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WOLF CREEK GENERATING STATION CONSTRUCTION ENVIRONMENTAL MONITORING PROGRAM, APRIL 1980-JANUARY 1981

Prepared for

Kansas Gas and Electric Company
Wichita, Kansas

Prepared by

Ecological Analysts, Inc.
221 Oakcreek Drive
Lincoln, Nebraska 68528

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3 June 1981

CONTENTS

	Page
1. INTRODUCTION	1-1
1.1 Objectives	1-1
1.1.1 Water Chemistry	1-2
1.1.2 Aquatic Biology	1-2
1.1.3 Vegetation Monitoring	1-3
1.1.4 Wildlife Monitoring	1-3
1.2 Station Description	1-3
1.3 Description of Study Area	1-3
1.3.1 Aquatic Habitat	1-3
1.3.1.1 Neosho River	1-4
1.3.1.2 Wolf Creek	1-4
1.3.2 Terrestrial Habitat	1-6
1.4 Status of Construction	1-6
2. WATER QUALITY	2-1
2.1 Methods	2-1
2.1.1 Surface Water	2-1
2.1.2 Groundwater	2-1
2.1.3 Data Analysis	2-1
2.2 Results and Discussion	2-9
2.2.1 Surface Water Hydrology	2-9
2.2.2 Neosho River	2-9
2.2.2.1 General Water Quality	2-9
2.2.2.2 Aquatic Nutrients	2-12
2.2.2.3 Indicators of Municipal and Industrial Contamination	2-12
2.2.2.4 Trace Metals	2-12
2.2.3 Wolf Creek	2-12
2.2.3.1 General Water Quality	2-12
2.2.3.2 Aquatic Nutrients	2-13
2.2.3.3 Indicators of Municipal and Industrial Contamination	2-13
2.2.3.4 Trace Metals	2-13

CONTENTS (CONT.)

	Page
2.2.4 Comparison to Previous Data	2-14
2.2.5 Comparison of Results to Kansas Water Quality Criteria	2-14
2.2.6 Groundwater	2-16
2.3 Summary and Conclusions	2-16
3. PHYTOPLANKTON	3-1
3.1 Field and Analytical Methods	3-1
3.2 Results and Discussion	3-2
3.3 Summary and Conclusions	3-8
4. PERIPHYTON	4-1
4.1 Field and Analytical Procedures	4-1
4.2 Results and Discussion	4-1
4.3 Summary and Conclusions	4-8
5. ZOOPLANKTON	5-1
5.1 Field and Analytical Procedures	5-1
5.2 Results and Discussion	5-1
5.3 Summary and Conclusions	5-8
6. MACROINVERTEBRATES	6-1
6.1 Field and Analytical Procedures	6-1
6.2 Results and Discussion	6-1
6.2.1 Neosho River	6-1
6.2.1.1 Macroinvertebrate Drift	6-1
6.2.1.2 Benthic Samples	6-7
6.2.2 Wolf Creek	6-10
6.3 Summary and Conclusions	6-15
7. FISHERIES	7-1
7.1 Field and Analytical Procedures	7-1
7.1.1 Sampling Locations	7-1
7.1.2 Sampling Methods	7-1
7.1.2.1 Electroshocking	7-1
7.1.2.2 Seining	7-1
7.1.2.3 Larval Fish Sampling	7-1
7.1.3 Data Analysis	7-1

CONTENTS (CONT.)

	Page
7.2 Results and Discussion	7-2
7.2.1 Physical Conditions	7-2
7.2.2 Species Composition and Relative Abundance	7-2
7.2.2.1 General	7-2
7.2.2.2 Neosho River	7-7
7.2.2.2.1 Electroshocking	7-7
7.2.2.2.2 Seining	7-16
7.2.2.3 Wolf Creek	7-22
7.2.2.3.1 Seining	7-22
7.2.3 Larval Fish	7-22
7.3 Summary and Conclusions	7-28
8. VEGETATION MONITORING	8-1
8.1 Methods	8-1
8.1.1 Field Procedures	8-1
8.1.2 Analytical Procedures	8-1
8.2 Results and Discussion	8-3
8.2.1 North Floodplain Woods (Community 1)	8-3
8.2.1.1 Present Status	8-3
8.2.1.2 Comparisons with Previous Studies	8-4
8.2.2 Abandoned Railroad Right-of-Way (Community 2)	8-10
8.2.2.1 Present Status	8-10
8.2.2.2 Comparison with Previous Studies	8-14
8.2.3 South Floodplain Woods (Community 8)	8-14
8.2.3.1 Present Status	8-14
8.2.3.2 Comparison with Previous Studies	8-15
8.2.4 Flood Susceptibility Analysis	8-21
8.2.5 Land Use Disturbance	8-21
8.3 Summary and Conclusions	8-23

CONTENTS (CONT.)

	Page
9. WILDLIFE	9-1
9.1 Field and Analytical Procedures	9-1
9.1.1 Mammals	9-1
9.1.1.1 Small-mammal Trapping	9-1
9.1.1.2 20-Mile Wildlife Survey Route	9-2
9.1.1.3 Habitat Searches	9-2
9.1.1.4 Supplemental Data	9-2
9.1.1.5 Nomenclature	9-2
9.1.2 Avifauna	9-2
9.1.2.1 Transect Counts	9-2
9.1.2.2 20-Mile Wildlife Survey Route	9-3
9.1.2.3 John Redmond Reservoir and Dam	9-3
9.1.2.4 Supplemental Data	9-4
9.1.2.5 Nomenclature	9-4
9.1.3 Herpetofauna	9-4
9.1.3.1 20-Mile Wildlife Survey Route	9-4
9.1.3.2 Habitat Searches	9-4
9.1.3.3 Supplemental Data	9-4
9.1.3.4 Nomenclature	9-4
9.1.4 Endangered and Threatened Species	9-4
9.2 Results and Discussion	9-5
9.2.1 Mammals	9-5
9.2.1.1 Small Mammals	9-5
9.2.1.2 Eastern Cottontail Census	9-9
9.2.1.3 Incidental Mammal Observations	9-9
9.2.1.4 The 20-Mile Wildlife Survey Route	9-11
9.2.1.5 Endangered and Threatened Species	9-11
9.2.2 Avifauna	9-11
9.2.2.1 Community Surveys	9-11
9.2.2.1.1 North Floodplain Woods Transect	9-11
9.2.2.1.2 Abandoned Railroad Right-of-Way Transect	9-25
9.2.2.1.3 Bird Species Diversity	9-27
9.2.2.1.4 Comparison with Previous Studies	9-28

CONTENTS (CONT.)

