonas_ sp.
- _Closterium_ spp.
- _Coelastrum_ sp.
- _Cosmarium_ sp.
- _Crucigenia_ spp.
- _Dictyosphaerium ehrenbergianum_*
- _Dictyosphaerium pulchellum_*
- _Eudorina elegans_
- _Gloeocystis_ sp.
- _Golenkinia_ spp.
- _Gonium pectorale_*
- _Kirchneriella lunaris_*
- _Kirchneriella_ sp.
- _Lagerheimia_ sp.*
- _Mougeotia_ sp.
- _Oocystis pusilla_*
- _Oocystis_ sp.*
- _Pediastrum biradiatum_*
- _Pediastrum duplex_
- _Pediastrum tetras_
- _Polyedriopsis spinulosa_*
- _Pteromonas_ sp.*
- _Scenedesmus arcuatus_*
- _Scenedesmus bijuga_
- _Scenedesmus denticulatus_*
- _Scenedesmus dimorphus_
- _Scenedesmus incrassatulus_*
- _Scenedesmus opoliensis_*
- _Scenedesmus quadricauda_
- _Scenedesmus_ sp.
- _Schroedaria_ sp.*
- _Selenastrum minutum_*
- _Selenastrum westii_*
- _Sphaerocystis schroeteri_
- _Spondylosium_ sp.*
- _Staurastrum chaetoceras_*
- _Staurastrum_ sp.
- _Tetraedron_ spp.
- _Tetraspora lacustris_*
- _Tetrastrum heteracanthum_*
- _Treubaria_ sp.

Table 2.3.1 (Continued)

Chlorophyta (continued)
Ulothrix sp.
Wislouchiella _planctonica_*

Total Chlorophyta Taxa 48

Chrysophyta
Achnanthes _detha_*
Achnanthes _exigua_*
Achnanthes _hungarica_*
Achnanthes _lanceolata_
Achnanthes _lewisiana_*
Achnanthes _linearis_*
Achnanthes _microcephala_*
Achnanthes _minutissima_*
Achnanthes _peragalli_*
Achnanthes _stewartii_*
Amphipleura _pellucida_*
Amphora _ovalis_
Anomoeoneis _serians_*
Anomoeoneis _vitrea_*
Asterionella _formosa_
Bacillaria _paradoxa_*
Biddulphia _laevis_*
Caloneis _bacillaris_*
Caloneis _bacillum_*
Caloneis _hyalina_*
Caloneis _limosa_*
Caloneis _ventricosa_
Cocconeis _fluviatilis_*
Cocconeis _placentula_
Cyclotella _atomus_*
Cyclotella _meneghiniana_
Cyclotella _pseudostelligera_*
Cyclotella _stelligera_
Cymbella _affinis_
Cymbella _gibba_*
Cymbella _gracilis_*
Cymbella _lanceolata_*
Cymbella _naviculiformis_*
Cymbella _perpusilla_*
Cymbella _prostrata_*
Cymbella _tumida_*
Cymbella _turgida_*
Cymbella _ventricosa_*
Diploneis _elliptica_*
Diploneis _marginestriata_*
Diploneis _puella_*

Table 2.3.1 (Continued)

Chrysophyta (continued)
Epithemia zebra*
Eunotia curvata
Eunotia incisa*
Eunotia maior*
Euontia pectinalis*
Euontia praerupta*
Euontia rabenhorstii*
Euontia tenella*
Euontia sp.
Fragilaria brevistriata*
Fragilaria construens
Fragilaria crotonensis
Fragilaria leptostauron*
Fragilaria pinnata
Fragilaria vaucheriae*
Frustulia rhomboides*
Frustulia vulgaris
Frustulia weinholdii*
Gomphonema acuminatum*
Gomphonema angustatum*
Gomphonema gibba*
Gomphonema gracile*
Gomphonema intricatum*
Gomphonema lanceolatum*
Gomphonema longiceps*
Gomphonema parvulum*
Gomphonema sp.
Gyrosigma exilis*
Gyrosigma nodiferum*
Gyrosigma scalproides*
Gyrosigma spencerii*
Gyrosigma sp.
Hantzschia amphioxys*
Hydrosera sp.*
Melosira ambigua
Melosira distans
Melosira granulata
Melosira islandica*
Melosira varians
Meridion circulare
Navicula accomoda*
Navicula aikenensis
Navicula anglica*
Navicula arenaria*
Navicula arvensis*
Navicula atomus*
Navicula auriculata
Navicula bicephala*
Navicula biconica*
Navicula capitata*
Navicula clementis*

Table 2.3.1 (Continued)

Chrysophyta (continued)
- Navicula cocconeiformis*
- Navicula confervacea*
- Navicula contenta*
- Navicula convergens*
- Navicula cryptocephala
- Navicula cuspidata*
- Navicula decussis*
- Navicula dystrophica*
- Navicula elginensis*
- Navicula festiva*
- Navicula gottlandica*
- Navicula gregaria*
- Navicula gysingensis
- Navicula halophila*
- Navicula hambergii*
- Navicula heufleri*
- Navicula hustedtii*
- Navicula lanceolata*
- Navicula latelongitudinalis*
- Navicula lateropunctata*
- Navicula luzonensis*
- Navicula menisculus*
- Navicula minima*
- Navicula minuscula*
- Navicula muralis
- Navicula mutica
- Navicula notha*
- Navicula placenta*
- Navicula pseudoreinhardtii*
- Navicula pupula
- Navicula phgmaea*
- Navicula radiosa*
- Navicula rhynchocephala*
- Navicula salinarum*
- Navicula schroeteri*
- Navicula secreta*
- Navicula secura*
- Navicula seminulum*
- Navicula symmetrica*
- Navicula tenera*
- Navicula tripunctata
- Navicula viridula
- Navicula zanoni*
- Navicula sp.*
- Neidium affine*
- Neidium bisulcatum*
- Nitzschia acicularis
- Nitzschia amphibia

Table 2.3.1 (Continued)

Chrysophyta (continued)
_Nitzschia biacrula_*
_Nitzschia clausii_*
_Nitzschia dissipata_*
Nitzschia filiformis
_Nitzschia fonticola_*
_Nitzschia gracilis_*
_Nitzschia hungarica_*
_Nitzschia ignorata_*
_Nitzschia linearis_*
Nitzschia lorenziana
_Nitzschia obtusa_*
Nitzschia palea
_Nitzschia parvula_*
_Nitzschia sigma_*
_Nitzschia sublinearis_*
Nitzschia tryblionella
Nitzschia sp.
_Pinnularia abaujensis_*
Pinnularia biceps
_Pinnularia bogotensis_*
_Pinnularia borealis_*
_Pinnularia braunii_*
_Pinnularia brebissonii_*
_Pinnularia divergens_*
_Pinnularia gibba_*
_Pinnularia intermedia_*
_Pinnularia obscura_*
_Pinnularia termitina_*
Pinnularia sp.
Pleurosigma sp.
_Rhoicosphenia curvata_*
_Rhopalodia gibba_*
_Rhopalodia gibberula_*
_Stauroneis anceps_*
_Stauroneis crucicula_*
_Stauroneis obtusa_*
_Stauroneis smithii_*
_Stenopterobia intermedia_*
Stephanodiscus astrea
_Stephanodiscus hantzschii_*
Stephanodiscus invisitatus
_Surirella angustata_*
_Surirella ovata_*
_Surirella robusta_*
_Surirella stalagma_*
_Surirella suecica_*
Surirella sp.
_Synedra acus_*

Table 2.3.1 (Continued)

Chrysophyta (continued)
- *Synedra delicatissima*
- *Synedra filiformis**
- *Synedra pulchella*
- *Synedra rumpens*
- *Synedra ulna*
- *Tabellaria fenestrata*
- *Tabellaria flocculosa**
- *Terpsinoe musica**
- *Thalassiosira fluviatilis**
- *Mallomonas* sp.
- *Ophiocytium* sp.

Total Chrysophyta Taxa 199

Cyanophyta
- *Anabaena* sp.
- *Aphanocapsa* sp.
- *Chroococcus* sp.
- *Microcystis* sp.
- *Oscillatoria* spp.
- *Spirulina* sp.

Total Cyanophyta Taxa 6

Euglenophyta
- *Euglena acus*
- *Euglena* spp.
- *Lepocinclis* sp.*
- *Phacus* spp.
- *Trachelomonas* spp.

Total Euglenophyta Taxa 5

Pyrrophyta
- *Glenodinium* spp.
- *Peridinium* sp.

Total Pyrrophyta Taxa 2

TOTAL TAXA 260

*Not reported in baseline collections.

In baseline collections, a total of 173 taxa had been observed. The higher number of taxa in September 1974 possibly reflects more detailed species analyses for diatom genera previously collected. For example, Table 2.3.1 includes 45 Navicula species not reported in the baseline survey. Similarly, the table also includes 12 Nitzschia species, 10 Pinnularia species, 9 Cymbella species and 8 Gomphonema species not collected previously. Eleven additional diatom genera were identified in September samples. These were Amphipleura, Anomoeoneis, Bacillaria, Biddulphia, Diploneis, Hantzschia, Hydrosera, Rhoicosphenia, Rhopalodia, Stenopterobia, and Thalassiosira.

Table 2.3.2 includes the percentage composition in the samples of diatoms and Chlorophyta, the two major groups. The table also includes principal taxa, those which constituted at least five percent of cells counted in a sample. Diatoms comprised from 32 percent of the total phytoplankters at Collecting Point 2 of Transect B to almost 80 percent of the total at Collecting Point 3 of Transect C. Chlorophyta were less abundant, comprising approximately 11 percent of the total phytoplankters at Collecting Point 4 of Transect D to approximately 51 percent of the total at Collecting Point 2 of Transect C. Of principal phytoplankters for September, Melosira distans, Nitzschia palea, Achnanthes lanceolata, Trachelomonas and those listed as unidentified Chlamydomonadaceae were not predominant in baseline collections.

2.3.3.1.2 Quantitative Analysis

Phytoplankton densities during September 1974 averaged 497 per liter and ranged from 134 per liter at Collecting Point 1 of Transect D to 1163 per liter at Collecting Point 1 of Transect B. These densities are within the range of those previously reported in the study area. As in the baseline survey, highest densities generally occurred at Transect B while

Ta[illegible] 2.3.2 Densi[illegible], percentages [illegible] Chlorophyta and diatoms and d[illegible]ty percentages of principal ta[illegible] in phytoplank[illegible] collections [illegible]om September 1974 in the Broad River Study Area.

Collecting Point	Depth (meters)	Total Number/l (all species)	Percentage of Chlorophyta	Percentage of Diatoms	Principal Taxa*	Percentage of Total
B1	1.0	1163	43.4	48.2	Unidentified Chlamydomonadaceae Melosira distans	35.6 16.3
B2	2.1	1081	49.0	32.0	Unidentified Chlamydomonadaceae Phacus spp. Nitzschia palea	39.6 5.8 5.0
B3	1.8	308	22.7	65.6	Melosira distans Trachelomonas spp. Phacus spp. Oscillatoria spp.	24.4 8.1 7.8 7.8
C1	2.5	203	27.1	59.6	Unidentified Chlamydomonadaceae Melosira distans Nitzschia palea Achnanthes lanceolata	13.8 8.4 7.4 5.9
C2	1.8	477	51.4	35.2	Unidentified Chlamydomonadaceae Oscillatoria spp.	35.2 7.1
C3	0.7	902	12.7	79.5	Achnanthes lanceolata Nitzschia palea	9.0 5.2
D1	1.4	134	18.7	54.5	Oscillatoria spp. Trachelomonas spp. Melosira distans Achnanthes lanceolata Nitzschia palea Unidentified Chlamydomonadaceae	11.2 8.2 8.2 5.2 5.2 5.2
D2	1.7	156	14.1	65.4	Melosira distans Unidentified Chlamydomonadaceae Oscillatoria spp. Achnanthes lanceolata	11.5 5.8 5.1 5.1
D3	1.0	185	15.7	68.6	Nitzchia palea Melosira distans Phacus spp. Unidentified Chlamydomonadaceae	8.1 7.6 5.0 5.0
D4	1.1	481	10.6	73.6	Melosira distans Melosira granulata Phacus spp. Trachelomonas spp. Nitzschia palea	18.1 5.8 5.4 5.2 5.0
D5	10.0	372	14.5	70.2	Melosira distans Unidentified Chlamydomonadaceae Nitzschia palea	23.4 6.2 5.6

*Taxa which composed at least 5 percent of the phytoplankters in a sample lowest densities generally occurred at Transect D.

The most abundant algae in the samples were those described as unidentifed Chlamydomonadaceae. Table 2.3.2 shows that they were the most abundant algae in four of eleven samples and were included among principal taxa in eight of eleven samples. They comprised as much as 40 percent of the phytoplankters at Collecting Point 2 of Transect B. Melosira distans, the second most abundant alga, was also among principal taxa in eight of eleven samples. At Collecting Point 3 of Transect B, it comprised approximately 24 percent of the total phytoplankters. Nitzschia palea was among the principal taxa in seven of eleven samples, but its maximum percentage of the total was about 8 percent at Collecting Point 3 of Transect D.

As with phytoplankton densities ^{14}C values decreased from Transect B to D. Primary productivity at Transect B was 47.0 mg $C/m^3/hr$ while values 0.5 mi upstream from Transect D and at Transect D were 5.2 and 2.6 mg $C/m^3/hr$, respectively.

2.3.3.2 Zooplankton

2.3.3.2.1 Qualitative Analysis

A total of 34 zooplankton taxa were collected in the Broad River Study Area in September 1974 (Table 2.3.3). The number of taxa in each major group was Protozoa, 6; Rotatoria, 20; Copepoda, 2; and Cladocera, 3. These numbers are similar to those reported for the baseline survey. Table 2.3.3 includes three rotifers, two cladocerans, one protozoan and one endoproctan not reported in the baseline collections.

Number of taxa per transect ranged from 4 at Collecting Point 1 of Transect C to 15 in the littoral zone of Transect B. Generally, fewer taxa were collected from Transect D than from Transects B and C.

As in baseline samples, rotifers were the predominant taxonomic group. They comprised up to 73 percent of the total at Collecting

Table 2.3.3 Zooplankton in surface plankton samples in the Broad River Study Area in September 1974.

Rotatoria
- *Asplancha* sp.
- *Brachionus angularis**
- *Brachionus* spp.
- *Conachiloides* sp.
- *Conochilus unicornis**
- *Filinia longiseta*
- *Keratella cochlearis*
- *Lecane* sp.
- *Monostyla* sp.
- *Platyias patulus**
- *Polyarthra* spp.
- *Synchaeta* spp.
- *Trichocerca* spp.
- Unidentified Bdelloidea
- Unidentified Flosculariacea
- Unidentified Flosculariidae
- Unidentified Monogononta
- Unidentified Ploima

Copepoda
- Cyclopoid copepodite
- Copepod nauplii

Cladocera
- *Diaphanosoma leuchtenbergianum**
- *Pleuroxus* sp.*
- Unidentified Moinidae

Protozoa
- *Arcella* sp.*
- *Centropyxis* spp.
- *Difflugia* spp.
- Unidentified Difflugiidae
- Unidentified Ciliata
- Unidentified Testacea

Diptera
- *Chaoborus* sp.
- Unidentified Chironomidae

Entoprocta
- *Urnatella gracilis**

Unidentified Nematoda

Unidentified Ostracoda

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*Not reported in baseline collections

Point 2 of Transect B, which were characterized by the highest zooplankton densities.

2.3.3.2.2 Quantitative Analysis

Low zooplankton populations characterized the study area in September 1974. Densities averaged approximately 13 per liter and ranged from 1 per liter at Collecting Point 3 of Transect D to 60 per liter at Collecting Point 2 of Transect B. In general, densities at Transect B were much higher than those at Transects C and D. Although densities were low, they are within the range of those previously reported for the area. As mentioned above, rotifers were the dominant taxonomic group, yet their numbers were generally low compared to most aquatic ecosystems. Their densities ranged from less than 1 at Collecting Point 3 of Transect D to 44 at Collecting Point 2 of Transect B. Most plankton communities average 40 to 500 rotifers per liter (Pennak, 1953).

The rotifer *Brachionus* was the most abundant taxon, though no single genus was extremely abundant. It comprised approximately 27 percent of the zooplankters at Collecting Point 2 of Transect B. *Conochilus unicornis* and *Trichocerca* spp. were second and third in abundance, respectively.

2.3.4 DISCUSSION

2.3.4.1 Phytoplankton

The abundance of green, blue-green and euglenoid algae in the September 1974 samples reflected the existing light and temperature conditions. Diatoms, which typically dominate the phytoplankton of temperate rivers (Hynes, 1972), were numerically dominant at most sampling stations. However, the warmer water temperatures of late summer are optimal for the development of these other forms (Hynes, 1972; Williams, 1966).

Principal taxa were sufficiently abundant in September to warrant evaluation of their ecological significance. The factors stimulating the extremely high abundance of unidentified Chlamydomonadaceae cannot be determined from existing data. However, the best-known genus of the family, Chlamydomonas, has been ranked third on Palmer's (1963) list of the 52 most pollution tolerant genera. All of the genera included among the principal taxa (Table 2.3.2) were on Palmer's list. These genera and their ranks follow: Oscillatoria, 2nd; Nitzschia, 6th; Navicula, 7th; Phacus, 11th; Melosira, 19th; Trachelomonas, 26th; and Achnanthes, 43rd. In a similar list of the 60 most pollution tolerant species, Nitzschia palea, the third most abundant species in the September collections, is ranked second.

As in baseline studies, highest densities occurred at Transect B, near the mouth of Frees Creek, even though Secchi disc readings indicate lower light penetration there than at Transects C or D. The highest light penetration occurred at D, the transect with the lowest densities. The composition of the benthos at Transect D indicate that it may be an area of environmental stress.

The primary productivity value at Transect B (47.0 mg $C/m^3/hr$) was similar to that for April/May 1974 of the baseline survey. According to Samsel's (1974) study, values of this magnitude are characteristic of eutrophic systems. The much lower values upstream from Transect D and at Transect D are more typical of a nutrient-poor environment, though water quality data are not indicative of differences. In the study area, highest primary productivity has been associated with highest algal density and vice versa, thus, reflecting the fact that algal standing crop affects ^{14}C assimilation, though assimilation apparently is more directly related to algal growth rate (Tunzi and Porcella, 1974).

In conclusion, phytoplankton diversity and density apparently have not been adversely affected by construction activities from May-September 1974, although water quality data indicated a reduction in transparency. Present data are insufficient to explain the abundance of eutrophic taxa in the September collections.

2.3.4.2 Zooplankton

Because zooplankton composition and densities during September 1974 were similar to those reported in the baseline survey to date, construction activities appear to have had no significant effects on the zooplankton community.

As with phytoplankton, highest and lowest zooplankton densities occurred at Transects B and D, respectively. This relationship was also reported during the baseline survey. Williams (1966) in analyzing plankton data from national water quality network samples, found that stations with high phytoplankton populations usually had high rotifer populations.

Williams (1966) also observed that the five most widely distributed and dominant rotifer genera in water samples from the U.S. are *Keratella*, *Polyarthra*, *Brachionus*, *Synchaeta*, and *Trichocera*. All occurred in the September 1974 samples (Table 2.3.3). *Brachionus* and *Trichocera* were the most abundant and third most abundant taxa, respectively. The second most abundant genus, *Conochilus*, was extremely abundant in the April/May 1974 samples.

Specific zooplankters in these collections have not been discussed as trophic indicators because present knowledge of their ecology is inadequate to classify them by this criterion (Gannon, 1972). The indicator organism concept is not supported among dominant rotifers in a sample because dominant species apparently are determined by edaphic factors within a watershed (Williams, 1966).

2.3.5 SUMMARY

2.3.5.1 Phytoplankton

A total of 260 phytoplankton taxa were collected in the study area in September 1974, during the construction phase of the project. This includes 173 taxa not reported in the baseline survey. The higher number of taxa in September appears to reflect more detailed diatom species analyses. Qualitatively and quantitatively, chlorophytes and diatoms were the prominent groups.

Phytoplankton densities averaged 497 per liter and were within the range of those reported previously for the area. The most abundant algae were unidentified Chlamydomonadaceae, *Melosira distans* and *Nitzschia palea*. All of the principal algal taxa are on Palmer's (1963) list of the most pollution tolerant genera.

Primary productivity values at Transect B were similar to those which have been reported for eutrophic systems, while much lower values characterized the area near Transect D.

At present, there is no evidence that phytoplankton diversity and density have been adversely affected by construction activities. The factors stimulating the abundance of eutrophic taxa in the September collections have not been determined.

2.3.5.2 Zooplankton

A total of 34 zooplankton taxa were collected in the study area in September 1974, including three rotifers, two cladocerans, one protozoan and one endoproctan not reported in the baseline collections. As in baseline samples, rotifers were the dominant taxonomic group, comprising as much as 73 percent of the total zooplankters at one collecting point.

Population densities were very low, averaging 13 per liter. As in past studies, zooplankton densities appeared to be directly related to phytoplankton abundance. Zooplankters in greatest abundance were Brachionus, Conochilus unicornis and Trichocerca.

Zooplankton composition and densities during September 1974 were similar to those reported in the baseline survey, indicating that construction activities have had no detectable effect on the zooplankton community.

2.4 BENTHOS

2.4.1 INTRODUCTION

The objectives of this portion of the survey were to determine if there were any construction effects to the aquatic ecosystem as reflected by changes in the benthic macroinvertebrate community structure. In order to evaluate possible changes, the data from the baseline survey (June 1971 to April/May 1974) were compared with data collected during the initial phase of the construction period (May - September 1974). During this initial phase of the construction program, one field survey was made in September 1974. The evaluation of the environmental effects of construction were based on comparisons of species present, indicator species, and density.

2.4.2 METHODS AND MATERIALS

Refer to Section 3.5.1 and 3.5.1.2 of the Baseline Biotic Survey.

2.4.3 FINDINGS

2.4.3.1 Insects

A total of 16 insect species were identified at least to genus, with an additional 2 identified to family for a total of 18 taxa collected in the Broad River Study Area in September 1974 (Table 2.4.1). The species composition by major taxonomic groups was as follows: Diptera (flies, mosquitoes, midges), 15; Ephemeroptera (mayflies), 1; and Odonata (dragonflies), 2.

The total insect taxa reported for September 1974 (18 was slightly higher than reported in September 1972 (16) in the baseline survey. The total insect species by taxa was 5, 8, and 12, respectively at Transects B, C, and D (Table 2.4.2). The values reported at Transects B and C were slightly lower than any reported during the baseline survey where a minimum of 6 and 10 taxa, respectively were reported.

Sialis sp. (alderfly) was not reported in September 1974; this

Table 2.4.1 Species list of benthic macroinvertebrates present in September 1974 in the Broad River Study Area

Taxa

- Ectoprocta
  - Lophopodidae
    - *Pectinatella magnifica*

Ectoprocta Total - 1

- Insecta
  - Diptera
    - Ceratopogonidae
      - Unidentified*
    - Chironomidae
      - *Cladotanytarsus* sp.
      - *Chironomus* sp.
      - *Coelotanypus* sp.
      - *Cryptochironomus* sp.
      - *Dicrotendipes* sp.
      - *Epoicocladius* sp.
      - *Eukiefferiella* sp.
      - *Harnishia* sp.
      - *Procladius* sp.
      - *Tanypus* sp.
      - *Tanytarsus* sp.
      - *Pentaneurini* Unidentified*
    - Culicidae
      - *Chaoborus punctipennis*

Diptera Total - 15

- Ephemeroptera
  - Ephemeridae
    - *Hexagenia limbata*

Ephemeroptera Total - 1

- Odonata
  - Gomphidae
    - *Stylurus* sp.
  - Macromiidae
    - *Didymops* sp.

Odonata Total - 2

Insecta Total - 18

Table 2.4.1 (Continued)

Taxa
Crustacea
Decapoda
Palaemonidae
Palaemonetes kadiakensis?
Crustacea Total - 1
Archnoidea
Hydracarina
Pionidae
Forelia sp.
Archnoidea Total - 1
Hirudinea
Glossiphoniidae
Unidentified*
Hirudinea Total - 1
Oligochaeta
Lumbriculidae
Unidentified*
Naididae
Dero digitata
Dero sp.
Tubificidae
Aulodrilus limnobius
Aulodrilus pigueti
Branchiura sowerbyi
Limnodrilus hoffmeisteri
Immature sp.1
Immature sp.2
Oligochaeta Total - 9
Nematoda
Unidentified*
Nematoda Total - 1

Table 2.4.1 (Continued)

Taxa
Mollusca
Pelecypoda
Corbiculidae
Corbicula manilensis
Sphaeriidae
Pisidium sp.
Sphaerium partumeium
Mollusca Total - 3
Taxa Total - 35

*Species unknown, may be more than one species but considered here as one.

Table 2.4.2 Total insect species by order and mean number per square meter (in parentheses) on transects in the Broad River Study Area in September 1974.

	B	C	D
Insecta			
Diptera	5 (2336)	7 (2499)	11 (116)
Ephemeroptera	0 (0)	1 (55)	1 (258)
Odonata	0 (0)	0 (0)	1 (5)
Total Taxa Mean No. /m^2	5 (2336)	8 (2554)	12 (374)

was one of the three ubiquitous species of the baseline survey. New species of insects collected for the first time in the Broad River Study Area included the dipteran larvae, Epoicocladius sp. and Eukiefferiella sp. and one odonate, Didymops sp. Coleopterans were absent from the September 1974 samples (Table 2.4.1), as they have been from all samples since May 1973.

The Diptera and Ephemeroptera were the numerically predominant orders of insects during September 1974. The mean insect density at Transects B, C, and D were 2336, 2554, and 374/m^2 respectively (Table 2.4.2). The densities were within the range reported for the baseline survey.

2.4.3.2 Other Benthic Macroinvertebrates

There were no new species of oligochaetes identified, which had not been reported during the baseline survey (Table 2.4.1). Oligochaete density ranged from about 200 to 800/m^2 for Transects B, C, and D (Figure 2.4.1). Branchiura sowerbyi was present at all transects and was usually more abundant than all of the other species of oligochaetes combined (Figure 2.4.1).

One mollusc, Sphaerium partumeium, which had not been reported during the baseline survey, was found (Table 2.4.1). Gastropods (snails) were also absent from the September 1974 samples (Table 2.4.1), as they have been from all samples since November 1972. The density of pelecypod molluscs, represented primarily by Corbicula manilensis, was usually low except from Transect D (Table 2.4.3). At Transect D densities of molluscs ranged from 311 to 1675/m^2 while maximum densities at Transects B and C ranged from 0 to 104/m^2 (Table 2.4.3).

2.4.4 DISCUSSION

In an attempt to evaluate construction effects on the benthic macroinvertebrates, comparisons of species present, indicator organisms, and densities were made with data collected during the baseline survey.

There were several species of facultative, pollution tolerant and pollution sensitive organisms present. The facultative organisms included:

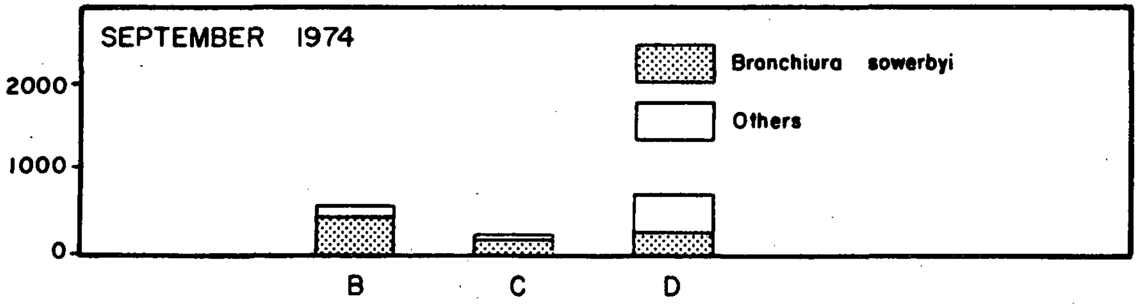

Figure 2.4.1 Mean number of oligochaetes (Branchiura sowerbyi and other species) per square meter on Transects B through D in the Broad River Study Area in September 1974

Table 2.4.3 Quantitative comparison (number per square meter) of pelecypod families Sphaeriidae and Corbiculidae at eleven collecting points along three transects in the Broad River Study Area in September 1974

	B			C			D				
	1	2	3	1	2	3	1	2	3	4	5
Sphaeriidae											
<u>Sphaerium</u> sp.	15	0	0	0	0	0	0	0	0	0	0
<u>Pisidium</u> sp.	0	0	0	0	0	15	0	0	0	0	0
Corbiculidae											
<u>Corbicula</u> <u>manilensis</u>	0	0	0	0	0	89	341	311	444	1674	474

Cryptochironomus sp. and Chaoborus punctipennis; the pollution sensitive organisms included: Tanytarsus sp. and Hexagenia limbata; and the pollution tolerant organisms included: Chironomus sp., Coelotanypus sp. and Procladius sp. Therefore, on the basis of indicator species, it appears that the study area is receiving waters moderately enriched organically, but no significant change has occurred.

Densities of insects in September 1974 (Table 2.4.2) were compared with those of September 1971 and November 1972 (baseline data) to minimize seasonal variation. The insect densities were within the seasonal range reported for Transects B and C; however, they were much lower at Transect D. The great density variation at Transect D may be partially due to its new location. Since there was little change in density reported for Transect B, which is just below the direct impact area, it is unlikely that the low insect density is related to construction effects.

Oligochaete densities of September 1974 were within the range reported in the baseline survey during September 1971 and November 1972 and Branchiura sowerbyi continued to be the numerically dominant oligochaete at all transects. Since there has been no significant change in the density or dominance of oligochaetes collected during similar times of the year, the effects of construction on the oligochaete community, if any, are negligible.

Molluscs densities were highest at Transect D and very low at Transects B and C during similar seasons of the baseline survey. The high density of Corbicula manilensis and absence of other molluscs at Transect D indicates some environmental stress; however, this condition prevailed during the baseline survey. The similarities of molluscs communities at various transects during the baseline survey and the recent survey (September 1974), indicates no major changes to the molluscs communities have occurred due to construction effects.

2.4.5 SUMMARY

Data collected to date on the species present, indicator organisms, and density of the benthic macroinvertebrate community of the Broad River Study Area indicate that, at present, no significant change has taken place.

2.5 FISH

2.5.1 INTRODUCTION

In September 1974 the first of a series of fisheries studies was conducted to monitor effects of construction on the fishes of the Broad River Study Area. By observing possible adverse effects of construction, attempts can be made to minimize their effect. The following biological functions were analyzed: species composition, distribution, relative abundance, length-weight relationships, standing crop estimates, age and growth, sex ratio, gonad condition, condition factors, and food habits.

2.5.2 METHODS AND MATERIALS

2.5.2.1 Collection

Electrofishing, seining, and backpack shocking methods were described in the baseline survey Section 3.6.2.1 or 3.6.2.1a of the addendum.

2.5.2.2 Age and Growth

Described in the baseline survey, Section 3.6.2.2.

2.5.2.3 Length-Weight Relationship

Described in Section 3.6.2.3 of the baseline survey.

2.5.2.4 Condition Factor

Described in Section 3.6.2.4 of the baseline survey.

2.5.2.5 Sex Ratios and Gonad Condition

Described in Section 3.6.2.5 of the baseline survey.

2.5.2.6 Standing Crop Estimate

Described in Section 3.6.2.6 and 3.6.2.6a of the baseline survey.

2.5.2.7 Food Habits

Described in Section 3.6.2.7 of the baseline survey.

2.5.3 FINDINGS AND DISCUSSION

2.5.3.1 Species Composition and Relative Abundance

Three new *Notropis* spp., (whitefin shiner, sandbar shiner, and spottail shiner [Table 2.5.1]), were collected in September. A new darter, the tessellated darter, was also collected. Cole (1967), cited by Bailey et al., (1970) removed this species from synonomy with the johnny darter (*Etheostoma nigrum*). The appearance of these four new species reflects the added sampling effort in the littoral area (Section 3.6.2.1a of the Baseline Addendum).

Two new species belonging to the sucker family (Catostomidae) were collected at both Transects B and D (Table 2.5.2). These species were the golden redhorse and highfin carpsucker. Pflieger (1971) has characterized the first as tolerant of moderate turbidity and the second as having limited distribution in Missouri because of its intolerance of turbidity. Turbidity is one of the more noticeable effects of construction, therefore, the presence of these species, along with black crappie, which is intolerant of turbidity, at Transects B and D indicates that turbidity is not excluding intolerant species.

Changes in the relative abundance of the five dominant species reported in the baseline survey, bluegill, gizzard shad, white crappie, redear sunfish and largemouth bass, were observed in September 1974. The largemouth bass was not among the dominant five species and the mosquitofish was ranked third. The latter species was associated almost exclusively with the littoral area (Table 2.5.3). Consequently, with increased sampling effort in that area, its rank shifted. The bluegill retained first ranking and increased from 34.1 to 37.8 percent. Gizzard shad retained its secondary position, but decreased from 19.4 to 15.4 percent. Both white crappie and redear sunfish were displaced one rank downward which appears to be associated primarily with the increased sampling effort in the littoral area. Largemouth bass dominance decreased significantly from fifth to eighth, with a percent abundance decrease

Table 2.5.1 Species composition and relative abundance of all fishes collected from the Broad River Study Area, September 1974.

Common Name	Scientific Name	No.	Percent
Bluegill	*Lepomis macrochirus*	379	37.8
Gizzard shad	*Dorosoma cepedianum*	154	15.4
Mosquitofish	*Gambusia affinis*	73	7.3
White crappie	*Pomoxis annularis*	64	6.4
Redear sunfish	*Lepomis microlophus*	55	5.5
Black crappie	*Pomoxis nigromaculatus*	51	5.1
Longnose gar	*Lepisosteus osseus*	41	4.1
Largemouth bass	*Micropterus salmoides*	27	2.7
Warmouth	*Lepomis gulosus*	23	2.3
Quillback	*Carpiodes cyprinus*	21	2.1
Channel catfish	*Ictalurus punctatus*	18	1.8
Shorthead redhorse	*Moxostoma macrolepidotum*	15	1.5
Whitefin shiner	*Notropis niveus*	10	1.0
Redbreast sunfish	*Lepomis auritus*	9	0.9
Carp	*Cyprinus carpio*	8	0.8
Sandbar shiner	*Notropis scepticus*	8	0.8
Brown bullhead	*Ictalurus nebulosus*	6	0.6
White catfish	*I. catus*	5	0.5
River carpsucker	*Carpiodes carpio*	5	0.5
Snail bullhead	*Ictalurus brunneus*	4	0.4
Tessellated darter	*Etheostoma olmstedi*	4	0.4
Golden redhorse	*Moxostoma erythrurum*	3	0.3
Highfin carpsucker	*Carpiodes velifer*	3	0.3
Silvery minnow	*Hybognathus nuchalis*	3	0.3
Spottail shiner	*Notropis hudsonius*	3	0.3
Yellow bullhead	*Ictalurus natalis*	2	0.2
Pumpkinseed	*Lepomis gibbosus*	1	0.1
Black bullhead	*Ictalurus melas*	1	0.1
Silver redhorse	*Moxostoma anisurum*	1	0.1
Striped jumprock	*M. rupiscartes*	1	0.1
Spotted gar	*Lepisosteus oculatus*	1	0.1
Swamp darter	*Etheostoma fusiforme*	1	0.1
Golden shiner	*Notemigonus chrysoleucas*	1	0.1
Margined madtom	*Noturus insignis*	1	0.1
Hybrid sunfish	*Lepomis* sp.	1	0.1
Total No.		1003	
Total Species		35	

Table 2.5.2 Species composition and relative abundance of fishes collected from four transects in the Broad River Study Area, September 1974.

	B		C		D		E	
Common Name	#	%	#	%	#	%	#	%
Bluegill	95	33.0	38	17.5	53	39.8	7	7.9
Gizzard shad	36	12.5	84	38.7	28	21.1	5	5.6
White crappie	37	12.8	26	12.0	1	0.8	-	-
Redear	22	7.6	9	4.1	18	13.5	-	-
Black crappie	48	16.7	-	-	1	0.8	2	2.2
Longnose gar	15	5.2	21	9.7	3	2.3	2	2.2
Largemouth bass	10	3.5	7	3.2	7	5.3	2	2.2
Warmouth	10	3.5	5	2.3	-	-	-	-
Quillback	4	1.4	5	2.3	7	5.3	5	5.6
Channel catfish	-	-	12	5.5	2	1.5	4	4.5
Shorthead redhorse	-	-	-	-	2	1.5	13	14.6
Whitefin shiner	-	-	-	-	1	0.8	9	10.1
Redbreast	-	-	6	2.8	-	-	3	3.4
Carp	1	0.3	-	-	-	-	7	7.9
Sandbar shiner	-	-	-	-	-	-	8	9.0
Brown bullhead	5	1.7	-	-	1	0.8	-	-
White catfish	1	0.3	3	1.4	1	0.8	-	-
River carpsucker	-	-	-	-	-	-	5	5.6
Snail bullhead	-	-	-	-	-	-	4	4.5
Tessellated darter	-	-	-	-	-	-	4	4.5
Golden redhorse	1	0.3	-	-	2	1.5	-	-
Highfin carpsucker	2	0.7	-	-	1	0.8	-	-
Silvery minnow	-	-	-	-	3	2.3	-	-
Spottail shiner	-	-	-	-	-	-	3	3.4
Yellow bullhead	-	-	-	-	-	-	2	2.2
Pumpkinseed	1	0.3	-	-	-	-	-	-
Black bullhead	-	-	1	0.4	-	-	-	-
Silver redhorse	-	-	-	-	-	-	1	1.1
Striped jumprock	-	-	-	-	-	-	1	1.1
Spotted gar	-	-	-	-	-	-	1	1.1
Golden shiner	-	-	-	-	1	0.8	-	-
Margined madtom	-	-	-	-	-	-	1	1.1
Hybrid sunfish	-	-	-	-	1	0.8	-	-
Total No.	288		217		133		89	
Total Species	15		12		18		21	

Table 2.5.3 Species composition and relative abundance of fishes collected from nine littoral collecting points in the Broad River Study Area, September 1974.

	BL-1		BL-2		BL-3		CL-1		CL-2		CL-3		DL-1		DL-2		DL-3	
Common Name	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Bluegill	46	86.8	33	97.1	45	93.8	25	89.3	4	57.1	30	93.8	-	-	2	14.3	1	100.0
Gizzard shad	-	-	-	-	-	-	1	3.6	-	-	-	-	-	-	-	-	-	-
Mosquitofish	-	-	-	-	-	-	-	-	1	14.3	-	-	60	100.0	12	85.7		
Redear	-	-	1	2.9	2	4.2	2	7.1	-	-	1	3.1	-	-	-	-	-	-
Largemouth bass	-	-	-	-	-	-	-	-	1	14.3	-	-	-	-	-	-	-	-
Warmouth	6	11.3	-	-	1	2.1	-	-	-	-	1	3.1	-	-	-	-	-	-
Swamp darter	1	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total No.	53		34		48		28		7		32		60		14		1	
Total Species	3		2		3		3		3		3		1		2		1	

from 3.8 to 2.7.

Other shifts in relative abundances were noted but their significance is not clear because only one sampling period was involved and the number of species collected was small. A total of 1,003 specimens were collected including 34 species and a hybrid sunfish. Eight families of fishes were represented.

2.5.3.2 Age and Growth

High natural variability may account for the lower growth rate of bluegill and white crappie observed in September 1974 in contrast to the baseline survey (Table 2.5.4). Similarly, a slower growth rate was observed among gizzard shad after the first year of baseline survey. Another possible explanation for the slower growth of these species is that siltation resulting from construction activities may have adversely affected the food supply.

In the third year class, growth of redear sunfish surpassed values reported in the baseline survey. This species began feeding predominantly on pelecypods between the second to third year class (101-150 mm) (Sections 3.6.3.8 and 3.6.3.8a). Therefore, a change in the diet of this species and increased pelecypod population in the study area over the past three years may favor more rapid growth.

Largemouth bass was the other species that had a higher growth rate than that reported in the baseline survey. Increased numbers of bluegill, may have created a forage base which stimulated growth of age groups above the second year class.

2.5.3.3 Length-Weight Relationship

Table 2.5.5 contains regression equations for fishes collected in September 1974. When compared to August 1973, a general reduction in coefficient b for all species and most transects indicates a reduction in condition or well-being. However, small sample size may have biased the data. This general

Table 2.5.4 Mean back calculated total lengths and average growth increments of selected fishes from all Parr Reservoir Transects (B, C, D), September 1974.