	Page
9.2.2.2 20-Mile Wildlife Survey Route	9-28
9.2.2.2.1 Seasonal Analysis	9-28
9.2.2.2.2 Comparison with Previous Studies	9-30
9.2.2.3 Game Species	9-30
9.2.2.3.1 Bobwhite	9-30
9.2.2.3.2 Mourning Dove	9-32
9.2.2.4 Endangered and Threatened Species	9-32
9.2.3 Reptiles and Amphibians	9-32
9.2.3.1 Community Distribution	9-32
9.2.3.2 Endangered and Threatened Species	9-36
9.2.4 Relationship Between Wildlife and the Environment	9-36
9.2.4.1 Mammals	9-36
9.2.4.2 Avifauna	9-37
9.2.4.3 Herpetofauna	9-37
9.2.5 Construction Impacts	9-38
9.2.5.1 Sampling Communities	9-38
9.2.5.2 Site	9-38
9.3 Summary and Conclusions	9-39
10. REFERENCES	10-1
APPENDIX A: WATER CHEMISTRY AND BACTERIOLOGY METHODS	
APPENDIX B: PHYTOPLANKTON DATA	
APPENDIX C: PERIPHYTON DATA	
APPENDIX D: ZOOPLANKTON DATA	
APPENDIX E: MACROINVERTEBRATE DATA	
APPENDIX F: FISHERIES DATA	
APPENDIX G: VEGETATION DATA	
APPENDIX H: FLINT HILLS NATIONAL WILDLIFE REFUGE WILDLIFE USE TABLES	
APPENDIX I: WILDLIFE DATA	

LIST OF TABLES

Number	Title
2-1	Water quality parameters measured in surface water and groundwater samples.
2-2	Seasonal and annual mean concentrations of general water quality parameters measured in the Neosho River and Wolf Creek near Wolf Creek Generating Station, April to December 1980.
2-3	Seasonal and annual mean concentrations of major dissolved ionic constituents measured in the Neosho River and Wolf Creek near the Wolf Creek Generating Station, April to December 1980.
2-4	Seasonal and annual mean concentrations of aquatic nutrients measured in the Neosho River and Wolf Creek near the Wolf Creek Generating Station, April to December 1980.
2-5	Seasonal and annual mean concentrations of parameters indicative of municipal and industrial pollution measured in the Neosho River and Wolf Creek near the Wolf Creek Generating Station, April to December 1980.
2-6	Seasonal and annual mean concentrations of trace metals measured in the Neosho River and Wolf Creek near the Wolf Creek Generating Station, April through December 1980.
2-7	Groundwater data collected near Wolf Creek Generating Station, April and October 1980.
2-8	Mean daily river flow (cfs) in the Neosho River, 1980.
2-9	Water quality criteria for Kansas surface waters applicable to the Neosho River.
3-1	Algae identified in phytoplankton samples from the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.
3-2	Mean density and biovolume of total phytoplankon and major algal groups in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.
3-3	Mean density and biovolume of taxa composing at least 5 percent of total phytoplankton in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.
3-4	Average diversity indices for phytoplankton collected from the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.

LIST OF TABLES (CONT.)

Number	Title
3-5	Mean carbon fixation rates and chlorophyll a concentrations of phytoplankton samples collected from the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.
4-1	Algae identified in periphyton samples from artificial substrates in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.
4-2	Mean density, biovolume, and percent composition of major taxonomic groups in periphyton samples collected from artificial substrates in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.
4-3	Algal taxa composing at least 5 percent of total density of biovolume in periphyton collected from artificial substrates in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.
4-4	Mean biomass and chlorophyll a production, Autotrophic Index, and diversity measures for periphyton collected from artificial substrates in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.
5-1	Mean density (No./m^3) of zooplankton identified from samples collected in the Neosho River near Wolf Creek Generating Station, April through December 1980.
5-2	Percent composition of zooplankton identified from samples collected in the Neosho River near Wolf Creek Generating Station, April through December 1980.
5-3	Zooplankton taxa collected in the Neosho River near Wolf Creek Generating Station, Kansas 1980.
5-4	Annual mean densities (No./m^3) of selected major microcrustacean taxa from John Redmond Reservoir (Location 1), 1974 through 1980.
6-1	Summary of macroinvertebrate occurrence in quantitative collections near Wolf Creek Generating Station, Burlington, Kansas, 1980.
6-2	Dominant groups and diversity indices of the macroinvertebrate drift collected from the tailwaters of John Redmond Reservoir on the Neosho River (Location 1) near Wolf Creek Generating Station, Burlington, Kansas, 1980.
6-3	Drift densities (No./100m^3) of selected macroinvertebrate families in the tailwaters of John Redmond Reservoir on the Neosho River (Location 1) near Wolf Creek Generating Station, Burlington, Kansas, 1976-1980.

LIST OF TABLES (CONT.)

Number	Title
6-4	Dominant groups and diversity index of benthic macroinvertebrates collected in Ponar grab samples from the Neosho River (Locations 10 and 4) near Wolf Creek Generating Station, Burlington, Kansas, 1980.
6-5	Benthic macroinvertebrate data from the Neosho River (Locations 10 and 4) near Wolf Creek Generating Station, Burlington, Kansas, 1973-1980.
6-6	Significant differences ($P \leq 0.05$) in species diversity and density of the dominant benthic macroinvertebrates collected from the Neosho River (Locations 4 and 10) near Wolf Creek Generating Station, Burlington, Kansas, 1980.
6-7	Benthic macroinvertebrate occurrence in qualitative collections near Wolf Creek Generating Station, Burlington, Kansas, 1980.
6-8	Dominant groups and diversity indices of the benthic macroinvertebrates collected from Wolf Creek near Wolf Creek Generating Station, Burlington, Kansas, 1980.
6-9	Significant differences ($P \leq 0.05$) in species diversity and density of the dominant benthic macroinvertebrates collected from Wolf Creek (Locations 3 and 7) near Wolf Creek Generating Station, Burlington, Kansas, 1980.
6-10	Macroinvertebrate densities (No./m^2) from Wolf Creek (Locations 7, 3, and 5) near Wolf Creek Generating Station, Burlington, Kansas, 1974-1980.
7-1	Water temperature recorded at locations sampled by electroshocking and seining in the Neosho River and Wolf Creek near the Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.
7-2	Checklist of fishes collected by seining and electrofishing near Wolf Creek Generating Station, Burlington, Kansas, 1980.
7-3	Number and relative abundance of fish collected by electroshocking and seining in the Neosho River and Wolf Creek near the Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.
7-4	Comparison of blue suckers collected in the Neosho River in 1980 with other populations.
7-5	Number and relative abundance of fish collected by electroshocking in the Neosho River near the Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.