		Total Length (mm) at Annulus							
Year Class	n*	1	2	3	4	5	6	7	8
Bluegill									
1973	35	55							
1972	45	48	77						
1971	18	49	75	96					
1970	2	49	78	106	132				
Mean Length		50	77	101	132				
Mean Increment		50	28	24	26				
Gizzard shad									
1973	8	109							
1972	6	118	193						
1971	23	121	187	237					
1970	2	124	204	242	299				
1969	3	132	194	250	302	351			
1968	2	110	154	195	237	270	302		
1967	1	96	167	212	282	342	396	410	
Mean Length		116	183	227	280	321	349	410	
Mean Increment		116	66	46	56	47	43	14	
White Crappie									
1973	12	77							
1972	8	80	116						
1971	11	78	125	157					
1970	4	75	110	143	171				
1969	2	72	100	142	188	222			
Mean Length		76	113	147	180	222			
Mean Increment		76	37	35	37	34			

Table 2.5.4 (Continued)

Year Class	n*	Total Length (mm) at Annulus							
		1	2	3	4	5	6	7	8
Redear sunfish									
1973	8	44							
1972	7	47	89						
1971	13	55	114	153					
1970	9	58	99	147	182				
1969	3	41	70	135	187	228			
1968	1	51	79	143	166	189	213		
1966	1	39	56	117	147	183	206	223	242
Mean Length		48	85	139	170	200	210	223	242
Mean Increment		48	36	55	34	33	24	17	19
Largemouth bass									
1973	3	105							
1972	2	114	174						
1971	2	98	168	234					
1970	5	120	187	256	316				
1969	3	130	200	276	332	373			
1968	1	138	202	264	363	416	435		
Mean Length		118	186	288	337	394	435		
Mean Increment		118	66	99	72	47	19		

* Number of fishes examined.

Table 2.5.5 Regression equations of length-weight relationships for fishes collected from the Broad River Study Area, September 1974.

Species	Transect	Equation
Bluegill	B	$W=3.610x10^{-5}L^{2.838}$
	B (cove)	$W=1.556x10^{-5}L^{2.955}$
	C	$W=1.161x10^{-6}L^{3.526}$
	C (cove)	$W=4.202x10^{-5}L^{2.777}$
	D	$W=2.697x10^{-6}L^{3.371}$
	E	$W=2.502x10^{-5}L^{2.934}$
Gizzard Shad	B	$W=1.200x10^{-5}L^{2.937}$
	B (cove)	$W=1.140x10^{-5}L^{2.960}$
	C	$W=9.560x10^{-6}L^{2.973}$
	C (cove)	$W=7.637x10^{-6}L^{3.024}$
	D	$W=1.486x10^{-5}L^{2.911}$
	E	$W=2.047x10^{-5}L^{2.857}$
White Crappie	B	$W=1.008x10^{-5}L^{3.044}$
	B (cove)	$W=4.409x10^{-6}L^{3.201}$
	C	$W=1.372x10^{-6}L^{3.423}$
	C (cove)	$W=2.682x10^{-5}L^{2.836}$
Black Crappie	B	$W=6.251x10^{-6}L^{3.141}$
	B (cove)	$W=9.177x10^{-6}L^{3.053}$
	C (cove)	$W=2.841x10^{-5}L^{2.829}$
Redear	B	$W=1.454x10^{-5}L^{3.016}$
	B (cove)	$W=2.554x10^{-5}L^{2.894}$
	C	$W=9.365x10^{-6}L^{3.080}$
	C (cove)	$W=1.094x10^{-3}L^{2.040}$
	D	$W=4.777x10^{-6}L^{3.249}$
Largemouth Bass	B	$W=3.115x10^{-6}L^{3.250}$
	C	$W=2.687x10^{-6}L^{3.321}$
	C (cove)	$W=1.554x10^{-6}L^{3.375}$
	D	$W=1.941x10^{-6}L^{3.346}$

Table 2.5.5 (Continued)

Species	Transect	Equation
Warmouth	B	$W=7.915x10^{-5}L^{2.702}$
	B (cove)	$W=5.895x10^{-5}L^{2.699}$
	C	$W=1.221x10^{-4}L^{2.588}$
	C (cove)	$W=1.596x10^{-4}L^{2.519}$
Redbreast	C (cove)	$W=1.413x10^{-4}L^{2.534}$
Carp	E	$W=2.110x10^{-6}L^{3.291}$
Golden Shiner	C (cove)	$W=1.531x10^{-5}L^{2.843}$
Longnose Gar	C	$W=4.866x10^{-8}L^{3.615}$
Shorthead Redhorse	E	$W=5.301x10^{-5}L^{2.721}$
Quillback	D	$W=1.705x10^{-6}L^{3.344}$
	E	$W=1.176x10^{-8}L^{4.196}$
River Carpsucker	E	$W=4.565x10^{-6}L^{3.195}$
Channel Catfish	B (cove)	$W=2.977x10^{-4}L^{2.204}$
	C	$W=9.709x10^{-6}L^{2.954}$
	C	$W=7.674x10^{-5}L^{2.603}$
White Catfish	C (cove)	$W=3.106x10^{-5}L^{2.801}$

reduction in condition factor was not as noticeable when compared with November 1972 data.

2.5.3.4 Condition Factor

Condition factors are subject to wide variability depending upon size of fish collected, sex, season, feeding activity, and numerous other factors. To reduce the bias, a large sample size (>40) is needed. During the construction survey, condition factors of species with fewer than 40 specimens did not differ greatly from those reported in the baseline survey. Likewise, condition factors of species with more than 40 specimens, for example, bluegill, gizzard shad, and black crappie, changed little from previous studies. The white crappie had a somewhat lower condition factor than that previously reported. Redear and largemouth bass, which had increased growth rates compared to baseline studies, also had higher condition factor values. Condition factors and sample size are summarized in Table 2.5.6.

2.5.3.5 Sex Ratio

Half of the species presented in Table 2.5.7 did not contain enough specimens for any estimate of sex ratios. The remaining species vary greatly from that reported in the baseline. There are many sources of variability, such as natural segregation of sexes, which may result in sample bias. Therefore, more data are needed to determine if the observed changes are true or merely artifacts.

2.5.3.6 Gonad Condition

As in previous fall baseline samples, all species had spawned prior to the September collection (Table 2.5.8).

2.5.3.7 Standing Crop

Data for rotenone samples are present in Table 2.5.9 and 2.5.10 for Cannons Creek and Frees Creek, respectively. The Cannons Creek Cove sample (September 1974) showed a reduction from November 1972 in both numbers/

Table 2.5.6 Mean condition factors of fishes collected from the Broad River Study Area, September 1974.

Common Name	Total Number	Condition Factor
Bluegill	299	1.8
Gizzard shad	102	0.9
White crappie	64	1.2
Redear	47	1.9
Black crappie	49	1.2
Longnose gar	41	0.3
Largemouth bass	27	1.4
Warmouth	18	2.0
Quillback	21	1.4
Channel catfish	17	0.7
Shorthead redhorse	15	1.1
Whitefin shiner	10	0.9
Redbreast	8	1.7
Carp	8	1.4
Sandbar shiner	8	0.9
White catfish	5	1.1
River carpsucker	5	1.4
Brown bullhead	6	1.4
Snail bullhead	4	1.1
Tessellated darter	4	0.9
Golden redhorse	3	0.8
Highfin carpsucker	3	1.5
Silvery minnow	3	1.0
Spottail shiner	3	0.8
Yellow bullhead	2	0.8
Pumpkinseed	1	1.7
Black bullhead	1	1.0
Silver redhorse	1	1.0
Striped jumprock	1	0.9
Spotted gar	1	0.3
Swamp darter	1	1.4
Golden shiner	1	0.9
Margined madtom	1	1.1
Hybrid sunfish	1	2.0

Table 2.5.7 Sex ratios of fishes collected from the Broad River Study Area, September 1974.

Species	Male	Female	Ratio
Bluegill	42	54	1/1.3
Gizzard Shad	24	43	1/1.8
White Crappie	10	24	1/2.4
Redear	16	39	1/2.4
Black Crappie	35	33	1/0.9
Warmouth	13	17	1/1.3
Largemouth Bass	12	12	1/1.0
Quillback	3	2	1/0.7
Channel Catfish	1	4	1/4.0
Shorthead Redhorse	0	6	0/6.0
Carp	4	4	1/1.0
White Catfish	2	4	1/2.0
River Carpsucker	3	2	1/0.7
Brown Bullhead	3	0	3/0.0

Table 2.5.8 Mean gonadal condition of mature female fishes from the Broad River Study Area, September 1974.

Common Name	Number	Average Condition
Bluegill	21	2.5*
Gizzard Shad	9	2.1
White Crappie	2	2.0
Redear	21	3.0
Black Crappie	5	2.0
Largemouth Bass	8	2.5
Warmouth	5	2.0
Shorthead Redhorse	6	2.7
Carp	3	3.0

*A gonadal condition of 2 indicates a resting stage, when sexual products have not yet begun to develop. A condition of 3 indicates maturation of sexual products, accompanied by a very rapid increase in gonadal weight.

Table 2.5.9 Standing crop estimates of the fishes from a shoreline rotenone sample of the Cannons Creek area of Parrk Reservoir, South Carolina, September 9-11, 1974.

Species	Number Collected	Grams Collected	Recapture Factor	Number/Hectare	Kg/Hectare
Bluegill	1554	6332	.435	9655	39.341
Gizzard shad	1085	7077	.333	8806	57.438
Warmouth	111	509	.500	600	2.751
Redear	101	1438	.556	492	6.989
Black crappie	88	2421	-	238*	6.543*
White crappie	79	1996	-	214*	5.395*
Tadpole madtom	34	96	-	92*	0.259*
White catfish	26	3172	.333	211	25.746
Golden shiner	22	89	-	59*	0.241*
Largemouth bass	14	2210	.250	151	23.892
Redbreast	12	66	-	32*	0.178*
Channel catfish	5	540	.250	54	5.838
Whitefin shiner	4	0.5	-	11*	0.001*
Hybrid sunfish	3	64	-	8*	0.173*
Black bullhead	2	16	-	5*	0.043*
Mosquitofish	2	0.6	-	5*	0.002*
Swamp darter	2	1.2	-	5*	0.003*
Brown bullhead	1	192	-	3*	0.519*
Highfin carpsucker	1	776	-	3*	2.097*
				20642	177.451

* Minimum estimate because no recapture data available.

Table 2.5.10 Standing crop estimates of the fishes from a shoreline rotenone sample of the Frees Creek area of Parr Reservoir, South Carolina, September 11-13, 1974.

Species	Number Collected	Grams Collected	Recapture Factor	Number/Hectare	Kg/Hectare
Bluegill	1313	2578	.611	5808	11.403
Gizzard shad	324	3462	.207	4230	45.203
Black crappie	226	1552	.500	1222	8.389
Warmouth	175	398	.667	709	1.613
White crappie	153	1750	1.000	414	4.730
Redear	54	565	.500	292	3.054
Channel catfish	8	20	-	22	.054
Golden shiner	7	10	-	19*	.027*
Mosquitofish	7	4	-	19*	.010*
Largemouth bass	5	737	.500	27	3.984
Tadpole madtom	2	4	-	5*	.011*
White catfish	1	0.2	.500	5	.001
				12771	78.480

* Minimum estimate because no recapture data available.

hectare and kg/hectare, but an increase in number of species from 14 to 18. The Frees Creek Cove sample (September 1974) showed the opposite trend when compared with November 1972 data. An increase in estimated number/hectare and kg/hectare was noted, with a decrease in the number of species from November 1972.

During the baseline survey, the gizzard shad was second and third in importance as a contributor to the standing crop at Transects C and B, respectively. In September 1974, however, more biomass was contributed by gizzard shad than any other species. This shift at both Cannons Creek and Frees Creek compares well with data reported by Jenkins (1967) for other South Carolina reservoirs, where gizzard shad commonly comprise more than half of the standing crop.

The mean value for both cove samples was 128 kg/hectare. This was lower than the November 1972 average of 132 kg/hectare. This relatively small deviation may be accounted for by the difference in sampling dates, resulting in additional growth for the November sample. The biomass increase in Frees Creek may be attributed to a more abundant gizzard shad population. This species is particularly mobile and such variation probably is a common factor influencing standing crop of both coves in the Broad River Study Area.

At present, the results of rotenone sampling in Frees Creek indicates no direct effect from construction.

2.5.3.8 Food Habits

No deviations from food habits reported in the baseline survey were noted in September 1974. However, information for the five dominant species in the baseline survey is reiterated below.

Bluegills fed on zooplankton initially and consumed more benthos with increasing age. Limited use of Pelecypoda was noted at every transect. Zonation between transects was attributed to different benthic assemblages.

Gizzard shad relied on UOM (unidentified organic matter). However, occasional chironomid larvae and other benthos were picked up while feeding on UOM. White crappie depended on both fish and benthos as a food source with mosquitofish being the predominant fish species ingested. All ages of redear sunfish fed at least occasionally on Pelecypoda, although they were utilized increasingly in older fish. The Asiatic clam was used more by this species than bluegills, who preferred Sphaerium sp. Largemouth bass utilized zooplankton when under 50 mm. After that time, fish, particularly Centrarchidae (sunfish), become a dominant food item. The only exception noticed was at Transect E, below the dam, where gizzard shad were utilized almost exclusively.

2.5.4 SUMMARY

The only data which indicates possible reduction in the fisheries quality of the Broad River Study Area were growth values for all age classes of bluegill and white crappie and age 1 gizzard shad. However, largemouth bass and redear sunfish had a significant increase in growth rate.

Most other parameters such as condition factor showed no change from the data reported in the baseline survey. Also, species distribution confirms assumptions that little change has occurred because species intolerant of turbidity were collected at Transects B and D.

The only parameter that changed significantly was the standing crop of the two cove samples. Biomass of Frees Creek Cove sample increased, while that of Cannons Creek decreased. This may indicate possible construction effects. It may also indicate variability in rotenone samples and possibly a decrease in productivity of Cannons Creek. In both samples, gizzard shad was the largest contributor to biomass. In the previous sample, bluegill had the highest biomass.

3.0 TERRESTRIAL SURVEY

3.1 PHOTOGRAMMETRIC ANALYSIS OF THE BROAD RIVER STUDY AREA

Changes in land use patterns have occurred within the Broad River Study Area over the past four years. These changes have been documented through comparison, photogrammetric analysis of 1970 SCS (1:20,000) black and white aerial photography with 1974 D&M (1:24,000) false-color infrared aerial photography. A map (included) was prepared showing the areas altered since 1970, the nature of the alteration, and the acreage of the land changed. For the percentage acreages of the 1970 survey, refer to Section 2.6 of the baseline survey.

Land use changes within the Broad River Study Area fall into five predominant forms: lumbering and logging activities, construction activities (including land clearing), roadway construction, transmission corridor construction and railroad construction. Each of these land uses creates distinct activity patterns which may be interpreted on aerial photographs. The following table illustrates the land use changes in acres and in percent of the total land change.

Activity	Acres	Percent of Total
Lumbering and logging	2,120.6	76
Construction (clearing)	551.9	20
Roadway	88.1	3
Transmission corridors	25.3	0.9
Railroad	15.6	0.5
TOTAL ACRES	2,801.5	100.4

As illustrated on the map (Figure 3.1.1, Baseline Biotic Survey), the predominant location of the construction activities was surrounding the plant site. There was, however, some activity in the form of lumbering and logging and roadway construction in the southern portion of Sumter National Forest amounting to 224.96 acres.

In addition to the photo interpretation for land use changes, analysis for insect and pathogen infestation was conducted. Throughout the study area no major outbreaks of infestation were observed. The predominant disease-causing pests and pathogens of South Carolina are listed in Table 3.1.1. However, the presence of these infestations on the site have not been documented.

Due to the dynamics of land use within the Broad River Study Area, this analysis is accurate through 19 April 1974. Logging and construction activities conducted since April have utilized more land, but aerial surveys have not been conducted for further photogrammetric analyses.

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:
"MAP OF PROJECT AREA SHOWING LAND MODIFICATION FROM 1970 TO 1974"

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Table 3.1.1 - Infestations of major South Carolina coniferous species occurring in the Broad River Study Area.*

Host Species	Pest or Pathogen
Loblolly Pine (*Pinus taeda*)	Seedling Diseases Fusiform Rust (*Cronartium fusiforme*) (*Thelephora terrestris*)
	Foliage Diseases Needle Rust (*Coleosporium* sp.) (*Ploioderm* [*Hypoderma*] *lethale*)
	Insect Southern Pine Beetle (*Dendroctonus frontalis*) Black Turpentine Beetle (*Dendroctonus terebrans*)
Virginia Pine (*Pinus virginiana*)	Seedling and Foliage Diseases Fusiform Rust (*Cronartium comptonme*) (*Cronartium appalachianum*)
	Insect Southern Pine Engraver (*Ips grandicouis*)
Longleaf Pine (*Pinus palustris*)	Foliage Disease Brown Spot (*Scirrhia acicola*)
	Insect Southern Pine Beetle (*Dendroctonus frontalis*)
Shortleaf Pine (*Pinus echinata*)	Stem Disease Pitch Canker (*Fusarium lateritium* f. *pini*)
	Root Disease Root Rot (*Fomes annosus*)
	Insect Core Borer (*Dioryctria amatella*)

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*Data obtained from:

Baker, W. L. 1972. Eastern forest insects. U.S.D.A., Forest Service, Miscellaneous Publication No. 1175. 642p.

Hepting, G.L. 1971. Diseases of forest and shad tress of the United States. U.S.D.A., Forest Service, Agriculture Handbook Number 386. 658p.

3.2 BIRDS

3.2.1 INTRODUCTION

The data included in this report are the result of five quarterly sampling periods following the completion of a baseline survey on environmental conditions prior to construction at the proposed Summer Nuclear Station and the Fairfield Pumped-Storage Facility near Parr, South Carolina. The periods of biotic sampling were August 1973 and January, April, June, and September 1974. Information gathered during these periods will be compared to information reported in the baseline survey and addendum for the purpose of noting any changes which may be interpreted as impacts resulting from construction activities in the area.

3.2.2 METHODS AND MATERIALS

3.2.2.1 Strip Census

Six survey areas were established in the Broad River area for the purpose of conducting strip censuses. Two areas were established in each of three habitat types for comparative purposes. One area termed the "control" area, was located in an area removed from disturbances occurring from site preparation for the power plant and the other area, the "test" area, was located in close proximity to construction activities. In this manner, the effects of environmental changes on bird populations could be monitored. Areas 1C and 5B are located in pine habitats and represent the "control" and "test" sites, respectively. Areas 1B and 5C are located in deciduous tree habitats with 1B being the "control" and 5C the "test" area. The "test" sites 5B and 5C were established in January, 1974 near the area of construction of the nuclear power plant. The third habitat type common to this area is pine habitat that has been selectively cut for harvestable pine trees. A large portion of the Broad River area is vegetated with pine which are periodically harvested for either pulpwood or saw timber. This practice will become increasingly common as much of the land under study will be selectively cut by many of the ex-land owners who retained timber rights when they sold their land. Area 7 ("control") was established in an area near the upper end of the proposed upper reservoir and was selectively cut during the summer of 1973. Area 4 ("test") which was selectively cut in the spring of 1974, is very near the construction site of the proposed nuclear plant.

The survey methods used during the strip census are the same as previously described in Section 5.6.2.3 of the baseline survey. Strip censuses were conducted during each of the five survey periods since the baseline survey.

3.2.2.2 Auto Survey

The auto surveys were discontinued after January 1974. They will be re-established at a later date after cutting and clearing operations in the area of the "test" survey routes have reached a stage where these will be sufficient change in habitat to show a change in avian species composition. The "test" survey routes are routes A, B and C, while the "control" route is route D. These routes along with the methods used during the auto survey are described in Section 5.6.2.2 of the baseline survey.

3.2.2.3 Waterfowl Survey

Waterfowl were surveyed along the Board River from the point where the Broad and Enoree Rivers join north of Blair, South Carolina, south to the Parr Shoals dam. The river was divided into seven survey sections which include three adjacent creeks and the Parr Reservoir. Methods employed are the same as those presented in Section 5.6.2.5 of the baseline survey.

3.2.3 FINDINGS

3.2.3.1 Effect of Timber Harvest

Timber harvest has become extensive in the Frees Creek Watershed.

This is partially related to the construction of the nuclear power plant and pumped-storage facilities. Many land owners retained timber rights when they sold their property to SCE&G and are presently exercising these rights. Paper companies also are removing timber from their properties in the Frees Creek Watershed and on many lands throughout the Piedmont Counties.

Between November 1970 and April 1974, approximately 2800 acres within the project area have been affected in some way by lumbering activities. Most of this area was selectively cut for pole-sized pine trees which results in trees smaller and larger than pole-sized pines being left on the site. Some of the area has been clear-cut which effectively removes all trees from the site.

3.2.3.2 Effect of Construction Activities

As of April 1974, 552 acres had been cleared for construction of the nuclear power plant. Eighty-eight acres had been cleared for roads and another 41 acres had been cleared for transmission line and railroad corridors.

Generally the changes in habitats by construction activity are more drastic than clear-cutting since natural vegetation is not allowed to come back into the area. Exceptions are the banks along roads and railroad cuts which have been dressed with grass to stabilize erosion. The current cover and food value of this grass is low for wildlife, but in time herbaceous vegetation will invade these areas and an increase in value will be apparent.