LIST OF TABLES (CONT.)

Number	Title
7-6	Number and average CPE of each fish species collected by electroshocking at sampling locations in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.
7-7	Average CPE (by electrofishing at Location 1) of commercial fishes in the Neosho River, Burlington, Kansas, 1977 through 1980.
7-8	Number and relative abundance of fish collected by electroshocking in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1977-1980.
7-9	Catch rates (CPE) of selected species collected by electroshocking at the tailwaters of John Redmond Reservoir (Location 1) near Wolf Creek Generating Station, Burlington, Kansas, 1980.
7-10	Number of fish collected by seining in the Neosho River near the Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.
7-11	Number and relative abundance of fish collected by seining in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.
7-12	Number of selected fishes collected by seining in the Neosho River near the Wolf Creek Generating Station, Burlington, Kansas, 1973 through 1980.
7-13	Number of fish collected by seining in Wolf Creek near the Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.
7-14	Number, density, and taxa of larval fish collected during diurnal sampling at Location 1 in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, April through July 1980.
7-15	Number, density, and taxa of ichthyoplankton collected during nocturnal sampling at Location 1 in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, April through July 1980.
7-16	Number, relative abundance, and average density of larval fish collected at Location 1 in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, April through July, 1980.
8-1	Phytosociological data summary of trees in the north floodplain woods, Community 1, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

LIST OF TABLES (CONT.)

Number	Title
8-2	Phytosociological data summary of saplings in the north floodplain woods, Community 1, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.
8-3	Phytosociological data summary of species in the shrub stratum of the north floodplain woods, Community 1, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.
8-4	Frequency of species in the ground layer and average ground layer cover in the north floodplain woods, Community 1, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.
8-5	Density (stems/ha) of saplings and trees by diameter classes in the north floodplain woods (Community 1) near Wolf Creek Generating Station, Burlington, Kansas, September 1980.
8-6	Year to year data comparisons expressed as percent similarity for three plant communities near Wolf Creek Generating Station, Burlington, Kansas.
8-7	Frequency of species in the ground layer and average ground layer cover in the abandoned railroad right-of-way, Community 2, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.
8-8	Percent cover of species in the ground layer, community ground layer cover, and mean canopy height in the abandoned railroad right-of-way, Community 2, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.
8-9	Phytosociological data summary of trees in the south floodplain woods, Community 8, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.
8-10	Phytosociological data summary of saplings in the south floodplain woods, Community 8, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.
8-11	Phytosociological data summary of species in the shrub stratum of the south floodplain woods, Community 8, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.
8-12	Frequency of species in the ground layer and average ground layer cover in the south floodplain woods, Community 8, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.
8-13	Density (stems/ha) of saplings and trees by diameter classes in the south floodplain woods (Community 8) near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

LIST OF TABLES (CONT.)

Number	Title
8-14	Shrub stratum flood susceptibility index, for all years sampled, of the north and south floodplain woods (Communities 1 and 8, respectively), near Wolf Creek Generating Station, Burlington, Kansas.
9-1	Mammals observed near Wolf Creek Generating Station, Burlington, Kansas, 1974-1980.
9-2	Small mammal capture data for two communities near Wolf Creek Generating Station, Burlington, Kansas, September 1980.
9-3	Summary of small mammal densities (no./ha) in two communities near Wolf Creek Generating Station, Burlington, Kansas, 1974-1980.
9-4	Incidental wildlife observations near Wolf Creek Generating Station, Burlington, Kansas, May 1980 - January 1981.
9-5	Species list, residency status, and community and monthly occurrence of avifauna near Wolf Creek Generating Station, Burlington, Kansas, May 1980 through January 1981.
9-6	Avian species observed near John Redmond Reservoir, Burlington, Kansas, May 1980 through January 1981.
9-7	Avian species observed near Wolf Creek Generating Station, Burlington, Kansas, 1974 through 1980.
9-8	Avian species observed near John Redmond Reservoir, Burlington, Kansas, 1976 through 1890.
9-9	The number of birds observed per hour in the north floodplain woods, Community 1, near Wolf Creek Generating Station, Burlington, Kansas, May 1980 - January 1981.
9-10	Number of species, birds per hour, and species diversity of avifauna recorded in two communities near Wolf Creek Generating Station, Burlington, Kansas, May 1974 - January 1980.
9-11	The number of birds observed per hour in the abandoned railroad right-of-way, Community 2, near Wolf Creek Generating Station, Burlington, Kansas, May 1980 - January 1981.
9-12	Number of avian species and individuals observed along the 20-mile wildlife survey route near Wolf Creek Generating Station, Burlington, Kansas, May 1973 - January 1981.
9-13	Quail call counts along the 20-mile wildlife survey route near Wolf Creek Generating Station, Burlington, Kansas, May and June 1980.

LIST OF TABLES (CONT.)

Number	Title
9-14	Mourning dove observations along the 20-mile wildlife survey route near Wolf Creek Generating Station, Burlington, Kansas, May and June 1980.
9-15	Herpetofauna observed near Wolf Creek Generating Station, Burlington, Kansas, May 1980 - January 1981.
9-16	Herpetofauna observations near Wolf Creek Generating Station, Burlington, Kansas, 1974 - 1980.

LIST OF FIGURES

Number	Title
1-1	Aquatic sampling locations in the vicinity of Wolf Creek Generating Station, 1980.
1-2	Terrestrial sampling locations in the vicinity of Wolf Creek Generating Station, 1980.
2-1	Precipitation at John Redmond Reservoir near the Wolf Creek Generating Station, 1980.
7-1	Length-weight relationship of blue suckers collected by electroshocking in the Neosho River near the Wolf Creek Generating Station, Burlington, Kansas, 1980.
7-2	Catch-per-unit-effort of electrofishing at three locations (1, 10, and 4) in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.
7-3	Number of fish collected during seining in the Neosho River (Locations 1, 10, 11, and 4) near the Wolf Creek Generating Station, Burlington, Kansas, 1980.
8-1	Schematic representation of nested quadrat layout for sampling floodplain woods vegetation near Wolf Creek Generating Station, Burlington, Kansas, 1980.

1. INTRODUCTION

1.1 OBJECTIVES

This report presents the results of the fourth year of Construction Monitoring in the vicinity of Wolf Creek Generating Station (WCGS) as outlined in Section 6.1 of the WCGS Environmental Report (Construction Permit Stage). Environmental monitoring programs near the WCGS site have been conducted since 1973. The initial studies (1973-1974) were conducted to collect baseline data on water quality, aquatic biology, and terrestrial biology to partially fulfill the Nuclear Regulatory Commission's (NRC) requirements for preparing an Environmental Report prior to issuance of a construction permit for WCGS. Subsequent monitoring programs were modified as necessary to obtain as complete a data base as practical for the ecosystem near WCGS. Major changes in the terrestrial biology, water quality, and aquatic biology monitoring programs were made after issuance of the Final Environmental Statement (FES) for WCGS by the NRC in 1975. Changes recommended by the NRC were implemented in the 1976 construction phase environmental monitoring program. Environmental monitoring data collected through 1978 were summarized in Chapter 2 of the Operating License Stage Environmental Report prepared for the NRC.

Design changes were incorporated into the 1980-1981 program following completion of an expanded three-year monitoring program based on recommendations of the NRC staff in the Final Environmental Statement for WCGS. Alterations in the 1980-1981 construction environmental program included:

1. sampling frequency for surface water quality and aquatic biology was reduced from a bimonthly to quarterly program.

2. all monitoring at Location 5 on the lower reach of Wolf Creek was discontinued.

3. water quality and plankton monitoring was discontinued during the May and July surveys of the John Redmond Reservoir tailwaters. In addition, seining at Location 11 was eliminated during these two survey periods.

4. field and laboratory methodologies utilized during this study period remained essentially the same except for the phycology program. Periphyton was collected from artificial substrates at Locations 4 and 10 which replaced collections from natural substrates at Locations 1, 4, and 10. Phytoplankton analyses were performed using the inverted microscope method, which replaced the bright field-phase contrast scan technique.

5. groundwater sampling was reduced from three times a year at eight wells to twice a year at four wells.

6. hardness was added to the water quality parameters measured in the groundwater samples.

7. vegetation monitoring in April and June was discontinued. The September survey included sampling of all strata.
8. small mammal trapping in June and avifauna surveys in November were eliminated from the wildlife monitoring program.

9. construction site overviews were reduced from five to three times per year and were conducted in June, September, and January.

The overall objective of the 1980-1981 program was to assess the land and water environments in areas which will, or may be, influenced by construction and operation of WCGS. Potential near-field impacts could result from construction and operation of the makeup water pumphouse located in the tailwaters of John Redmond Dam. Construction activities could influence water quality downstream of the construction area and operation of the pumphouse will result in losses of organisms through entrainment and impingement processes. Potential far-field effects could be manifested downstream of the confluence of Wolf Creek depending on the quantity and quality of water discharged from Wolf Creek during construction and operation of WCGS. Specific objectives of the 1980 program are listed below.

1.1.1 Water Chemistry

The objectives of the water chemistry study during this phase of the Construction Environmental Monitoring Program for WCGS were to

1. document changes in water quality, if any, resulting from construction related activities,

2. provide additional data on the general water quality of the aquatic environment (both surface water and groundwater) in the vicinity of the facility,

3. document the concentrations of aquatic nutrients, organically-derived materials, and certain trace metals.

1.1.2 Aquatic Biology

The objectives of the aquatic biology monitoring study were to

1. provide additional baseline data on the periphyton, phytoplankton, zooplankton, macroinvertebrate, and fish communities in the vicinity of the facility,

2. document any natural year-to-year changes in the aquatic community,

3. provide reference information to be used in the formulation of management programs to minimize effects of construction and operation on the environment.

1.1.3 Vegetation Monitoring

Specific objectives of the vegetation program were to

1. evaluate changes in the vegetation since the 1973 baseline study,
2. provide additional data for comparison with subsequent monitoring studies,
3. evaluate any relationships between phytosociological changes and construction activities,
4. record total 1980 construction-related land-use disturbance at the WCGS site.

1.1.4 Wildlife Monitoring

The 1980 wildlife monitoring program was designed to determine

1. species composition and abundance of game and nongame wildlife,
2. naturally occurring variations in species composition and abundance,
3. faunal changes that may have resulted from construction activities associated with WCGS.

1.2 STATION DESCRIPTION

Kansas Gas and Electric Company's Wolf Creek Generating Station (WCGS) is located in Coffey County approximately 5.6 kilometers northeast of Burlington, Kansas. Upon completion in 1983, the station will employ a pressurized water reactor to produce 1,150 megawatts (net output) of electrical power. The site encompasses 9,818 acres of range, cropland, and woodland typical of southeastern Kansas. The station will occupy 135 acres and the cooling lake will inundate approximately 5,090 acres. A once-through cooling system, utilizing water from the WCGS cooling lake, will be utilized. The cooling lake will be formed by impounding Wolf Creek approximately 8.8 kilometers upstream from its confluence with the Neosho River. A surface elevation of 1,087 feet above sea level will be maintained in the cooling lake by precipitation and runoff in the Wolf Creek watershed and makeup water from the Neosho River. A makeup water pumphouse on the Neosho River in the tailwaters of John Redmond Reservoir will provide water to the cooling lake via an underground pipeline.

1.3 DESCRIPTION OF STUDY AREA

1.3.1 Aquatic Habitat

The Neosho River is a relatively slow meandering stream that rarely exceeds a gradient of 1 m/km (Prophet 1966). The river was significantly altered in 1964 with the completion of John Redmond Dam. River flow in the study area is dependent upon discharge from John Redmond Reservoir which is regulated by the U.S. Army Corps of Engineers.

Substrates in the tailwaters of the John Redmond Reservoir Dam were layered limestone, shale, and sandstone bedrock. Flow was variable and entirely dependent upon releases from John Redmond Reservoir. Pools, gravel bars, and riffles characterize the lower river near the confluence with Wolf Creek. Substrates in the riffle habitats were rock, rubble, and gravel, whereas the pools were characterized by bedrock overlaid by silt.

Wolf Creek, a small intermittent tributary of the Neosho River, is subject to brief periods of high flow following snowmelt or stormwater runoff and long periods of low or zero flow, during which the creek often consists of a series of isolated pools. In October and December, small isolated pools were present. Various mixtures of silt, clay, sand, and gravel were present in the substrates of Wolf Creek during 1980. The creek bottom above the cooling lake site was heavily overlaid with leaf litter in October and December.

Four locations in the Neosho River and two in Wolf Creek were sampled to characterize the aquatic community of each system (Figure 1-1). A description of the physical characteristics associated with each location is presented below.

1.3.1.1 Neosho River

Location 1 was in the tailwaters of John Redmond Dam near the make-up water intake structure for the station. The bottom substrate was bedrock, with rock riprap along the banks. Flow was entirely dependent on releases from John Redmond Reservoir.