3.2.3.3 Results of Strip Censuses

Forty-one species of birds were observed in the three control sites during the course of this phase of the monitoring program. These species along with their season of occurrence are recorded in Table 3.2.1. The density (birds per acre) on these sites is given in Figure 3.2.1. The diversity (number of species per site) of birds is presented in Figure 3.2.2.

Table 3.2.1 Results of avian strip censuses conducted on control site from fall 1973 to fall 1974

	PINE					SELECTIVELY CUT PINE					DECIDUOUS				
	Fall	Win	Spr	Sum	Fall	Fall	Win	Spr	Sum	Fall	Fall	Win	Spr	Sum	Fal
Bobwhite		11					13					8			
Yellow-billed Cuckoo	1			1							2			2	3
Whip-poor-will								1							
Ruby-throated Humingbird											1				
Common Flicker														1	
Red-bellied Woodpecker			2	4				1				2			
Downy Woodpecker				2	1						1		10	1	
Great-crested Flycatcher				3											
Acadian Flycatcher														1	2
Eastern Wood Pewee				1										3	
Blue Jay	7		1	6	9			1	2						1
Common Crow		2		1											
Carolina Chickadee	13		3		2				43	32	11	14	4	3	4
Tufted Titmouse	1		1								1			1	
Brown-headed Nuthatch	5		3	13	6			1	11	10	1	11			
Carolina Wren			1	6					1	2	4	1	13		8
Brown Thrasher				3										1	
Wood Thrush			1	1											
Hermit Thrush							3								
Blue-Gray Gnatcatcher													10	3	
Ruby-crowned Kinglet			2				1					2	14		
Golden-crowned Kinglet												18			
White-eyed Vireo													3		1
Yellow-throated Vireo													3		
Red-eyed Vireo													1	3	
Parula Warbler													11	1	
Myrtle Warbler			17					2							3
Pine Warbler	6	2	10	4	4			1	2		10				
Prairie Warbler								3	3						
Yellowthroat									2				11	2	
Hooded Warbler											6		1		
Warbler sp.			3												
Summer Tanager					1				1	1				3	
Cardinal	3			4	1		6	1			4	3	4	3	3
Indigo Bunting														2	
Purple Finch								2							
American Goldfinch												5			
Rufous-si[illegible] Towhee				5			2		2			5	3		1

Table 3.2.1 (continued)

	PINE					SELECTIVELY CUT PINE					DECIDUOUS				
	Fall	Win	Spr	Sum	Fall	Fall	Win	Spr	Sum	Fall	Fall	Win	Spr	Sum	Fall
Bachman's Sparrow													4		
White-throated Sparrow												15			
Fox Sparrow							6								
Song Sparrow												4			
Unidentified	12		5	6	3	1	2		2	1	18	6	20		1
Total	48	16	49	60	27	3	35	11	30	18	59	94	112	30	24

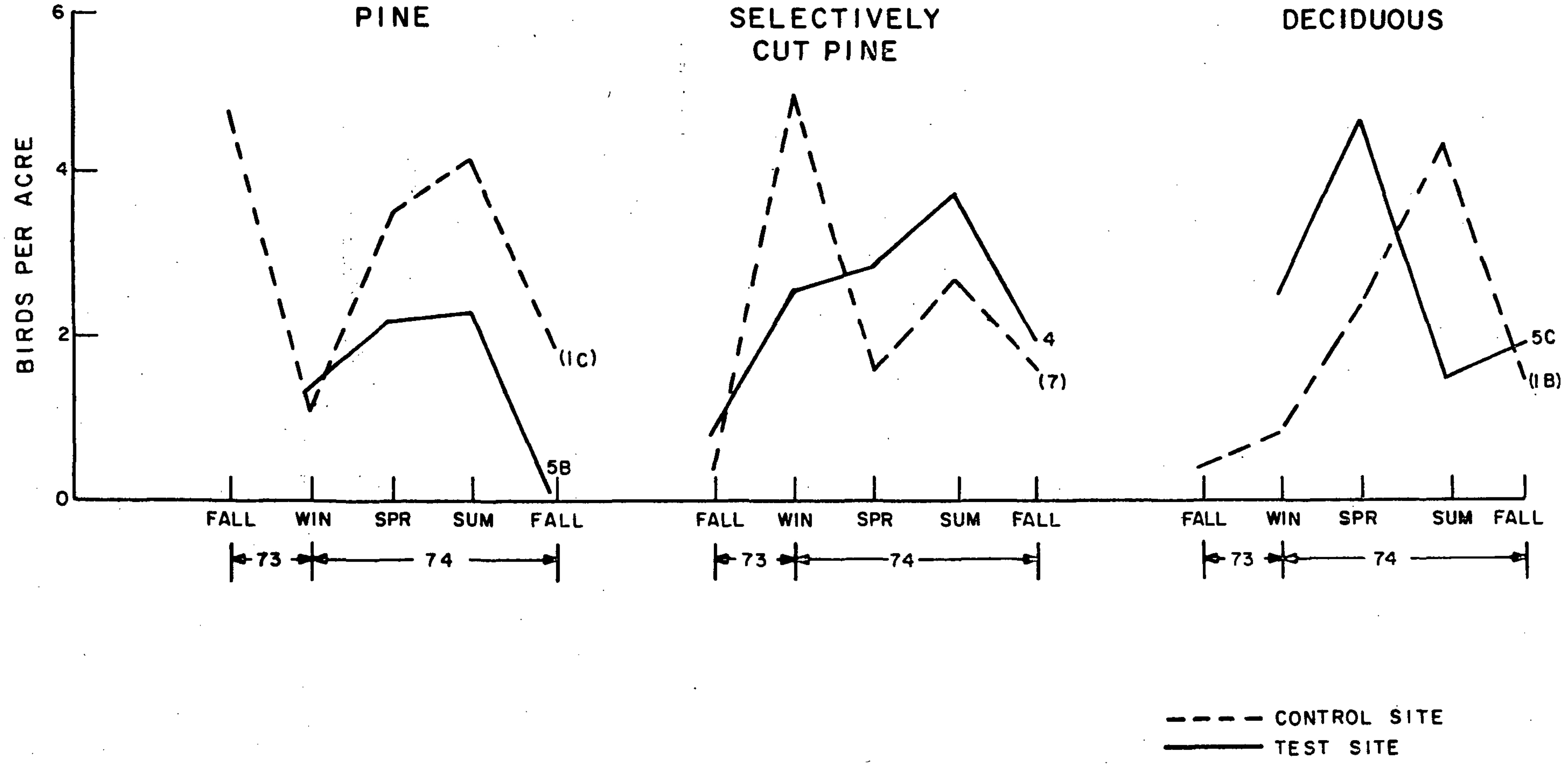

Figure 3.2.1 Avian density in selected habitats during strip censuses

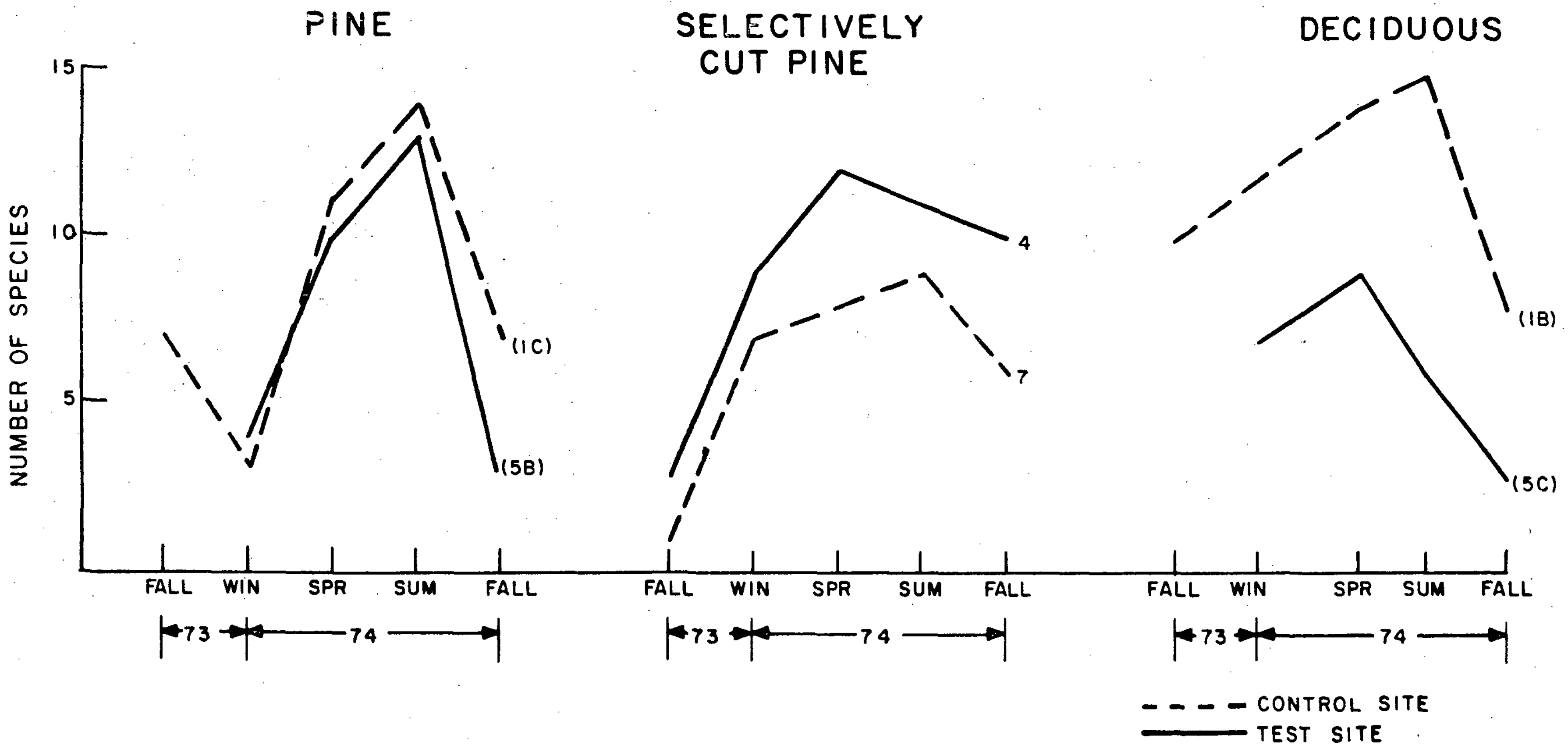

Figure 3.2.2 Avian diversity in selected habitats during strip censuses

Eight species of birds were chosed as indicators of environmental change in the Addendum to the Baseline Biotic Survey. These eight indicator species are the following:

Mockingbird	Cardinal
Loggerhead Shrike	Pine Warbler
Eastern Meadowlark	Rufous-sided Towhee
Mourning Dove	Carolina Chickadee

Four of these species occurred in the control sites (Table 3.2.2).

Thirty-seven species of birds were observed in the three "test" sites during this portion of the monitoring program. The seasonal occurrence of these species is given in Table 3.2.3. The avian density occurring on the "test" sites is presented in the same figure (Figure 3.2.1) as the density of "control" site species for comparison purposes. In like manner, the diversity of species in the "test" sites are presented in Figure 3.2.2 along with that of the "control" site species. Five of the "indicator" species occurred in the "test" sites and their time and area of occurrence are recorded in Table 3.2.2.

3.2.3.4 Results of the Waterfowl Survey

Waterfowl were surveyed along the Broad River and adjacent creeks during August 1973 and January and June 1974. The ducks and shorebirds observed during these periods are listed in Table 3.2.4.

3.2.4 DISCUSSION

3.2.4.1 Effect of Timber Harvest

The act of harvesting timber from an area has immediate impact on whatever wildlife resides in the area. Generally the noise associated with harvesting drives most animals temporarily from the area. If only selected trees are harvested, obviously there will be some trees over or under

Table 3.2.2 Indicator species recorded by strip census in different habitats from fall 1973 to fall 1974

Species	PINE					SELECTIVELY CUT PINE					DECIDUOUS				
	Fall	Win	Spr	Sum	Fall	Fall	Win	Spr	Sum	Fall	Fall	Win	Spr	Sum	Fall
"CONTROL" SITES															
Cardinal	3			4	1		6	1			4	3	4	3	3
Carolina Chickadee	13		3		2				4	3	11	14	4	3	4
Rufous-sided Towhee				5		2	2		2	1		5	3		1
Pine Warbler	6	2	10	4	4			1	2		10				
Total	22	2	13	13	7	2	8	2	8	4	25	22	11	6	8
"TEST" SITES															
Cardinal				1	3		1	6	7			1	1	1	1
Carolina Chickadee		3	2	7	1		2	7	3	2		2	1	1	
Rufous-sided Towhee		2		2		3		1	4						
Pine Warbler			2				1		4						
Mockingbird				1											
Total	0	5	4	11	4	3	4	14	18	2	0	3	2	2	1

Table 3.2.3. Results of avian strip

	PINE					SELECTIVELY CUT PINE					DECIDUOUS			
	Fall	Win	Spr	Sum	Fall	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall
Bobwhite				1										
Yellow-billed Cuckoo													1	2
Chuck-wills-widow														
Whip-poor-will														
Common Flicker							3			1				
Red-Bellied Woodpecker										1				1
Yellow-Bellied Sapsucker		1												
Hairy Woodpecker							1	1	1		1			
Downy Woodpecker										1				
Great Crested Flycatcher				1	1									
Acadian Flycatcher										1			6	
Blue Jay					3		1		1	5		2		
Carolina Chickadee		3	2	7	1		2	7	3	2	2	1	1	
Tufted Titmouse									2	6				
Brown-headed Nuthatch			1	3			1	3		5			2	
Carolina Wren		2	1	3		1		1			2	1		
Mockingbird				1										
Catbird								1						
Robin							40							
Wood Thrush														
Hermit Thrush		2					1							
Blue-Gray Gnatcatcher			5					2	11			4		
Golden-crowned Kinglet											1			
Ruby-crowned Kinglet														
Kinglet sp.							3				6			
White-Eyed Vireo			1											
Red-Eyed Vireo				2					1				1	
Myrtle Warbler												6		
Pine Warbler			2				1		4					
Prairie Warbler			4	2				9	3	1		2		
Yellowthroat			1					1						
Warbler Sp.												20		
Orchard Oriole				1										
Cowbird								1						
Summer Tanager			3	2		1		1	5	2		1		

Table 3.2.3 (continued)

	PINE					SELECTIVELY CUT PINE					DECIDUOUS			
	Fall	Win	Spr	Sum	Fall	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall
Cardinal				1	3		1	6	7		1	1	1	1
Indigo Bunting				1										
Rufous-Sided-Towhee			2	2		3		1	4					
Unidentified		7	3			6	5	9	3	1	8	2	1	4
No. Species	0	5	10	13	3	3	9	12	11	10	7	9	6	3
Total No.	0	15	25	28	7	11	58	43	45	26	22	40	13	8

	Broad & Enoree River north of Blair, S.C.			Broad River from Blair South to Hellers Creek			Hellers Creek			Broad River from Hellers to Frees Creek		
	1973	1974		1973	1974		1973	1974		1973	1974	
Common Name	Aug*	Jan*	June	Aug*	Jan*	June	Aug*	Jan*	June	Aug*	Jan*	June
Great Blue Heron		1		3	1			2	1	2	1	
Common Egret										1		
Cattle Egret										1		
Green Heron	2								1	2		
Mallard		8										
Gadwall					2							
American Widgeon		2										
Pintail												
Blue-winged Teal							1					
Wood Duck	5	16		1	6		5	1		7		
Ringneck								2				
Bufflehead												
Unidentified Duck		8							3			
Spotted Sandpiper	5			5			1					
Belted Kingfisher	1	1		2	3		2	1	3	1	2	
Minimum #species	4	5		4	4		4	4	4	6	2	
# ducks	5	34		1	8		6	3	3	7		
# shorebirds	8	2		10	4		3	3	5	7	3	

* Two Day Observation

Table 3.2.4 (continued)

	Frees Creek			Cannons Creek			Parr Reservoir		
	1973	1974		1973	1974		1973	1974	
Common Name	Aug*	Jan*	June*	Aug	Jan*	June	Aug	Jan*	June
Great Blue Heron	2	3	4	2	5		2	2	
Common Egret									
Cattle Egret			1						
Green Heron	3		3	2		2	3		
Mallard			10					3	
Gadwall									
American Widgeon									
Pintail								2	
Blue-winged Teal									
Wood Duck	6		16	6	2	3	5	5	
Ringneck		2			1			2	
Bufflehead								12	
Unidentified Duck	1							16	
Spotted Sandpiper	4						3		
Belted Kingfisher	3	4	4	3	4	1	3	2	
Minimum #species	5	3	6	4	4	3	5	7	
# ducks	7	2	26	6	3	3	5	40	
# shorebirds	12	7	12	7	11	3	11	4	

* Two Day Observation

the selected size or age class which can provide a degree of cover or food to wildlife. Generally, the removal of a certain tree class will give additional growing space to the trees not harvested. An understory of hardwood species may be released to eventually dominate an area when a previously dominant overstory of pines is removed. The resultant hardwood stand would offer a different habitat in terms of food and shelter to the area's wildlife.

The opening of a pine stand through selective harvesting would cause more sunlight to reach the forest floor, allowing more ground vegetation to become established which, according to the plant species present, would support more or different wildlife species in this area. An example of this fact is seen in Area 7 which was selectively cut during the summer of 1973. Figure 3.2.1 shows a great increase in birds per acre in this area during the winter survey of 1974. More than one-third (34%) of the birds observed in Area 7 at that time were bobwhite quail. In all probability, this species would not have been present in large numbers had not the area been thinned out during the previous summer by selective harvesting.

A clear-cut timber harvest in which all vegetation is removed quite obviously results in an immediate reduction in habitat value for all wildlife species. Fortunately this denuded situation does not exist for a long period of time. Through natural succession, many forbs and grasses will invade the clear-cut area soon after timber harvest. While the clear-cut area will be of little use to wildlife during the first year, this habitat will be most useful from the second to about the fifth year following clear-cutting. For example, ground nesting birds such as bobwhite quail will find clear-cut land very attractive during the second and third year following clear-cutting, but after that the undergrowth will generally become too thick for these birds to find food, escape predators and raise young. Song birds such as meadowlarks, red-winged blackbirds and sparrows will find suitable food and cover in clear-cut areas for many years. Hawks and owls will generally thrive on the abundance of small rodents in recently clear-cut areas.

Areas 4 and 7 are the areas of main interest in determining the impacts of timber harvesting since they have been selectively cut at different times of the year. As has already been stated, Area 4 is also a "test" site as it is located in close proximity to the construction area for the nuclear power plant. No striking differences are apparent between these two sites in either density (Figure 3.2.1) or diversity (Figure 3.2.2) of birds besides the fact of the high density in the winter survey in Area 7 which has already been discussed. It is perhaps important to note that both density and diversity of avian populations have increased on both sites from fall 1973 to fall 1974. This may be partially due to selective harvesting, allowing the areas to be used by more avian species.

Timber harvesting may also affect the occurrence of waterfowl in the Broad River Area. The monitoring potentials of the waterfowl survey are very important and must not be overlooked. Once any large-scale timber harvest has occurred along the shore of the Parr Reservoir there will be substantial changes in the habitat which will especially affect shorebirds. Once the proposed pumped-storage facility has been established, there will be a great increase in aquatic habitat due to the formation of the Monticello Impoundment as the upper reservoir and the enlargement of the Parr Reservoir as the lower reservoir. The waterfowl survey will again be important in determining what impacts these changes will have on waterfowl in this area.

3.2.4.2 Effect of Construction Activities

The act of clearing and preparing land for the construction of something as large as a nuclear power plant has quite a disruptive impact on the affected area. Generally all vegetation is removed, thus totally eliminating the existing habitats. Giant earth-moving equipment is employed to prepare the area for the different facilities to be constructed. This, together with the noise and activity associated with actual construction, will quite effectively expel all wildlife species from the area. Many of the more mobile individuals will leave the area entirely while others will move into adjacent habitats where they may find it difficult to compete with already established populations. Once the power plant is completed, there may be new habitats available to animals. Usually lawns and cleared areas are planted with grasses and maintained for appearance and security. Many seed-eating avian species will find this type habitat attractive. Transmission line corridors are a necessary addition to the area surrounding a power plant and these are usually kept in a constant state of early succession by mowing and spraying with herbicides. These corridors provide a tremendous amount of "edge" which is useful to a great many avian species. "Edge" is the habitat at the point where two habitats join. An example would be a transmission line corridor passing through a forested area. The forested area would provide food according to the plants present and would also provide cover from predators while the various grasses and forbs in the corridor would provide additional sources of food and open areas essential for the reproduction of many ground nesting birds. Thus the "edge" is the best part of two habitats.

When a disruptive force such as construction activity is introduced into an area, the usual result is a decline in avian density and diversity in adjacent areas. In studying Figure 3.2.1, it is apparent that the density of birds in the pine "test" site which is very near the construction area declined in comparison to the "control" pine site. A definite decline is noted in fall of 1974 where there were 1.95 birds per acre on the "control" site but only 0.5 on the "test" site. A similar decline was apparent in the diversity (Figure 3.2.2) where the number of species present was seven on the "control" site and three on the "test" site. The numbers of species were very similar during all other seasons. Apparently an increase in construction activity during 1974 resulted in a decline of avian populations in the immediate area.

A decline in avian density and diversity is also apparent in the deciduous "test" site (5C). A distinct decline is noted in the summer 1974 survey where the "test" site had 1.5 birds per acre, while the "control" site (1B) had 4.4 birds per acre (Figure 3.2.1). A few months previous to this survey, the "test" site had twice as many birds per acre as the "control" site (4.4 and 2.2 birds per acre, respectively). A similar decline is noted in the diversity during this period (Figure 3.2.2). The "test" site had six species present while the "control" site had 15. The diversity of both the "test" and "control" sites declined in the fall survey, but the "test" site's avian density rose slightly during this period. It is quite likely that construction activity in the area of the "test" site caused the decline in avian density and diversity during the summer of 1974.

3.2.4.3 Effects of Other Environmental Factors

There are many factors which may influence avian populations in an area. The weather has a great effect on bird movement. Generally, more birds will be active on warm, sunny days than on cold, overcast days. A weather front moving through an area will also affect movement as birds usually do not move great distances in the presence of a low pressure area which may herald storm conditions. Migrating birds have been known to move with passing frontal conditions, i.e., thrushes are especially prone to move ahead of cold fronts when migrating south.

Changes in availability of food can influence avian populations inhabiting an area. If a fire sweeps through an area and kills all the understory hardwoods, if there is too much or too little rainfall, or if there is an early frost, it is likely there will be a lack of food for certain species of birds. These species will have to leave the deficient area and find food in another region. This may require moving many miles in search of food and may result in an abnormal number of birds congregating in an area of abundant food supply.

This discussion points out only a few environmental factors which have to be considered in determing causes of changes in avian populations. There are a multitude of additional factors which have not been discussed that are carefully considered before pinpointing any one factor or group of factors as the cause of any fluctuation in avian density or diversity at a site.

3.2.5 SUMMARY

The purpose of this study has been to determine what impacts the establishment of a nuclear power plant and a pumped-storage facility have had on the area surrounding the Broad River and Parr Reservoir area. Results show there has been a decline in numbers and number of species of birds in both pine and deciduous habitats near the construction site for the nuclear power plant. The density and diversity of birds in a selectively cut pine area near the construction site did not vary noticeably from a similar site located away from the activity. A large increase in bird density was noted in the latter site after the area had been selectively cut. This change was apparently due to new habitat made available by the selective harvest.

In order to better understand the changes that will be taking place in this area as construction of the power plant facilities proceeds, it will be necessary to continue the present studies and to re-establish the auto census at a time when the preparation of the Monticello Impoundment (upper reservoir) has reached a more advanced stage.

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APPENDIX 2D

REPORT - BIOLOGICAL ASSESSMENT
PROPOSED DREDGE DISPOSAL AREA
FAIRFIELD PUMPED STORAGE PROJECT
FAIRFIELD COUNTY, SOUTH CAROLINA
FOR SOUTH CAROLINA ELECTRIC & GAS COMPANY

Dames & Moore
Project No. 5182-066-09

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DESCRIPTION OF THE PROPOSED PROJECT

A. Introduction

The purpose of this report is to provide a general overall description of South Carolina Electric & Gas Company's Parr Hydroelectric Project and comprehensive environmental information that is specific for dredge disposal locations that are components of the Fairfield Pumped Storage Facility. Fairfield Pumped Storage Facility is a part of the Parr Hydroelectric Project and is presently being constructed by South Carolina Electric & Gas Company (SCE&G). The information included within this report supplements the Dredging and Disposal Permit Request submitted by South Carolina Electric & Gas Company to the Charleston District Corps of Engineers in correspondence dated October 24, 1975.

Emphasis has been placed in this report on the dredge disposal areas required for dredging excavation of the 3800 foot tailrace canal that will connect the new 480 MW Fairfield Pumped Storage Powerhouse, presently being constructed, with the existing Parr Reservoir. With respect to the planned dredging and disposal areas, this report provides information concerning the following environmental considerations:

1. Present environmental setting
2. Environmental impact of the proposed activity
3. Alternatives to the proposed activity
4. Any adverse environmental effects of the proposed activity and measures to avoid or mitigate damage during depositing from dredging activity.
5. The relationship between local short term uses of man's environment and the maintenance and enhancement of long term productivity.
6. Any irreversible and irretrievable commitments of resources which would be involved in the proposed activity should it be implemented.

B. Overview

The Parr Hydroelectric Project that is presently being constructed is located in Fairfield and Newberry Counties, South Carolina, about 26 miles northwest of Columbia as shown on Figures 1 and 2. The site is along the Broad River near Parr, South Carolina, where South Carolina Electric and Gas Company presently owns and operates Parr Steam Plant, which is a fossil-fuel steam electric generating plant; Parr Gas Turbines, which are oil or gas fired electric generating gas turbines; and Parr Hydroelectric, which is a water powered turbine plant receiving water from Parr Reservoir.

The existing and new SCE&G owned facilities that are presently being extensively modified or constructed include the existing Parr Reservoir Dam, Parr Reservoir, Fairfield Pumped Storage Powerhouse Tailrace, Fairfield Pumped Storage Powerhouse, and Monticello Reservoir. The V. C. Summer Nuclear Station is being constructed near the Monticello Reservoir.

The Parr Reservoir Dam is a concrete overflow type that extends 2000 feet across the Broad River. The original concrete dam was approximately 35 feet high with a crest elevation of 257 MSL. During periods when the incoming Broad River flow exceeded 6000 CFS (496 acre feet per hour), which is the amount that can be passed through the Parr Hydroelectric Plant Turbines, water flowed over the top of the original dam. This dam is presently being raised by installing spillway crest gates that are hinged across the entire 2000 foot crest. With the new gates in a raised position, water will be impounded to elevation 266 MSL. When the gates are in the lowered position, the crest will again be 257 MSL. The normal position of the gates will be in the up position.

Parr Reservoir at elevation 257 has a surface area of approximately 1850 acres and extends approximately 8-1/2 miles upstream. With the previously mentioned gates in the raised position, an additional area of approximately 2550 acres will be flooded and the reservoir will extend approximately 13 miles upstream. The water storage capacity of Parr Reservoir will be increased approximately 29,000 acre feet.

The increased storage capacity of Parr Reservoir is required in order to provide the lower pool storage for the new 480 MW Fairfield Pumped Storage Facility. This facility is being constructed several miles upstream from Parr Dam as shown on Figure 3.

The purpose of the new Fairfield Pumped Storage Facility is to provide economical peaking power. This is achieved by utilizing off peak generating power from the most economical steam power electric generating plants, normally during late evening and night, to pump water from the lower pool (Parr Reservoir) through the Fairfield Pumped Storage Powerhouse to the upper pool (Monticello Reservoir). During periods of high electric demand, normally from early morning to mid afternoon, water from the upper pool will flow back into the lower pool after passing through the Fairfield Pumped Storage Powerhouse generators.

The daily exchange of water will be 29,000 acre feet. The time required to pump all of the water from the lower to the upper pool will be approximately 10 hours. The average flow in the Broad River coming into Parr Reservoir is 496 acre feet each hour. In ten hours only 4960 acre feet would enter which would not be sufficient to satisfy the pumping requirements; hence, the need for the crest gates across the existing Parr Dam.

During the pumped modes of operation, the 29,000 acre feet of water will pass from Parr Reservoir to the Fairfield Powerhouse via the Tailrace canal and from the powerhouse through four 26-foot diameter penstocks up to the new 6800 acre Monticello Reservoir. The water will be stored in Monticello Reservoir until generation is required. The water level in Parr Reservoir will drop from 266 MSL to approximately 256 MSL during the pumping operation. The water level in Monticello Reservoir will increase from 420.5 MSL to 425 MSL during the pumping operation. During generation, the cycle is reversed with the water level in Parr returning to 266 MSL and the water level in Monticello dropping to 420.5 MSL.

During the pumping or generating modes of Fairfield Powerhouse, water will be exchanged via the Fairfield Tailrace Canal. The canal has been designed with a cross sectional area such that the velocity of the water flowing within the canal during pumping or generation will not cause erosion or scouring. The approximate 5500 foot long canal is 1125 feet wide and approximately 10 feet deep where it opens into Parr Reservoir, and 660 feet wide and 86 feet deep where it closes at the face of Fairfield Pumped Storage Powerhouse (see Figure 4).

The 76-acre surface area that will be dredged for Fairfield Tailrace is approximately 75 percent under water. The average water depth is approximately five feet.

The depth of dredging from the river bed to the powerhouse will be on a gradual slope starting at the river at Elevation 250 and increasing over the next 3800 feet to Elevation 232 to a point beneath the existing cofferdam. The area upstream and between the existing cofferdam to the powerhouse will be excavated in the dry by other means.

The material being excavated consists principally of soft brown inorganic silt with some sand. Construction of the tailrace will involve dredging approximately 1,500,000 cubic yards of this material.

The bottom substrate in the proposed dredge disposal area No. 1 as shown on Figure 4 is presently comprised almost entirely of silt and muck. This is a result of the silt laden inflow from the Broad River "dropping out" as it entered the lower velocity confines of Parr Reservoir. This mode of silt deposition will continue after the Fairfield Facility goes into operation; therefore, any effort to selectively dredge or to purposefully construct a sand-gravel top layer on the dredged material for certain species of nest building centrarchids will be futile.

The bottom substrate of disposal area 2 is generally cleared woodland. A small portion of this area presently contains the diverted Frees Creek. Upon closure of Monticello Reservoir Dam B near June of 1976, this flow will cease. During dredged material placement in area 2, the runoff will return to the tailrace area being excavated.

The embankment retaining dredged material in area 2 will be constructed to approximate elevation 276 MSL and will form part of the permanent tailrace canal embankment. The slope of the embankment will not be less than two to one and will be constructed of compacted earth fill. The slope facing the tailrace will be protected with riprap or by other means as required. Dredged material will be added to this area not to exceed Elevation 276 MSL at the embankment. The top of this embankment will be used as a permanent roadway for maintenance of the north side tailrace slope. Following dredged material placement and drying out, the area will be graded to drain and planted over with suitable ground cover as recommended by the U.S. Soil Conservation Service.

The dredged material embankment for area 1 will be constructed to approximate elevation 260 MSL and crowned to elevation 261 MSL.

The embankment parallel to the south side of the tailrace excavation will be constructed of compacted earth fill with a slope not less than two to one. This embankment will be protected with riprap or by other means as required to prevent erosion of the embankment. The top width will be limited to the minimum requirements of the contractor's equipment.

The remaining embankment enclosing area 1 will be constructed with a slope not less than two to one and will receive slope protection as required. The top width of the remaining embankment enclosing area 1 will be limited to the minimum requirements of the contractor's equipment and will be constructed of compacted fill.

During placement of dredged material in area 1, the runoff will return to Parr Reservoir after passing through a rock fill outfall located near the southern end of the disposal area.

The embankments of area 1 will not be maintained after operation of the project has begun with the exception of required maintenance to prevent erosion of the portion of the embankment parallel to the tailrace canal. The intent of the embankments of area 1 is to retain the dredged material during excavation of the tailrace and after operation has begun.

The Broad River upstream of Parr Reservoir has historically been recognized as carrying a large amount of suspended solids. This is primarily due to the fact that the watershed consists of very soluble soils. SCE&G estimates that the annual solids load of the Broad River passing through Parr Reservoir is in excess of 500,000 cubic yards annually.

As a result of the heavy solids load of Broad River, a large portion of the existing Parr Reservoir has silted up over the years to within a few feet of the original dam crest elevation of 257 MSL. The present silting condition appears to be near equilibrium.

SCE&G is aware that future silting of the enlarged Parr Reservoir may occur during the periods when the crest gates are up and that future maintenance dredging may be required. SCE&G is also aware that during the daily operations of the pumped storage facility that part of the solid load transported into Parr Reservoir by the incoming Broad River will be pumped up and into the Monticello Reservoir where settling out will occur; however, due to the 400,000 acre feet storage volume of Monticello this will not present a problem.

Due to the fact that the lower Parr Reservoir will likely experience high solids deposits, any effort to construct the dredged material embankments of area 1 to achieve an effective pool for maintaining or promoting aquatic development is not practical. The proposed embankments of area 1 will be constructed and maintained only to retain the dredged material.

C. Schedule of Dredging Operations

Dredging will commence in the fall of 1976. This will correspond to low water due to the traditional dry season, and the seasonal and cyclical activities of biological organisms which tend to be at their low point during this time of year.

ENVIRONMENTAL SETTING

The area of Parr Reservoir that will be affected by the proposed dredging operation is shown in Figure 4 as area 1. This area is located in the northern part of the reservoir about three miles upstream from Parr Dam. Area 3 (Figure 4) was also investigated as an alternate dredge disposal site in Parr Reservoir and, although this environmental description refers to area 1, the same information is applicable to area 3, due to the similarities of the areas.

The area in general is poor habitat for the aquatic resources due to the lack of vegetation, excessive turbidity and shallow water.

The shallow water is a result of natural causes and is due in part to the silt load that is carried by the Broad River and which is subsequently placed in these backwater areas. The excessive amounts of turbidity resulting from the silt load reduces light penetration, thereby eliminating, for the most part, the aquatic vegetation.

This part of the reservoir is not used to any extent by sport fishing enthusiasts since it is not very accessible by boat, and there is a general lack of sport fish present.

The description of the resources in the proposed dredge disposal area is based on sampling the benthic macroinvertebrates and summarizing data collected in previous years. These data include aquatic vegetation, fish and birds (waterfowl, wading and shore birds).

A. Fish

Fish are probably the most obvious component of the aquatic ecosystem. Thus it is important to know what species occur in the area and to understand certain aspects of their life history. The fisheries information is based on collections made by gill nets and electrofishing in the near vicinity of the proposed dredge disposal area (Transects A and A', Figure 5). These collections were made in June, 1971, and January, 1972; Table 1 summarizes the findings.

Species composition and relative abundance provide basic information about species diversity of the fish fauna and their numerical status in the fish community.

A total of 11 species of fish were collected during the two sampling periods. Gizzard shad was the most abundant species collected. Gizzard shad (24.5%), bluegill (19.6%), white crappie (14.7%), longnose gar (13.1%) and black crappie (9.8%) comprised about 82% of the fishes collected. Other species collected and listed in order of abundance include carp, redear sunfish, yellow bullhead, flat bullhead, channel catfish and largemouth bass.

The gizzard shad is ubiquitous throughout Parr Reservoir (Dames & Moore, 1974). This species is an important forage fish, forming an important link in the food chain of game fish and other piscivores. Because it has a high reproductive potential and rapid growth rate, this species tends to overpopulate some waters to the detriment of other fish populations. It is highly successful in Parr Reservoir because of its tolerance to excessive turbidity and waters supporting little or no vegetation and sparse benthic fauna. Food preference of the gizzard shad also favors its success in Parr Reservoir, since adults feed primarily on detritus (Hynes, 1972). Spawning of the gizzard shad occurs at temperatures of 64° to 75°F, and the eggs are scattered (Jester and Jensen, 1972).

The bluegill is also ubiquitous throughout Parr Reservoir, and was numerically the most abundant species collected in the baseline biotic survey (Dames & Moore, 1974). The bluegill is believed to be one of the primary sport fishes in the reservoir, and also is a major segment of the forage base. Bluegills spawn over an extended period of time, beginning when water temperatures reach 70°F and continuing until fall with the peak of spawning activity being in May. Bluegills forage on zooplankton and small insects.

The white crappie is also found throughout Parr Reservoir, and was numerically the third most abundant species collected in the baseline survey (Dames & Moore, 1974). The white crappie is considered to be an important segment of the sport fishery in Parr Reservoir. White crappie usually spawn from May through June, when water temperatures are from 64° to 68°F, and they spawn under a variety of conditions of bottom, water depth and vegetation. White crappie feed on zooplankton when they are small and insects when they are larger.

The longnose gar was collected throughout Parr Reservoir during the baseline biotic survey (Dames & Moore, 1974). This species is not considered a sport fish in Parr Reservoir. Larval and fingerling size gar feed on insect larvae, but adults feed almost exclusively on fish. Spawning occurs from late April throughout June.

The black crappie also occurs throughout the reservoir (Dames & Moore, 1974). This species follows the same pattern as the white crappie in spawning and feeding habits. The black crappie is less abundant than the white crappie, but is considered an important segment of the sport fishery and also contributes to the forage base.

The other species were collected in fewer numbers in the disposal area, but were found throughout the reservoir during the baseline biotic survey. These are all considered to be a segment of the sport fishery. In the baseline biotic survey, they were ranked in overall abundance as follows: redear sunfish - fourth, largemouth bass - fifth, carp - seventh, flat bullhead - eighth, channel catfish - twelfth, and yellow bullhead - twenty-two.

The data provided here generally indicates that the proposed dredge disposal area is not utilized to a great extent by the fish species that exist in Parr Reservoir and may be considered as an undesirable fish habitat for the following reasons: excessive turbidity, shallow water, and lack of aquatic vegetation. Excessive turbidity, which reduces light penetration in the water, thus reducing photosynthesis, tends to make the area an undesirable habitat. Only the more turbidity-tolerant species such as gizzard shad, longnose gar and some of the other species will inhabit the area.

There is a lack of aquatic vegetation in the proposed dredge disposal area. Table 4 shows the aquatic vegetation that is present in the Broad River and Parr Reservoir, and it should be pointed out that very few or none of the species exist in the proposed dredge disposal area. With the lack of vegetation, the area is undesirable for fish species to spawn and/or to forage in the area.

At times the water in the proposed dredge disposal area is very shallow and the area is almost dewatered due to natural causes. The depth of water is indicated in Table 2. This type of habitat is undesirable for fish since they may be subject to rapid and drastic changes caused by air temperature fluctuation.

In summary, 11 species of fish representing five families were collected in previous years from the proposed dredge spoil receiving area. This area is not deemed important for fish species due to excessive turbidity, lack of aquatic vegetation, and shallow water.

B. Benthic Macroinvertebrates

Benthic macroinvertebrates were sampled quantitatively in the dredge disposal area in February, 1976, with a 6-inch square Ekman dredge at three points from Stations 1 through 8 (Figure 6). At each station, point A was located approximately 40 feet from the north bank, point B was located approximately mid-distance between the north bank and the island, and point C was located approximately 40 feet from the island. The samples were washed in a U. S. Standard No. 30 wire mesh sieve. The organisms collected were preserved in formalin and identified in the laboratory.

In addition, since water quality can influence species composition or diversity of biota and can determine to some degree the population densities of specific organisms, a basic knowledge of physical and chemical characteristics is fundamental to a study of the benthic macroinvertebrates in the dredge spoil area.

Thus, selected physical and chemical parameters were measured at mid-water depth at each sampling point along the stations; these include *in situ* measurements of dissolved oxygen, temperature and conductivity. In addition, one water sample from each station was taken to the laboratory to determine the pH.

The results of all physical and chemical parameters, including a description of the benthic area, is presented in Table 2.

Benthic macroinvertebrates are important biological indicators of conditions within an aquatic system. Their analysis is fundamental to the examination of trophic relationships and the understanding of the aquatic system.

A total of 22 species representing 10 families of macroinvertebrates were collected in the proposed dredge disposal area (Table 3). The species composition by major taxonomic group was as follows: Diptera, 12; Annelida, 5; Mollusca, 2; Ephemeroptera, 1: Trichoptera, 1: Megaloptera, 1.

The insect species found in this survey that are considered ubiquitous to Parr Reservoir include: Diptera, (Chironomidae); Ablabesmyia sp.; Chironomus spp.; Coelotanypus sp.; Cryptochironomus sp.; Procladius sp.; Tanytarsus sp.; (Culicidae) Chaoborus punctipennis; Ephemeroptera, (Ephemeridae) Hexagenia limbata; and Megaloptera (Sialidae) Sialis sp. (Table 3). These species were found to be abundant in the biological surveys conducted in previous years (Dames & Moore, 1974).

The most abundant species collected in our samples were the Chironomidae, and they represented 44 percent of the benthic macroinvertebrates in the proposed dredge disposal area.

The next most abundant group of species were the Annelida, and they represented 35 percent of the total benthic fauna collected. The third most abundant species were the Ephemeroptera, and they represented about 18 percent of the total benthic fauna collected. Thus, as a whole, the three groups mentioned above accounted for 97 percent of the benthic fauna collected.

The density of organisms between sampling stations ranged from 472 at Station 1 to 1,528 at Station 6.