Pools and riffles characterized Location 10 which was 0.7 kilometers upstream of the confluence with Wolf Creek. The riffles had substrates of rock, rubble, and gravel, whereas the pools were characterized by bedrock overlaid with silt.

A riffle located approximately 0.5 kilometers below the confluence with Wolf Creek constituted Location 11. The riffle consisted of small rubble, gravel, and sand swept by swift current. During periods of low flow, the water depth ranged from 5 to 25 centimeters.

Location 4, 1.3 kilometers downstream of the confluence with Wolf Creek, was comprised of deep pools and a shallow gravel bar. The substrate of the pools was silt and sand, whereas the gravel bar consisted of sand and gravel.

1.3.1.2 Wolf Creek

Location 7 was upstream of the area to be inundated by the WCGS cooling lake. The substrate at this location consisted of sand, gravel, and clay which usually was covered by leaf litter.

Location 3 was a clay and silt bottomed pool located approximately 1.7 kilometers downstream of the cooling lake dam. Construction activities during 1976 altered the physical features of a portion of this location.

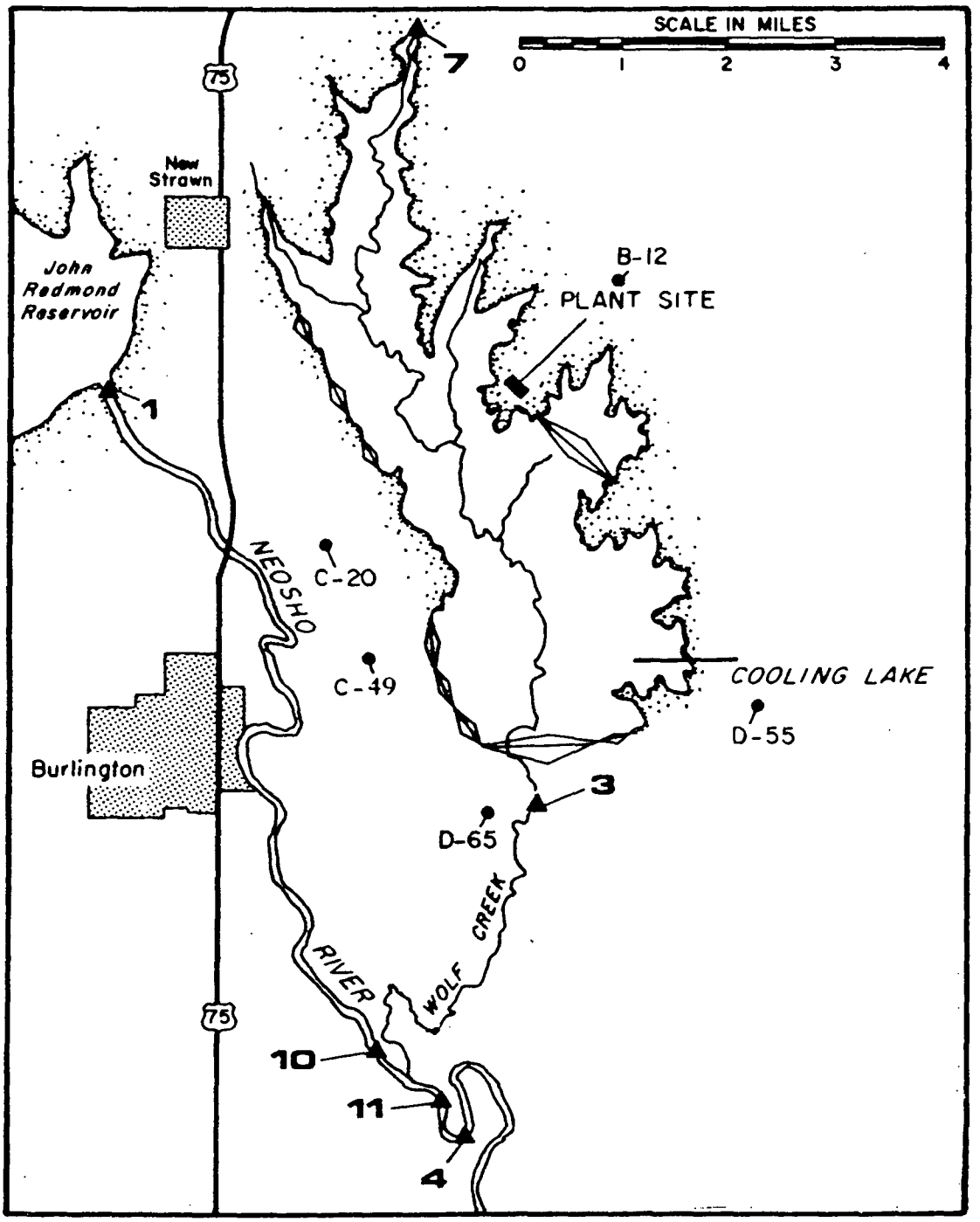

Figure 1-1 Aquatic sampling locations in the vicinity of Wolf Creek Generating Station, 1980.

1.3.2 Terrestrial Habitat

Studies of vegetation, mammals, avifauna, reptiles, and amphibians were conducted in the following communities (Figure 1-2)

1. north floodplain woods, Community 1, (NE 1/4, NW 1/4, Section 25, T20S, R15E),

2. abandoned railroad right-of-way, Community 2, (NE 1/4, NE 1/4, Section 6, T21S, R16E),

3. south floodplain woods, Community 8, (NE 1/4, NE 1/4, Section 12, T22S, R15E).

The north floodplain woods occupies a terrace above Wolf Creek and is located upstream from the WCGS cooling lake, near the approximate high water level for the cooling lake. The community is subject to periodic flooding and, due to community topography, some portions of the woods are inundated more frequently than others. The elevational gradient of the woods is not visually discernible, although the community slopes gently to the south and drops off steeply into the creek bed.

The abandoned railroad right-of-way is representative of protected prairie of the Kansas Osage plains. Community 2 has been protected from grazing, mowing, and fire since 1975; such prairie communities with protection from anthropogenic disturbances are uncommon in the area.

The south floodplain woods is located approximately 6 kilometers downstream from the cooling lake dam on Wolf Creek. Community topography is irreguar and portions of the community are periodically inundated. The locations of vegetation sampling plots vary from depressions on the first terrace of Wolf Creek to well-drained sites on the second terrace of the floodplain.

1.4 STATUS OF CONSTRUCTION

Construction-related land-use disturbances declined in 1980 and reflected near completion of the project (Section 8.2.5). Low rainfall and completion of certain projects reduced the likelihood of construction effects on the Neosho River in 1980. Major construction activities in 1980 included initial filling of the ultimate heat sink (UHS), completion of the makeup water pumphouse (MWPH), and closure of the cooling lake dam. Filling of the UHS began in mid-May and it has since served as a holding pond for a portion of the fish planned for stocking the cooling lake. The MWPH was completed soon after the initial aquatic survey in April 1980; consequently, construction activities in the tailwater area would not be expected to affect the 1980 data. Data collected during initial site clearing and ground construction activities for the MWPH indicated no near- or far-field impacts on the water quality or biota in the Neosho River. Testing of the MWPH began on 13 October 1890. Closure of the main dam began on August 1980 and was essentially completed by the end of September. Lake filling started on 27 October 1980. Low rainfall during 1980 (Section 2.2) and diversion of Wolf Creek through the borrow areas in 1979 limited runoff from the plant construction site prior to dam closure.

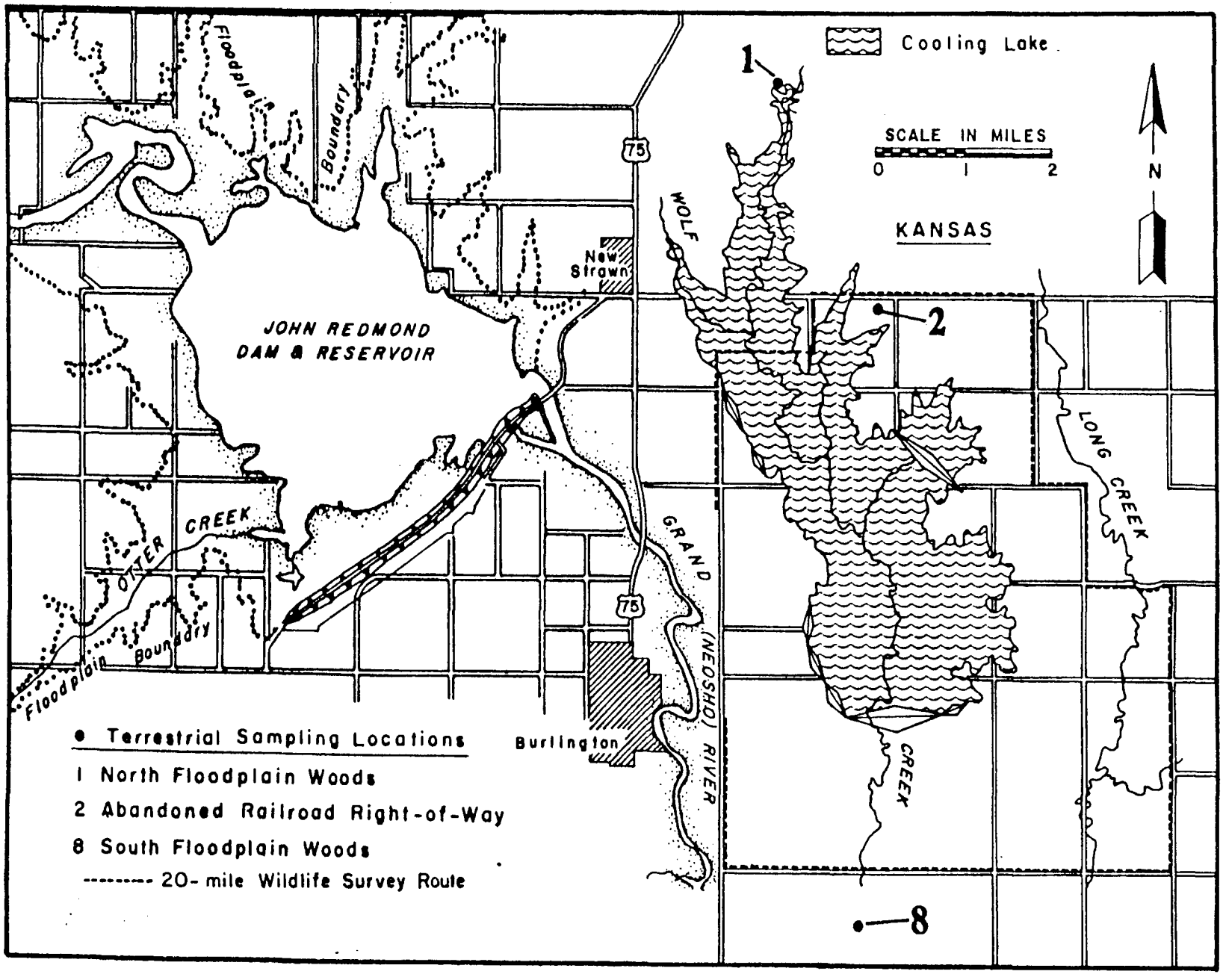

Figure 1-2 Terrestrial sampling locations in the vicinity of Wolf Creek Generating Station, 1980.

2. WATER QUALITY

2.1 METHODS

2.1.1 Surface Water

Quarterly water quality samples were collected from three locations in the Neosho River (1, 10, and 4) and two locations in Wolf Creek (3 and 7) during the 1980 study. Subsurface samples were collected using non-metallic water samplers. Bacteriological and oil-and-grease samples were collected at the surface in glass sample containers. Immediately following collection, samples were preserved, packed in ice, and shipped to the laboratory for analysis of the chemical parameters listed in Table 2-1.

Analytical procedures used during the study are presented in Table A-1. The methods used conform to procedures outlined in Standard Methods for the Examination of Water and Wastewater (APHA 1976). Analytical testing and quality control procedures were conducted in a manner consistent with the guidelines of the U.S. Environmental Protection Agency (1979a) and the EA Quality Assurance Program. Water temperature, dissolved oxygen, pH, total alkalinity, and turbidity were measured in the field. Enteric bacteria samples were processed at the Lincoln, Nebraska Regional Laboratory using standard delayed incubation methods; chemical parameters were measured at the Northbrook, Illinois Regional Laboratory with the exception of the October and December samples which were analyzed at the Sparks, Maryland Laboratory.

The differences in laboratory processing of samples by individual analysts and laboratories resulted in differences in analytical detection limits reported for the 1980 data. Data reporting conventions with regard to significant figures and rounding of values resulted in slightly different reporting values.

2.1.2 Groundwater

Single groundwater samples were collected from four wells (B-12, C-20, C-49, and D-65) in April and October. Samples were collected after the wells were pumped for approximately five minutes. Well C-20 was dry in October and no sample was recovered for analysis. Following collection, samples were processed using the same methods outlined for surface water samples in Section 2.1.1.