The index of diversity shows the similarity of each station. The numbers indicate that these stations are quite similar in numbers of organisms.

Cryptochironomus sp., Chaoborus punctipennis, and Sialis sp. are provisionally classified as facultative organisms with wide ranges of tolerance to environmental conditions while Chironomus sp., Coelotanypus sp., and Procladius sp. are pollution tolerant (Mason, et al. 1971). Ablabesmia sp. and Hexagenia limbata are provisionally classified as pollution sensitive by the same authors. Tanytarsus sp. is also pollution sensitive according to Brinkhurst, et al. (1968). The insects found in the study area were predominantly facultative or pollution tolerant, with the exception of H. limbata, which was found in large numbers. Both Corbicula manilensis and Sphaerium sp. are facultative organisms tolerant of wide ranges in environmental conditions. On the basis of indicator species and diversity, it appears that the study area is receiving waters moderately organically enriched.

Turbidity, currents, substrate types, and deposition of silt are a few environmental factors that probably limit the insect diversity and density. These properties vary with location and tend to explain the differences in species composition and density among transects.

In summary, a total of 22 species of benthic macroinvertebrates were identified from the proposed dredge disposal area. Diptera, annelida and ephemeroptera were the most abundant species present.

Density ranged from 472/sq. meter at Station 1 to 1,528/sq. meter at Station 6.

The diversity index was comparable at each station.

C. Aquatic Vegetation

Aquatic vegetation plays an important role in an aquatic ecosystem since it is utilized by birds, fish and numerous invertebrates.

Specimens of emergent and submergent vegetation were identified. Emergent hydrophytes were defined as plants attached to the substrate and occurring on exposed or submerged soils. Submerged hydrophytes are plants attached to the substrate and occurring on submerged soils at all water depths. These plants are characterized by foliage that is completely submerged.

A total of 17 species of aquatic vegetation were identified growing in or near the proposed dredge disposal area (Table 4). Sixteen species were classified as emergent and one species was submergent.

Cattail (Typha latifolia) was the predominant emergent species occurring in dense colonies along the shoreline. Arrowhead (Sagittaria latifolia) also was dispersed throughout the area. Marsh willow (Salix nigra) was an important woody hydrophyte growing in shallow water and on moist banks.

The relative abundance of aquatic vegetation near the dredge disposal area was generally very limited.

Turbidity limits light penetration in the water, which is probably the limiting factor in the growth of submergent vegetation in Parr Reservoir.

In summary, seventeen species of aquatic vegetation have been observed growing in the near vicinity of the proposed dredge disposal area. Emergent types predominated in shallow waters along the shoreline and moist banks. Cattail was the most common species.

D. Waterfowl, Wading and Shore Birds

Fifteen species of waterfowl, wading and shore birds have been observed in the Frees Creek area during surveys over the past four years (Table 5). The area which was surveyed as Frees Creek includes all water bodies north and south of Frees Creek which occur to the west of the Broad River. This survey area includes all the area presently under consideration as disposal ground for dredged material. The Frees Creek area has been utilized primarily by dabbling ducks rather than by diving ducks. Dabblers prefer fairly shallow, protected areas where they feed near the surface and can easily reach aquatic and marsh plants, as well as mast-bearing upland plants. Divers such as ringnecks, redheads, scaup and bufflehead are more common in the reservoir area where they congregate into "rafts" and feed on aquatic plants and aquatic insects and crustaceans.

The wood duck is the only duck that is a year-round resident in this section of South Carolina. This duck utilizes bottomland hardwoods for breeding and brood rearing. Large hardwood trees provide nesting cavities while young trees and shrubs provide cover and food. Frees Creek was assessed during biological baseline studies in 1972 and 1973 and determined to be fair to good breeding habitat but poor brood rearing habitat. This is due to an acceptable number of nesting cavities and cover for adult birds but a general lack of sufficient ground cover and middle story vegetation to provide cover and food for young ducklings. Other creeks in the vicinity afforded better breeding and brood rearing habitat.

The anhinga, great blue heron, green heron and kingfisher are found along the shoreline of Frees Creek where they feed on fish, crayfish, and other crustaceans, amphibians and aquatic insects. Clearing activities associated with preparing Parr Reservoir for an increase in water level has removed all shoreline vegetation and thereby reduced the area's ability to support wading and shore birds.

Other shore birds found around Frees Creek are the killdeer, common snipe, spotted sandpiper and herring gull. The killdeer feeds almost entirely on insects which are found in recently disturbed fields and pastures. Killdeer have been observed only around Frees Creek and only since the summer of 1975 when clearing operations began exposing shore land. The common snipe frequents marshes covered with low vegetation where it feeds on insects, crustaceans, small fish and aquatic plants. The sandpiper is found in grassy marshes but feeds almost entirely on animal matter (crustaceans, insects, worms, and mollusks). The herring gull is only an occasional winter visitor to this part of the state and was observed feeding along the recently cleared shoreline of Frees Creek where it was probably scavenging for insects or plant material.

THE ENVIRONMENTAL IMPACT OF THE PROPOSED ACTIVITY

A. General

The Broad River carries a large amount of silt which is deposited in the upper reaches of Parr Reservoir. This turbidity reduces the overall productivity of Parr Reservoir since it reduces light penetration, thereby eliminating aquatic vegetation and plankton. Both of these are primary producers (aquatic vegetation is also a form of cover), which in turn build populations to support the higher forms of aquatic life such as the invertebrates and fish.

Water fluctuations in the reservoir will cause an impact on the resources. The water level rise in the reservoir will result in about 2,550 acres of new potential aquatic habitat, but this will probably not increase the overall biomass, since the water level fluctuation will influence the production of the primary producers (plankton) and the spawning characteristics of certain species of fish. The effects of water level fluctuations as well as the anticipated impact on specific components of the aquatic ecosystem are discussed in the following paragraphs.

B. Fish

At the proposed dredge disposal site, an impact to the fishery resources will occur by the actual placement of dredged material, thus taking this area out of production. This is considered to be minimal, representing only 7-1/2% of Parr Reservoir. The fluctuating water levels will tend to change the topography of the bottom conditions, especially those in the photic zone. This condition will reduce the spawning potential of the centrarchids. The centrarchids represent an important segment of the sport fishery in Parr Reservoir at the present time, and this will likely be reduced to some small degree.

The fluctuating water levels and concomitant increased turbidity will cause a greater sedimentation rate, thereby producing silt in the water column, which tends to block out light penetration in the photic zone.

In summary, the proposed dredging operations will remove a small part of Parr Reservoir from fishery production and, with fluctuating water levels during operation and concomitant turbidity, a predicted shift in the fish population from the centrarchid base to the more turbidity-tolerant species (which include gizzard shad, gar and carp) is likely to occur.

C. Benthic Macroinvertebrates

When the dredged material is deposited as planned, the benthic macroinvertebrate community will be covered up and it is unlikely that any organisms will be able to survive. This is the most apparent biological impact of the dredging process. Although this process probably does result in a large kill of the benthic organisms, the impact does not appear to be significant for localized dredging operations. Researchers have measured an immediate decrease in the benthic populations after dredging, but a fairly rapid repopulation did occur (Saila, et al. 1972). Slotta (1972) showed that former abundance levels of some species occurred within two weeks of deposition.

The ability of animals to withstand the adverse effects of burial in areas near the dredge site or in the disposal site depends primarily on their behavior and morphology. Some large species of pelecypods which can burrow have been shown to survive burial up to 21 cm of sediments (Saila, et al. 1972). On the other hand, sessile species are probably killed by burial of any magnitude (Saila, et al, 1972).

Other species required several years to occupy new habitat created by silt deposition. For example, Benson and Hudson (1975) reported that Hexagenia sp. population in a reservoir required 13 - 22 months to complete a single life cycle and required several years to fully occupy new habitat created by silt deposition. Fluctuation of water levels has an adverse effect on benthic organisms, and it has been shown that when drawdown in a reservoir does not occur, the abundance of benthic organisms may increase threefold in a short period of time.

The benthic macroinvertebrates in the proposed dredge disposal area of Parr Reservoir will be impacted severely at the outset. However, it would be expected that the more tolerant species such as Hexagenia, sp. and many members of the Chironomidae family will recolonize the area within a period of time. Moreover, the proposed dredge disposal area represents a small area compared to Parr Reservoir as a whole, and the macroinvertebrate species present are found throughout the reservoir.

D. Aquatic Vegetation

When dredged material is deposited as planned, all aquatic vegetation in the impacted area will be covered up. However, new colonization by some emergents is likely to occur near the shoreline. Fluctuating water levels and concomitant turbidity along with an unstable substrate are the main limiting factors for submergent vegetation in the proposed dredge disposal areas.

E. Waterfowl, Wading and Shore Birds

The impact on vegetation and other land alterations in the Frees Creek area has caused an apparent change in species utilizing this area. No ducks have been recorded during the past two surveys. Whereas wood ducks were almost always present in this area in the past, the low water conditions last summer and the removal of shoreline vegetation this past winter appears to have made this area unattractive to this species. The great blue heron and belted kingfisher have always inhabited this section of the river and are still present in somewhat reduced numbers, which is quite likely due to the removal of essential shoreline vegetation. There appears to be an increase in shore birds in this area. Ring-billed gulls have been observed on other sections of the river in the past, and the occurrence of the herring gull in Frees Creek is not particularly significant. The occurrence of killdeer and a snipe may have some significance as these species have not been observed in the Broad River study area in the past and are presently found only in the Frees Creek area. These species are frequently found on recently disturbed land near water, and the recently cleared land surrounding Frees Creek is now attractive habitat to these species.

Therefore, it would appear that alterations to this area through present clearing operations or by adding dredged material will tend to decrease the area's usage by ducks and wading birds but increase its importance to certain shore birds.

ADVERSE ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTIVITY AND MEASURES TO AVOID OR MITIGATE DAMAGE DURING DEPOSITING FROM DREDGING OPERATIONS

There will be some unavoidable adverse effects in the part of Parr Reservoir that will receive the dredged material. This area will be taken out of production for the aquatic resources, and will represent about 7½% of Parr Reservoir. This will reduce the carrying capacity and overall productivity of the reservoir.

The benthic macroinvertebrate community in the disposal area will be covered up, and it is unlikely that any organisms will survive.

The aquatic vegetation that is present in the area will be covered up, thereby reducing protective areas for any young fish which may exist and cover for any waterfowl and other birds. The habitat for fish species will be removed, thereby eliminating potential spawning areas and general habitat.

It should be pointed out that all of the adverse effects mentioned will be minimized to the extent feasible. Furthermore, programs are planned to monitor effects on the environment, and management of land resources to minimize and offset adverse impact and to improve existing conditions will be accomplished.

Monitoring programs have already begun. The purpose of the monitoring programs is to establish baseline conditions and site characteristics, and to monitor the baseline conditions during construction and operation of the facility in order to detect and take corrective measures against any unforeseen developments. In addition, the Land Management Program will utilize much of the data collected to assure that any adverse effects of construction and operation are minimized and that the natural environment is preserved and enhanced as much as is practicable.

The environmental monitoring programs of particular importance to the dredging activity include the hydrologic and biologic programs.

The hydrologic monitoring program includes surface water and groundwater physical and chemical measurements. The purposes of the water monitoring programs will be (1) to evaluate baseline physical and chemical characteristics of the Broad River and Frees Creek before and during construction, (2) to monitor the quality of water in Monticello and Parr Reservoirs and the Broad River after construction, (3) to compare the quality of water in the impoundment reservoir and river with applicable standards to assure compliance with the regulations, and (4) to provide data for an evaluation of the impact of the project on the aquatic biota.

A water quality monitoring program is being conducted at selected locations on Parr Reservoir at the present time and will also include Monticello Reservoir after it is impounded. Mitigating measures would be provided if adverse effects are noted during construction or operation of the facility. Sampling and scope of examination are done in accordance with Figure 7 and include measurements of dissolved oxygen, pH, conductivity, temperature profiles, carbon dioxide, total dissolved solids, total alkalinity, total hardness, chloride, sulfate, phosphate, nitrate, BOD, COD, heavy metals, silica, calcium, magnesium, sodium and turbidity.

At the continuous water quality monitoring station in the Broad River downstream of Parr Reservoir, continuous monitoring of dissolved oxygen, temperature, stream flow, conductivity and pH is being performed. Identical continuous monitoring is being performed at stations on the Enoree and Tyger Rivers and the upper reaches of Parr Reservoir on the Broad River. Thus, a continuous record of the basic parameters of water quality entering and leaving the area is being developed. The monitoring stations were constructed and equipped by SCE&G in cooperation with the USGS and each station automatically reports data to a USGS receiving station in Columbia, South Carolina, on each hour.

To assist personnel in the Columbia water treatment plant in the early detection of musty odors in Broad River waters, odor samples in the water quality monitoring program are being taken each day and if any musty odors are detected, the Columbia water treatment plant personnel will be notified.

The current groundwater monitoring program provides data on the physical and chemical properties of the groundwater in the site vicinity.

The biological monitoring program includes assessing the ecological impact of construction and operation of the facility. The program is designed to document the present biological conditions, provide a basis for selecting measures which could minimize any projected adverse effects and to evaluate the effects of construction and operation of the proposed facility on the biota. The program is being conducted in two phases -- pre-operational and operational. The objective of the pre-operational phase is to provide baseline information on the various aquatic and terrestrial biota in the site vicinity. The pre-operational aquatic and terrestrial monitoring programs commenced in the spring of 1971 and were completed in 1973. An ongoing program to evaluate the effects of construction is presently being conducted.

The aquatic program consists of sampling fish, benthic macroinvertebrates and plankton. Evaluations are planned regarding the construction and operational effects on these organisms. In the Land Management Plan feasibility studies are planned to include the potential to develop a sport fishery resource in the reservoirs.

The development of a fishing lake in the upper portion of the Monticello Reservoir, and in a 90-acre greentree reservoir to be constructed, is expected to provide a quality of sport fishing not presently found in Parr Reservoir.

At present, there is very little, if any, sport fishing in the area of the proposed dredge disposal area. The shallow water and obstructions found in the area make it undesirable for recreation; thus the loss of fishing recreation at the present time in Parr Reservoir will be more than offset by the proposed plans to include a stocked constant level 300-acre fishing lake at the upper end of Monticello Reservoir and other potential managed areas that will not be influenced significantly by the daily water fluctuation in Parr Reservoir.

The terrestrial program consists of habitat classification and wildlife surveys. The habitat classification consists of mapping the various vegetative types. Attention is being given to evaluation of any enhancement potential.

In summary, many of the adverse effects that may be associated with the proposed dredge and disposal operations will be minimized by the implementation of features in the Land Management Plan.

ALTERNATIVES TO THE PROPOSED ACTIVITY

Construction of the tailrace canal is essential to the operation of Fairfield Facility. Without the canal, the facility cannot operate.

The technique by which the tailrace canal is excavated and the areas on which the excavated material may be placed was examined by SCE&G.

The technique of excavating the tailrace canal by dredging was selected as being the most appropriate and the one that would require less utilization of irrecoverable resources. The details supporting this conclusion will not be included with this report owing to the objective of this report to address the location of dredge disposal areas.

The area surrounding the Fairfield Powerhouse and Tailrace is not one that offers abundant terrain suitable for utilization as a dredge disposal area. Ideally, the area should be lowlying and near the operating path of the dredge if economical dredging is to be achieved.

Dredge production (cubic yards per hour) is related to the barometric pressure, the discharge pressure and the conveying capacity.

The barometric pressure is not an item that can be manipulated in the Fairfield Tailrace; therefore, it will not be discussed.

The discharge pressure varies with the horizontal length of the discharge line, the straightness of the line and the vertical height to which the material must be pumped. As the discharge pressure is increased, the cubic yards per hour of production from the dredge is decreased. This is due to the fact that the maximum horsepower of the dredge pump is fixed, and therefore the cubic yards per hour of production must be decreased as the discharge pressure is increased or maintained by adding a booster pump into the discharge line.

The conveying capacity of the dredge varies with the velocity of the material being conveyed in the dredge discharge line. The discharge pressure influences the conveying capacity such that with a fixed length discharge line, an increase in pressure due to increased pump speed will increase the conveying capacity. With a fixed horsepower and pump speed increasing the length or elevating the point of discharge from the discharge line, will produce an increase in pressure, and a reduction of the conveying capacity will result.

Realizing the factors previously mentioned, the dredge areas 1 and 2 as shown on Figure 4 were selected for the Fairfield Tailrace excavation after considering the overall utilization of all resources and future requirements of the project.

Alternative disposal sites included the following:

a. Depositing part of the material into disposal area 3 as shown on Figure 4.

b. Depositing part of or the total amount of the material in disposal area 4 as shown on the attached Figure 4.

The storage capacity of each of these areas including areas 1 and 2 are as follows:

Area	Storage Capacity(c.y.)	Dredged Material Elevation	Acres
1	1,000,000	260	116.0
2	500,000	275	15.0
3	231,500	260	24.0
4	74,000	280	8.14
	400,000	290	40.0
	1,216,000	300	69.4
	2,500,000	310	98.7

Areas 1 and 3 are in the backwaters of Parr Reservoir (Broad River). They are shallow and are presently covered by silt and will continue to be covered by silt whether or not dredged material will be placed on them.

Area 2 is predominantly above water except for a construction drainage ditch transporting the diverted Frees Creek. After the closure is made on the Monticello Impoundment (Dam B), this area will be dry. The bottom substrate of this area is predominantly cleared woodland.

The tailrace embankment in this area will also serve as the disposal area embankment. The area behind this portion of the tailrace embankment must be filled in regardless of whether dredged material is added or not, and, due to this fact, this area was selected as a desirable disposal site. The capacity of this area is limited to 500,000 cubic yards of material at elevation 276 MSL. Upon completion of dredged material placement and after the dredged material has drained sufficiently to support equipment, this area will be graded to achieve permanent drainage and will be planted as recommended by the U.S. Soil Conservation Service.

Area 4 is predominantly above water except for a small wet weather stream. The bottom substrate is entirely cleared woodland. This area is presently diked off in the position shown in Figure 4. The embankment is compacted with earth fill and is approximately 40 feet wide at the top with slopes not exceeding two to one. The fill composing the embankment was originally placed as a haul road to accommodate earth moving operations and other construction activity associated with construction of the above water portions of the tailrace, relocation of a portion of a railroad paralleling the existing Parr Reservoir, and relocation of electrical transmission towers affected by the tailrace canal.

The selection of location for this haul road was with three purposes in mind. First, it provided an economical access route for the previously described construction activity; second, it would provide an available dredged material disposal area to accommodate possible over dredging required for initial construction of the tailrace, and third, it would provide a desirable disposal site for future maintenance dredging of the tailrace.

In the event that dredged material is deposited in this area, it will be dewatered, graded and planted with suitable ground coverage recommended by the U. S. Soil Conservation Service.

This area is not desirable for initial dredge disposal due to the elevation to which the dredged material must be pumped and the resulting requirement of a booster pump in series with the dredge pump. Use of area 4 for depositing the entire tailrace excavation will increase the cost of the tailrace dredge excavation by approximately $936,000. Additionally, since future maintenance dredging is anticipated, utilization of any part of the area will impair future operation of the project.

Area 3 was not considered as a desirable disposal area since it would require sound diking between the dredged material and tailrace and along the western edge adjacent to the Broad River. Area 1 will require similar diking, but the quantity per cubic yard of dredged material will be approximately one-half of that required for area 3.

Once the project goes into operation, areas 1 and 3 will be very undesirable for dredged material placement due to the daily varying water elevations. These areas must be used for initial placement of the tailrace excavation or they will be for all practical purposes lost. Not using these areas will not produce a long lasting environmental advantage. The areas presently offer poor substrates for development and nourishment of aquatic life and will continue to offer the same regardless of whether dredged material is placed in them or not.

Based on the above considerations, areas 1 and 2 were selected for receiving the initial tailrace excavation dredged materials and are the areas for which a permit has been requested.

THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The short-term use of the environment includes some disruptive measures to the natural features, including the removal of about 7½% of Parr Reservoir from production as a fishery resource and general aquatic habitat, and the reduction of waterfowl habitat.

The long-term benefits in human consideration would be the implementation of certain features in the proposed Land Management Plan for land and water resources. These would include an improved fishery resource and a potential for greater recreational facilities, and would represent an enhancement of long-term productivity.

ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED

Numerous resources will be utilized in the proposed dredging operation including land, water area, materials and supplies involved in the activity, human talent, skill and labor as well as capital. Some of these resource commitments are irreversible and irretrievable, such as construction materials and supplies.

Other resource commitments are temporary, such as the use of the dredge disposal area. When the lifetime of the project is completed, it would be possible to remove the deposited material from the disposal area and return it to its original position. Essentially this would return the area to its original condition; however, it is unlikely that this would be done. Thus, the elimination of a small part of Parr Reservoir will represent an irretrievable commitment of resources.