2.1.3 Data Analysis

An analysis of variance test (Scheffe 1959; Steel and Torrie 1960) was used to test for significant differences ($P \leq 0.05$) in water quality between sampling locations. Seasonal and annual mean concentrations for each constituent measured in surface water samples are presented in Tables 2-2 through 2-6. Seasonal data for groundwater samples are presented in Table 2-7. Appendix A, Table A-2 contains physical and meterological data collected during the 1980 study.

Table 2-1 Water quality parameters measured in surface water and groundwater samples.

General Water Quality	Trace Metals
*Alkalinity, total	Copper, total
*Calcium	Lead, total
*Chloride	Mercury, total
Color, true	*Selenium, total
*Conductance, specific	Zinc, total
*Iron, soluble	
*Iron, total	
*Magnesium	
*Manganese, total	
Oxygen, dissolved	
Oxygen, saturation	
pH	
*Potassium	
Residue, filtrable (total dissolved solids)	
Residue, nonfiltrable (total suspended solids)	
*Sodium	
*Sulfate	
Temperature	
Turbidity	
*Hardness, total	

Aquatic Nutrients

Ammonia
*Nitrate
Nitrite
Organic nitrogen, total
Orthophosphate, soluble
*Phosphorus, total
*Silica, soluble

Indicators of Industrial and Municipal Contamination

Bacteria, fecal coliform
Bacteria, fecal streptococci
Biochemical oxygen demand (5 day)
Chemical oxygen demand
Hexane soluble materials
Organic carbon, total

* Indicates parameters measured in groundwater samples.

Table 2-2 Seasonal and annual mean concentrations of general water quality parameters measured in the Neosho River and Wolf Creek near Wolf Creek Generating Station, April to December 1980.

Location	Date	Temp (°C)	D.O. (mg/l)	Oxygen Saturation (%)	pH (units)	Alk. (mg/l)	Conductance (μmhos/cm)	TDS (mg/l)	TSS (mg/l)	Turb. (NTU)
1	15 Apr	9.4	11.5	100	6.9	128	340	262	142	55
	17 Jun	23.0	7.5	95	8.6	183	550	318	54	41
	28 Oct	8.0	13.8	115	7.5	143	530	311	15	30
	16 Dec	4.5	12.2	93	7.9	150	-[a]	348	38	20
	$\bar{x}$	11.2	11.2	101	7.7	150	473	310	62	36
10	15 Apr	9.4	10.5	95	7.8	130	355	250	55	53
	17 Jun	23.5	5.7	70	8.2	186	540	303	16	19
	28 Oct	8.0	10.7	90	7.3	144	530	292	11	10
	16 Dec	4.6	12.3	93	8.3	148	-[a]	362	16	15
	$\bar{x}$	11.4	9.9	87	7.8	152	475	302	25	24
4	15 Apr	9.4	11.7	101	7.9	128	350	265	58	53
	17 Jun	23.0	5.3	61	8.2	184	550	314	13	21
	28 Oct	8.0	10.6	90	7.1	145	540	294	7	12
	16 Dec	4.5	12.3	93	8.3	149	-[a]	357	18	16
	$\bar{x}$	11.2	10.6	86	7.8	152	483	308	24	26
7	15 Apr	9.4	11.1	97	7.3	148	450	306	22	19
	17 Jun	19.5	4.3	42	8.3	216	605	342	13	24
	28 Oct	8.0	5.7	47	7.6	83	215	139	35	32
	16 Dec	4.5	1.0	12	6.8	91	-[a]	194	41	20
	$\bar{x}$	10.4	5.5	50	7.5	134	423	245	28	24
3	15 Apr	9.4	10.7	95	7.3	121	350	281	90	90
	17 Jun	20	4.8	52	8.2	205	540	317	48	51
	28 Oct	8.0	11.1	93	6.6	57	480	290	22	34
	16 Dec	4.5	4.6	31	7.1	123	-[a]	370	30	34
	$\bar{x}$	10.4	7.8	68	7.3	126	457	315	48	52

[a] Not available.

Table 2-3 Seasonal and annual mean concentrations of major dissolved ionic constituents measured in the Neosho River and Wolf Creek near the Wolf Creek Generating Station, April to December 1980.

Location	Date	K (mg/l)	Ca (mg/l)	Cl (mg/l)	Na (mg/l)	Mn (µg/l)	Mg (mg/l)	SO_4 (mg/l)	Fe, total (mg/l)	Fe, soluble (µg/l)	Color (units)
1	15 Apr	4.1	51	10.7	14	54	9.6	40	2.5	67	44
	17 Jun	4.1	57	19	19	180	20	80	2.0	43	13
	28 Oct	4.3	61	30	26	125	18	81	0.83	100	12
	16 Dec	8.9	106	32	27	90	42	79	2.2	<200	-[a]
	$\bar{x}$	5.4	68	23	22	112	22	70	1.9	-[b]	23
10	15 Apr	3.7	52	7.6	15	67	9.7	33	2.2	60	40
	17 Jun	3.8	56	19	19	155	20	61	0.88	39	11
	28 Oct	4.2	57	27	24	100	17	95	0.26	300	11
	16 Dec	7.4	112	32	28	85	38	85	0.30	300	-[a]
	$\bar{x}$	4.8	69	21	22	102	21	69	0.9	174	21
4	15 Apr	3.7	55	7.7	15	70	9.9	46	2.3	63	37
	17 Jun	3.9	64	19	19	150	20	68	0.89	31	11
	28 Oct	4.1	59	28	24	100	17	97	0.34	150	10
	16 Dec	5.2	92	30	5	80	39	38	0.30	<550	-[a]
	$\bar{x}$	4.2	67	21	16	100	21	62	1.0	-[b]	19
7	15 Apr	2.8	69	6.5	20	100	12	76	0.86	32	27
	17 Jun	6.1	75	13	21	200	17	61	1.03	43	21
	28 Oct	8.4	26	3.3	5.7	-[a]	6.2	32	2.4	650	62
	16 Dec	8.2	48	5	4.5	2100	12.2	21	2.5	950	-[a]
	$\bar{x}$	6.4	54	7	13	101	11.9	48	1.7	419	37
3	15 Apr	3.1	54	15	16	220	8.4	43	3.9	105	45
	17 Jun	3.7	63	8.3	19	810	15	72	2.2	51	18
	28 Oct	2.5	58	4.3	9.4	-[a]	18	181	0.91	100	13
	16 Dec	3.6	118	17	19.5	560	38	106	2.0	400	-[a]
	$\bar{x}$	3.2	73	11	16	362	20	101	2.3	164	26

[a] Not analyzed.
[b] Not calculated.

Table 2-4 Seasonal and annual mean concentrations of aquatic nutrients measured in the Neosho River and Wolf Creek near the Wolf Creek Generating Station, April to December 1980.