TABLE 1: Species composition and relative abundance of fishes collected near the Dredge Disposal Area in June, 1971, and January, 1972.

Family Common Name	Scientific Name	1971		1972	
		No.	%	No.	%
Lepisosteidae					
Longnose gar	*Lepisosteus osseus*	8	16.7	--	--
Clupeidae					
Gizzard shad	*Dorosoma cepedianum*	14	29.1	1	7.7
Cyprinidae					
Carp	*Cyprinus carpio*	--	--	1	7.7
Ictaluridae					
Yellow bullhead	*Ictalurus natalis*	3	6.3	--	--
Flat bullhead	*Ictalurus platycephalus*	--	--	1	7.7
Channel catfish	*Ictalurus punctatus*	--	--	1	7.7
Centrarchidae					
White crappie	*Pomoxis annularis*	7	14.5	2	15.4
Black crappie	*Pomoxis nigromaculatus*	6	12.5	--	--
Bluegill	*Lepomis macrochirus*	6	12.5	6	46.0
Redear	*Lepomis microlophus*	3	6.3	1	7.7
Largemouth bass	*Micropterus salmoides*	1	2.1	--	--
	TOTALS	48	100.0	13	100.0

TABLE 2: Physical and chemical parameters taken at collecting stations in the Dredge Disposal Area of Parr Reservoir

	Collecting Stations							
	1	2	3	4	5	6	7	8
Temperature(°C)	17	16.5	17.7	16.8	16.5	16.2	19	17.3
Dissolved oxygen (ppm)	9.7	8.9	9.6	9.7	9.8	9.8	9.3	9.6
Specific conductance (umho)	77	75	70	65	61	56	73	73
pH (pH units)	6.5	6.7	6.9	6.9	7.1	7.1	6.4	6.5
Depth (inches)	16 - 32	12 - 38	12 - 25	21 - 27	24 - 33	15 - 18	18 - 34	20 - 36
Substrate	Silt	Silt	Silt	Silt	Silt, sand	Sand, gravel	Silt	Silt

TABLE 3: Density and species composition of benthic macroinvertebrates collected February 16-17, 1976 on the Broad River Study Area.

Taxa	Stations							
	1	2	3	4	5	6	7	8
Insecta								
Ephemeroptera								
Ephemeridae								
Hexagenia limbata	114	71	314	271	314	343	-	-
Trichoptera								
Psycomyiidae								
Lype sp.	-	14	-	-	-	-	-	-
Megaloptera								
Sialidae								
Sialis sp.	-	-	-	-	-	-	14	-
Diptera								
Culicidae								
Chaoborus punctipennis	14	71	14	29	-	-	143	100
Ceratopogonidae								
Palpomyia sp.	29	-	14	14	-	-	-	43
Chironomidae								
Ablabesmyia sp.	29	14	14	-	29	29	-	-
Chironomus anthracinus type	57	214	86	43	-	-	57	-
Chironomus plumosus type	-	-	14	-	-	-	-	-
Coelotanypus sp.	86	86	57	114	57	-	429	457
Cryptochironomus sp.	14	29	14	-	-	-	-	14
Dicrotendipes sp.	14	-	-	-	-	-	-	-
Glyptotendipes sp.	-	-	-	-	-	-	100	586
Procladius sp.	-	14	14	14	-	14	-	43
Tanypus sp.	-	14	-	-	29	-	-	-
Tanytarsus sp.	-	14	-	-	-	14	57	14
Mollusca								
Pelecypoda								
Corbiculidae								
Corbicula manilensis	29	29	14	29	14	114	-	-
Sphaeriidae								
Sphaerium sp.	-	-	-	-	14	-	14	-

TABLE 3 (Continued)

Taxa	Stations 1	2	3	4	5	6	7	8
Annelida								
Oligochaeta								
Naididae								
Naidium breviseta	-	14	29	29	29	-	71	-
Tubificidae								
Aulodrilus sp.	-	-	-	-	-	71	-	-
Branchiura sowerbyi	-	186	-	629	114	757	-	-
Limnodrilus hoffmeisteri	-	-	14	114	86	129	-	-
Potamothrix vejdovskyi	86	-	-	186	114	57	-	-
Total/m^2	472	770	598	1472	800	1528	885	1257
Diversity indices ($\bar{d}$)	2.95	2.99	2.45	2.53	2.67	2.18	2.28	1.81

TABLE 4: Aquatic vegetation found during a shoreline survey of the Broad River Study Area

*Family Scientific Name Common Name	Growth Form	Location
Typhaceae		
Typha sp.		
Cattail	Emergent	Broad River
Najadaceae		
Potamogeton foliosus		
Leafy pondweed	Submergent	Broad River
Alismataceae		
Sagittaria latifolia		
Arrowhead	Emergent	Broad River
Cyperaceae		
Carex lupulina		
Hop sedge	Emergent	Broad River
Cyperus sp.		
Sedge	Emergent	Broad River
Scirpus sp.		
Bulrush	Emergent	Broad River
Cyperus acuminatus		
Sedge	Emergent	Frees Creek
Rhynchospora sp.		
Beak rush	Emergent	Frees Creek
Scirpus cyperinus		
Wool grass	Emergent	Frees Creek
Gramineae		
Agrostis stolonifera		
Bent grass	Emergent	Broad River
Juncaceae		
Juncus effusus		
Soft rush	Emergent	Broad River
Juncus pelocarpus		
Bog rush	Emergent	Broad River
Saururaceae		
Saururus cernuus		
Water-dragon	Emergent	Frees Creek
Salicaceae		
Salix nigra		
Marsh willow	Emergent	Broad River Frees Creek
Polygonaceae		
Polygonum sp.		
Smartweed	Emergent	Broad River

TABLE 4 Continued:

*Family Scientific Name Common Name	Growth Form	Location
Umbelliferae		
Hydrocotyle umbellata		
Water pennywort	Emergent	Frees Creek
Acanthaceae		
Dianthera americana		
Water willow	Emergent	Frees Creek

TABLE 5: Waterfowl, wading and shore birds observed on Frees Creek, S. C.

	1972		1973			1974		1975		1976
	Spr	Fall	Spr	Sum	Fall	Win	Sum	Win	Sum	Win
Pied-billed Grebe	-	1	-	-	-	-	-	-	-	-
Anhinga	-	-	-	-	-	-	-	1	-	-
Great Blue Heron	4	12	5	1	2	3	4	6	2	1
Green Heron	-	-	-	6	3	-	3	-	-	-
Mallard	2	-	14	2	-	-	10	20	-	-
Black Duck	7	12	-	-	-	-	-	41	-	-
Pintail	-	-	1	-	-	-	-	-	-	-
Wood Duck	-	28	13	4	6	-	16	5	-	-
Ring-necked Duck	-	-	-	-	-	2	-	-	-	-
Ruddy Duck	-	6	-	-	-	-	-	-	-	-
Killdeer	-	-	-	-	-	-	-	-	2	3
Common Snipe	-	-	-	-	-	-	-	-	-	1
Spotted Sandpiper	-	-	-	-	4	-	-	-	-	-
Herring Gull	-	-	-	-	-	-	-	-	-	1
Belted Kingfisher	-	3	2	4	3	4	4	2	-	1
Total No. of Individuals	13	62	35	17	18	9	37	75	4	7
Total No. of Species	3	6	5	5	5	3	5	6	2	5

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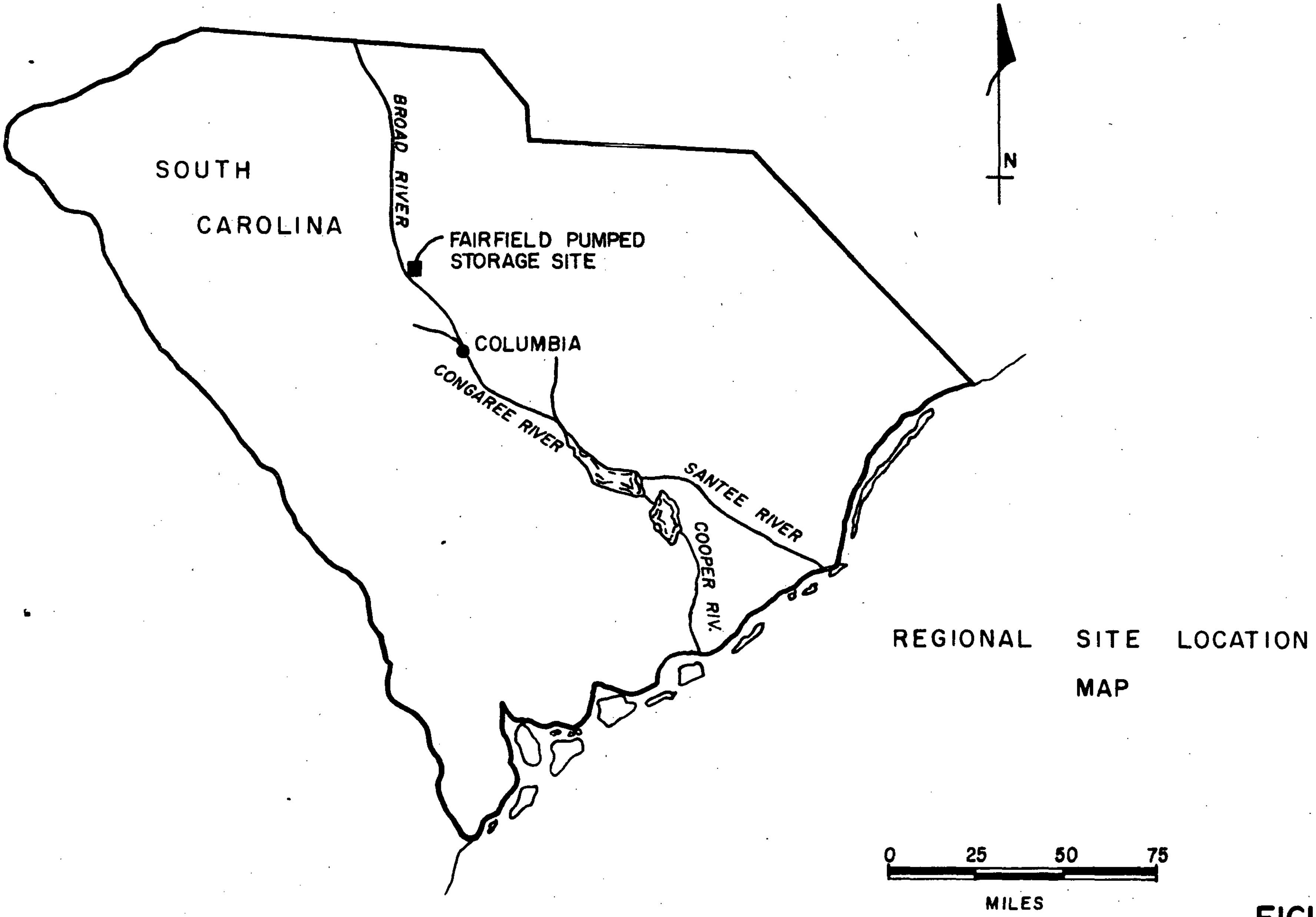
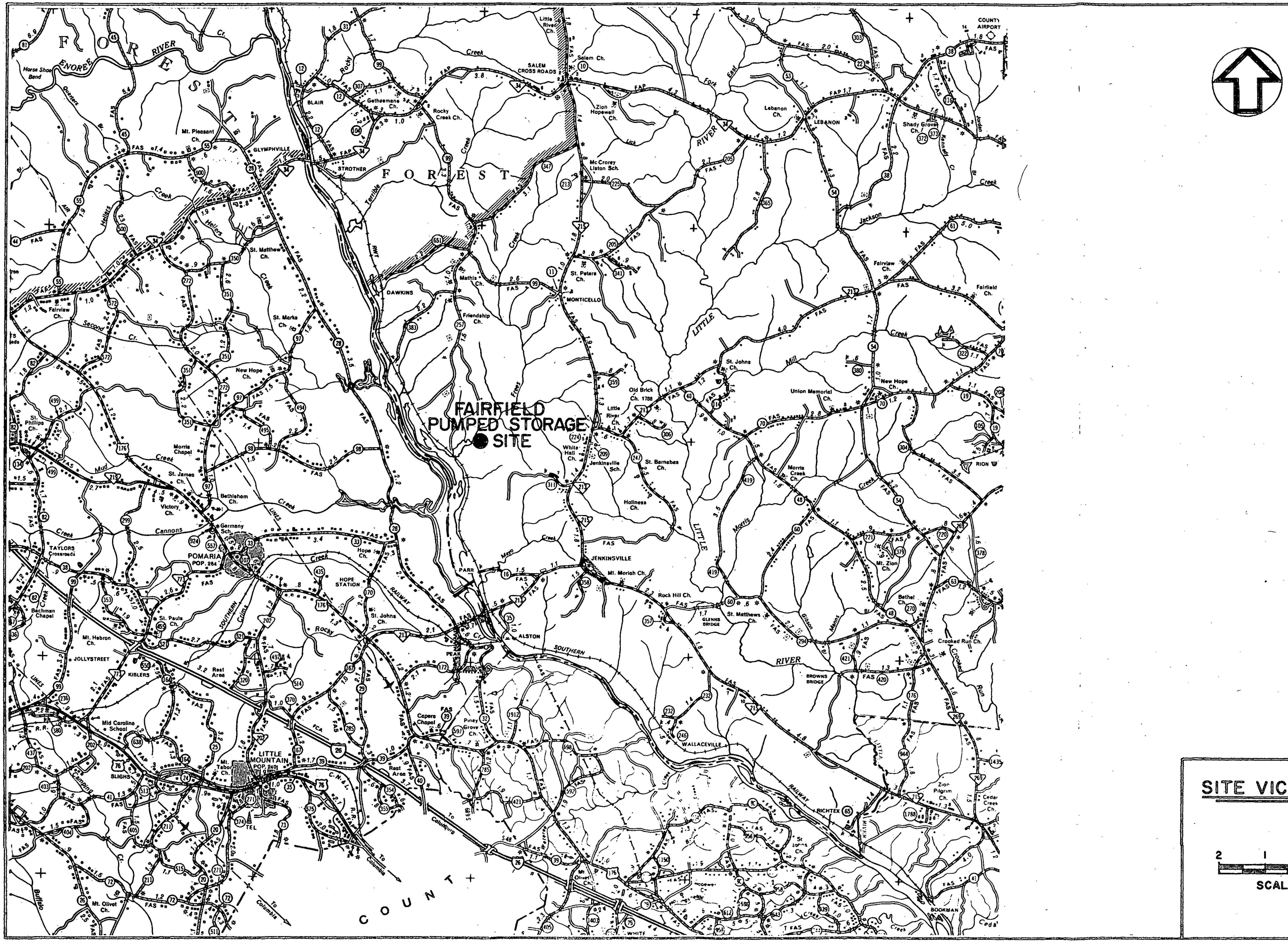


REGIONAL SITE LOCATION MAP

FIGURE I.

4-2-76

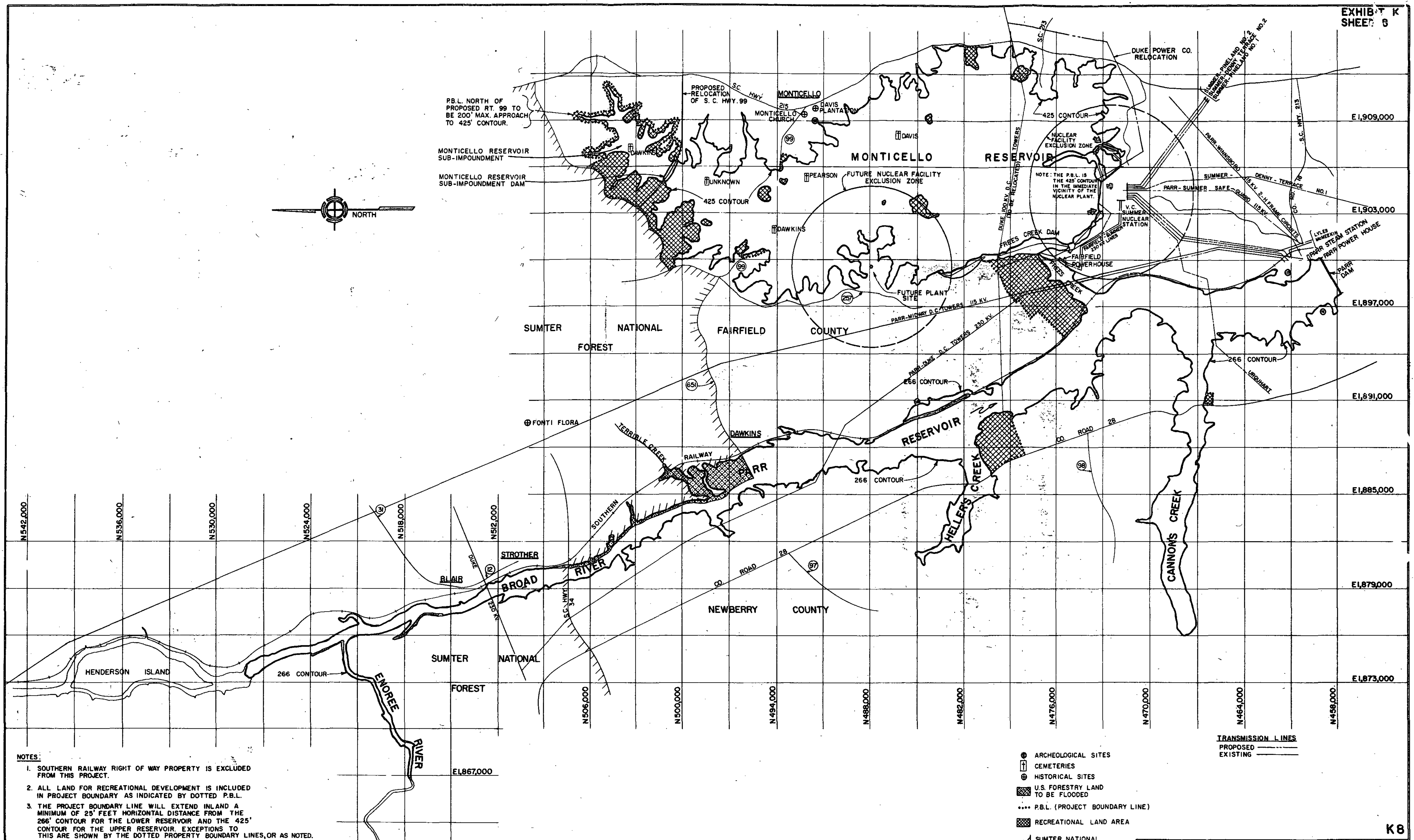


SITE VICINITY MAP

FIGURE 2

APRIL 1976

EXHIBIT K
SHEET 8



NOTES:

1. SOUTHERN RAILWAY RIGHT OF WAY PROPERTY IS EXCLUDED FROM THIS PROJECT.
2. ALL LAND FOR RECREATIONAL DEVELOPMENT IS INCLUDED IN PROJECT BOUNDARY AS INDICATED BY DOTTED P.B.L.
3. THE PROJECT BOUNDARY LINE WILL EXTEND INLAND A MINIMUM OF 25' FEET HORIZONTAL DISTANCE FROM THE 266' CONTOUR FOR THE LOWER RESERVOIR AND THE 425' CONTOUR FOR THE UPPER RESERVOIR. EXCEPTIONS TO THIS ARE SHOWN BY THE DOTTED PROPERTY BOUNDARY LINES, OR AS NOTED.
4. CO-ORDINATES SHOWN ARE BASED ON STATE GRID SYSTEM.
5. ELEVATIONS SHOWN ARE CORRECTED ACCORDING TO RECENT SURVEY BASED ON U.S.C. & G.S. DATUM (M.S.L.)

- ⊛ ARCHEOLOGICAL SITES
- † CEMETERIES
- ⊕ HISTORICAL SITES
- ▨ U.S. FORESTRY LAND TO BE FLOODED
- •••• P.B.L. (PROJECT BOUNDARY LINE)
- ▨ RECREATIONAL LAND AREA
- ⫽ SUMTER NATIONAL FOREST BOUNDARY

TRANSMISSION LINES
PROPOSED —·—·—
EXISTING ————

K8

GENERAL MAP OF PROJECT AREA
SHEET 8 OF 8
PARR HYDROELECTRIC PROJECT NO. 1894
SOUTH CAROLINA ELECTRIC & GAS COMPANY

SCALE: 1" = 2500'
0 2500 15,000

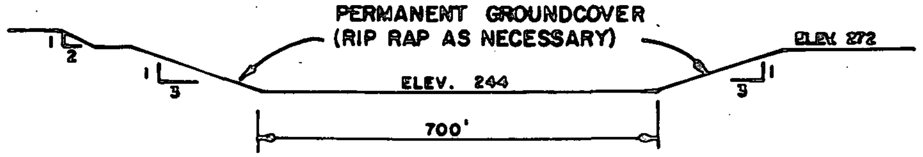
THIS DRAWING IS APPROVED AS CORRECTED, AS A PART OF THE AMENDED APPLICATION FOR A NEW LICENSE FOR PROJECT NO. 1894 MADE BY THE UNDERSIGNED THIS 17th DAY OF JULY, 1972.

SOUTH CAROLINA ELECTRIC AND GAS COMPANY
BY V. C. Summer
SENIOR VICE-PRESIDENT

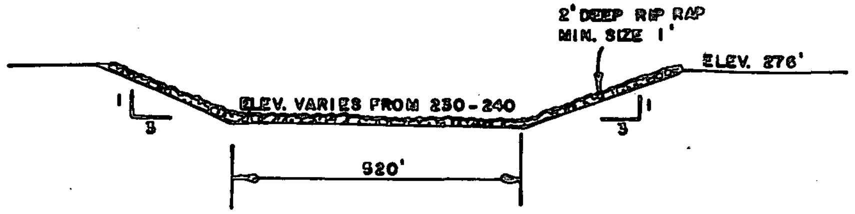
THIS DRAWING IS A PART OF THE AMENDED APPLICATION FOR A NEW LICENSE FOR PROJECT NO. 1894 MADE BY THE UNDERSIGNED THIS 22ND DAY OF FEBRUARY 1972

SOUTH CAROLINA ELECTRIC AND GAS COMPANY
BY V. C. Summer
SENIOR VICE-PRESIDENT

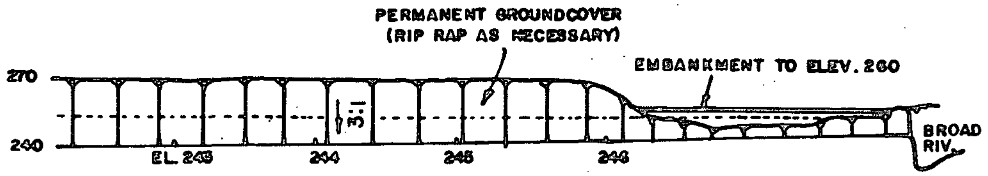
FIGURE 3
APRIL 1976



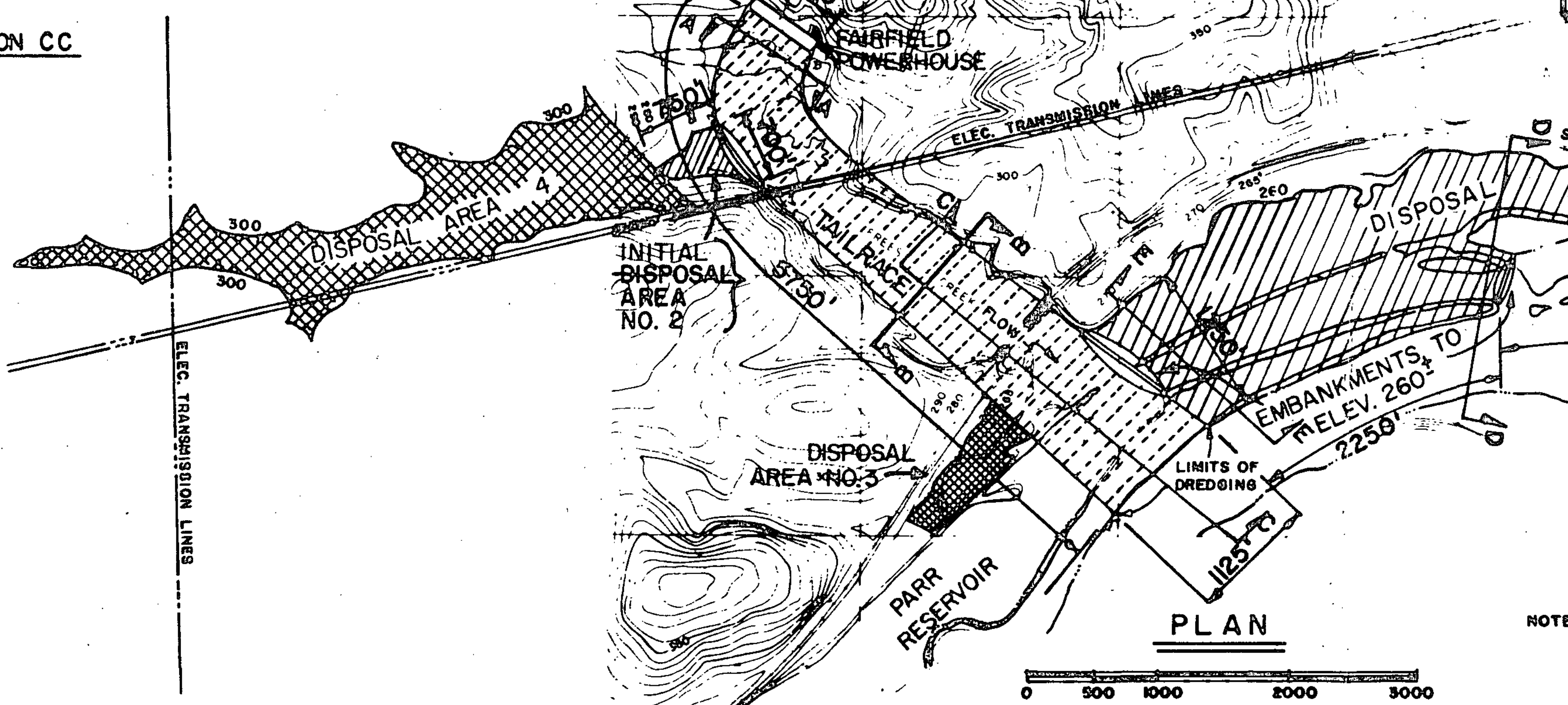
SECTION BB



SECTION AA

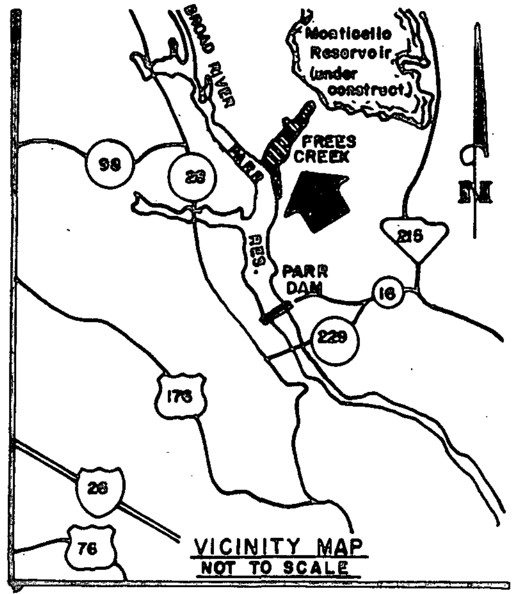


SECTION CC

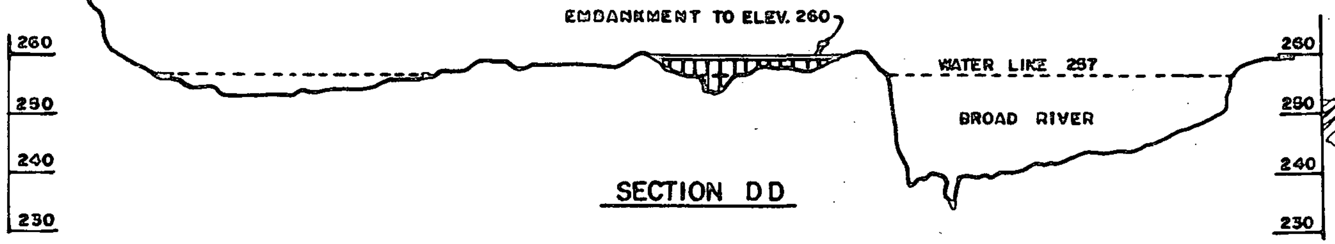


PLAN

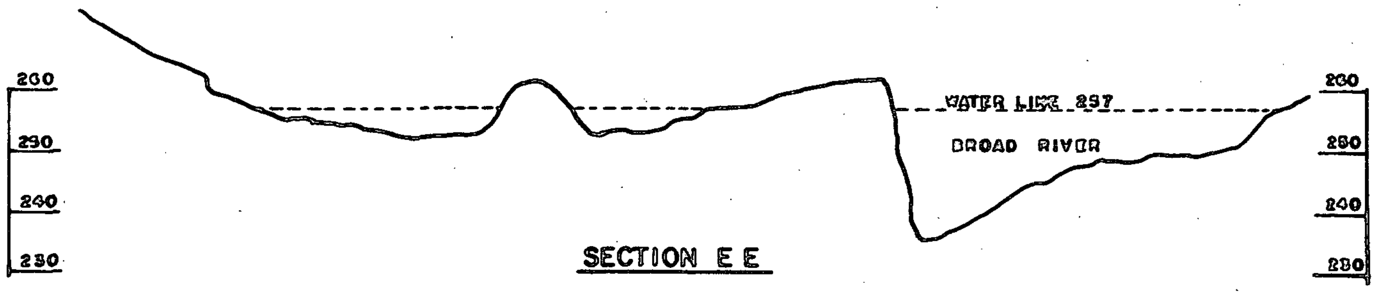
NOTE: APPROXIMATELY 1,500,000 CUBIC YARDS OF SOLID MATERIALS TO BE DREDGED BY DREDGING MACHINE ON BARGE AND DEPOSITED AT DISPOSAL AREAS NO. 1 AND NO. 2.



VICINITY MAP
NOT TO SCALE



SECTION DD



SECTION EE

PURPOSE: Dredge Tailrace Canal From Pumped Storage Facility To Broad River.
DATUM: Mean Sea Level

NAME AND ADDRESS OF ADJACENT PROPERTY OWNERS

1- South Carolina Electric & Gas Co.
P.O. Box 764, Columbia, S.C. 29218
Owns all adjoining property with the exception of that listed below.

2- Southern Railway Co.
1770 Andrews Rd.
Columbia, S.C. 29201
Owns right-of-way for existing railroad trestle.

PROPOSED DREDGING & DISPOSAL
IN: FREES CREEK & BROAD RIVER
AT: NEAR JENKINSVILLE, NORTH OF PARR DAM
COUNTY OF: FAIRFIELD STATE: S.C.
APPLICATION BY:
SOUTH CAROLINA ELECTRIC & GAS CO.

FIGURE - 4

DATE: MARCH 26, 1976

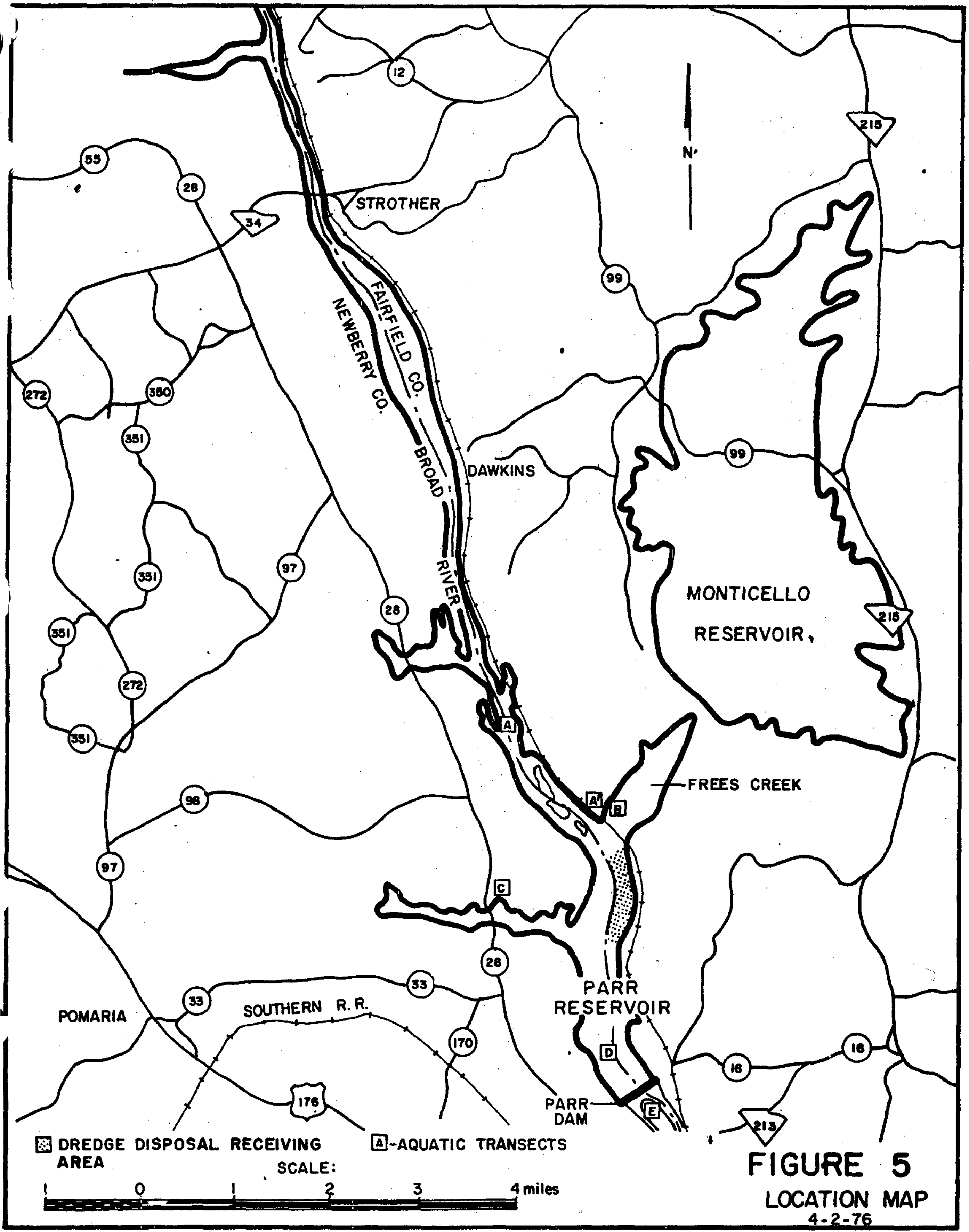
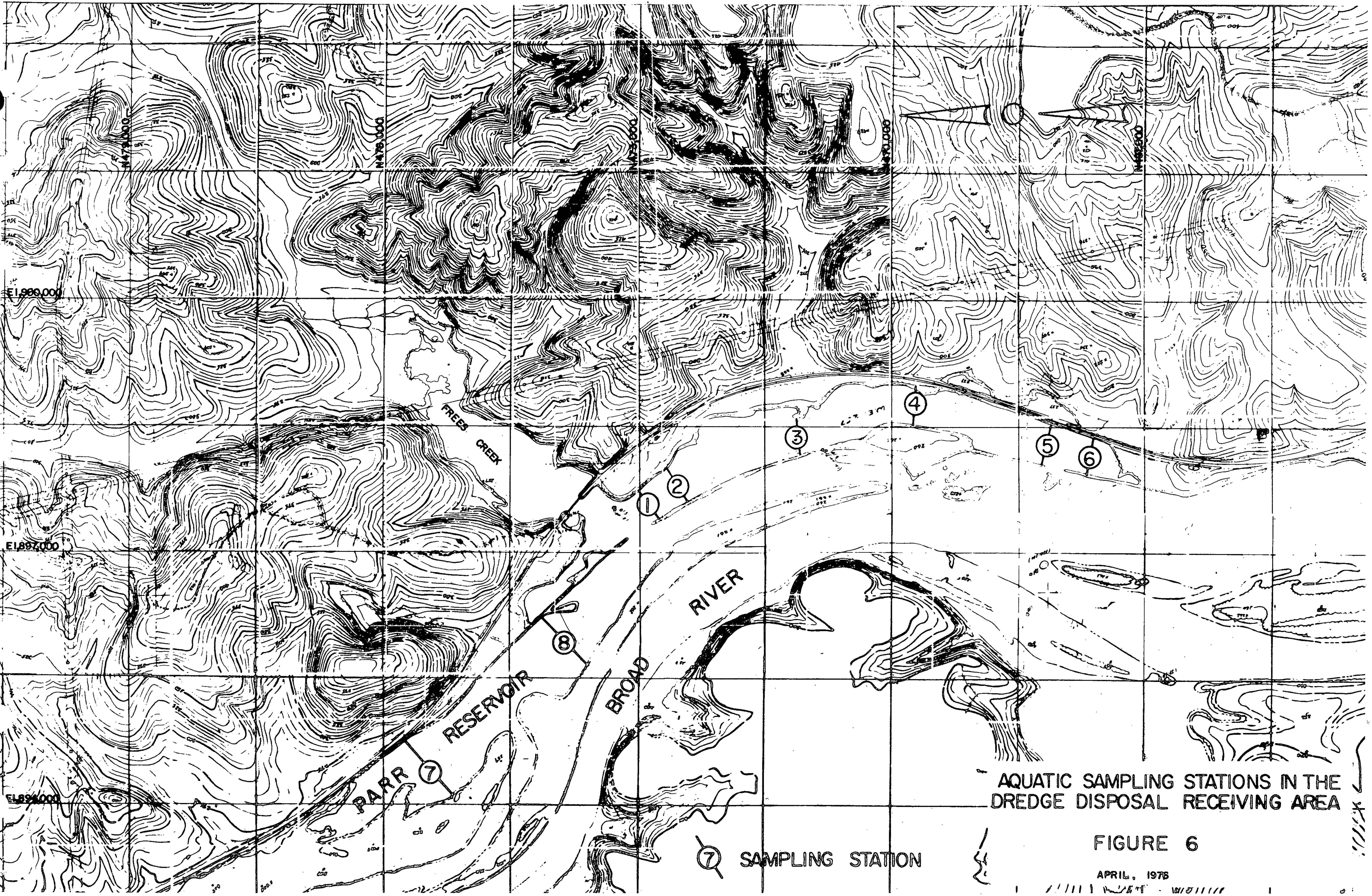


FIGURE 5

LOCATION MAP

4-2-76



AQUATIC SAMPLING STATIONS IN THE DREDGE DISPOSAL RECEIVING AREA

FIGURE 6

APRIL, 1976

PARR HYDROELECTRIC PROJECT

PRE-OPERATIONAL SAMPLING LOCATIONS AND SCOPE OF HYDROLOGICAL MONITORING PROGRAM

REVISED 3/25/75

LOCATIONS

(1) BROAD RIVER AT HIGHWAY34 BRIDGE
(2) BROAD RIVER AT FREES CREEK TRESTLE
*(3) FREES CREEK ABOVE DIVERSION DAM
(4) FREES CREEK AT HIGHWAY 99
(5) BROAD RIVER AT PARR DAM
(6) BROAD RIVER AT HIGHWAY 213 BRIDGE
(7) BROAD RIVER AT RICHTEX
(8) BROAD RIVER AT I-20
** (9) SPRINGS WA, WB, WC (WEST OF MONTICELLO RESERVOIR)
**(10) SPRINGS EA, EB, EC (EAST OF MONTICELLO RESERVOIR)

NOTE: * RELOCATED AS ADDED
** CONTACT FAIRFIELD CONSTRUCTION SITE FOR SPRING LOCATIONS
(779-8590 EXT. 357)

MONITORING PROGRAM

DAILY (MONDAY THROUGH FRIDAY)

LOCATION: STATION 5 ONLY
ANALYSES: ODOR, OBVIOUS OIL AND/OR GREASE, SEECHIE, pH, COND.

BI-WEEKLY (MONDAY & THURSDAY OR TUESDAY & FRIDAY)

LOCATION: STATIONS 1 THROUGH 6
ANALYSES: pH, D.O., COND., SED., T/H_20, T/AIR, ODOR, OBVIOUS OIL AND GREASE

MONTHLY

LOCATION: STATIONS 1 THROUGH 5
ANALYSES: T/H_20, T/AIR, pH, P-ALK, M.O.-ALK, CI, COND., Ca-HARDNESS, Mg-HARDNESS, TOTAL-HARDNESS, COLOR, TURB., TOTAL SOLIDS, SUSPENDED SOLIDS, NH_3, PO_4, $Si0_2$, NO_3, $S0_4$, $C0_2$, C.O.D., B.O.D., D.O., SEECHIE, OIL & GREASE, ALUMINUM, BERYLLIUM, BORON, COBALT, MAGNESIUM, MANGANESE, MOLYBDENUM, SELENIUM, SILVER, STRONTIUM, TIN VANADIUM

Figure 7

QUARTERLY

LOCATION: STATIONS 1 THROUGH 10

ANALYSES: SAME AS MONTHLY BUT ADD:
ARSENIC, CADMIUM, CHROMIUM, COPPER, IRON,
LEAD, MERCURY, NICKEL, ZINC