Location	Date	NH_3 (mg/l-N)	NO_3 (mg/l-N)	NO_2 (mg/l-N)	TON (mg/l-N)	O-PO_4 (µg/l-P)	P (µg/l-P)	Si (mg/l-SiO_2)
1	15 Apr	<0.01	2.9	0.032	1.05	75	160	3.90
	17 Jun	0.1	0.28	0.087	0.35	26	165	0.68
	28 Oct	0.11	0.04	0.004	0.95	63	120	0.41
	16 Dec	0.20	0.045	0.095	0.69	209	988	0.50
	$\bar{x}$	0.10	0.80	0.033	0.69	93	111	1.4
10	15 Apr	0.06	1.6	0.028	0.29	85	124	3.6
	17 Jun	0.03	0.38	0.022	0.29	32	96	1.2
	28 Oct	0.09	0.28	0.012	0.67	105	160	0.43
	16 Dec	0.13	0.06	0.003	0.49	269	340	0.20
	$\bar{x}$	0.08	0.56	0.016	0.43	123	180	1.4
4	15 Apr	0.04	1.7	0.029	0.46	79	110	3.6
	17 Jun	0.02	0.31	0.019	0.33	99	100	1.3
	28 Oct	0.09	0.33	0.004	0.77	135	195	0.37
	16 Dec	0.20	0.34	0.010	0.54	236	475	0.20
	$\bar{x}$	0.09	0.66	0.015	0.48	137	220	1.4
7	15 Apr	<0.01	0.33	0.007	0.37	6	41	3.6
	17 Jun	0.15	0.22	0.031	0.36	24	69	4.3
	28 Oct	0.06	0.01	0.001	1.44	108	350	2.2
	16 Dec	0.10	0.08	0.010	0.76	220	1007	3.7
	$\bar{x}$	0.08	0.16	0.012	0.73	88	367	3.5
3	15 Apr	<0.01	10.0	0.030	0.39	20	145	3.9
	17 Jun	0.08	0.2	0.011	0.36	7	115	10.5
	28 Oct	0.02	0.36	0.007	0.50	5	99	1.2
	16 Dec	0.12	0.37	0.012	0.71	252	459	3.9
	$\bar{x}$	0.06	2.73	0.015	0.49	70	204	4.9

Table 2-5 Seasonal and annual mean concentrations of parameters indicative of municipal and industrial pollution measures in the Neosho River and Wolf Creek near the Wolf Creek Generating Station, April to December 1980.

Location	Date	BOD (mg/l)	COD (mg/l)	TOC (mg/l)	Hexane, Soluble Material (mg/l)	Fecal Coliform (No./100 ml)	Fecal Streptococcus (No./100 ml)
1	15 Apr	2.4	22	8.7	<3	19	70
	17 Jun	2.3	23	8.6	<3	0	68
	28 Oct	5.0	25	6.7	208	76	36
	16 Dec	2.8	38	8.3	18	0	11
	$\bar{x}$	3.1	27	8.1	-[a]	24	46
10	15 Apr	1.7	20	9.2	5	180	47
	17 Jun	2.3	18	9.7	<3	>1000	130
	28 Oct	4.0	71	5.6	<3	645	232
	16 Dec	3.6	49	6.0	359	4	66
	$\bar{x}$	2.9	39	7.6	-[a]	457	119
4	15 Apr	1.7	20	7.8	4	108	69
	17 Jun	2.0	15	7.6	<3	520	18
	28 Oct	4.3	13	10	<3	171	186
	16 Dec	0.8	32	8.0	<3	0	36
	$\bar{x}$	2.2	20	8.4	-[a]	200	77
7	15 Apr	2.4	18	5.6	<3	18	46
	17 Jun	1.4	28	8.2	-[b]	49	255
	28 Oct	8.8	56	22	<3	>1000	570
	16 Dec	8.4	116	14.4	422	0	40
	$\bar{x}$	5.3	54	12.6	-[a]	344	228
3	15 Apr	2.5	23	9.1	4	105	30
	17 Jun	1.2	20	9.6	<3	33	4200
	28 Oct	6.6	98	7.8	81	98	193
	16 Dec	3.4	56	4.7	4	0	48
	$\bar{x}$	3.4	48	7.8	-[a]	59	1118

[a] Not calculated.
[b] Not available.

Table 2-6 Seasonal and annual mean concentrations of trace metals measured in the Neosho River and Wolf Creek near the Wolf Creek Generating Station, April through December 1980.

Location	Date	Cu (μg/l)	Pb (μg/l)	Hg (μg/l)	Se (μg/l)	Zn (μg/l)
1	15 Apr	10	<1	0.82	<2	36
	17 Jun	10	<1	<0.20	<2	18
	28 Oct	2.9	-[a]	.9	-[a]	<30
	16 Dec	7.4	5.3	<0.1	<1.0	60
	$\bar{x}$	7.6	-[b]	-[b]	-[b]	41
10	15 Apr	9	<1	10.24	<2	16
	17 Jun	4.5	<1	0.93	<2	74
	28 Oct	1.2	-[a]	<0.1	-[a]	<30
	16 Dec	2.1	3.2	2	<1.0	50
	$\bar{x}$	4.2	-[b]	-[b]	-[b]	48
4	15 Apr	12.5	<1	<0.20	<2	34
	17 Jun	6.2	<1	0.84	<2	31
	28 Oct	2.3	-[a]	<0.1	-[a]	<30
	16 Dec	2.6	3.4	0.7	<1.0	130
	$\bar{x}$	5.9	-[b]	-[b]	-[b]	61
7	15 Apr	3.5	<1	0.50	11	12
	17 Jun	2.0	<1	1.74	<2	36
	28 Oct	4.6	-[a]	<0.1	-[a]	<30
	16 Dec	5.6	8.2	<0.1	<1.0	55
	$\bar{x}$	3.9	-[b]	-[b]	-[b]	38
3	15 Apr	9.5	<1	1.05	<2	42
	17 Jun	7.5	<1	2.21	<2	66
	28 Oct	4.2	-[a]	<0.1	-[a]	<30
	16 Dec	4.3	1.8	<0.1	<1.0	50
	$\bar{x}$	6.4	-[b]	-[b]	-[b]	52

[a] Not available.
[b] Not calculated.

Table 2-7 Groundwater data collected near Wolf Creek Generating Station, April and October 1980.

Location	Date	Temperature (°C)	pH (units)	Alkalinity (mg/l $CaCO_3$)	Conductivity (μmhos/cm)	Hardness Total (mg/l)	TDS (mg/l)	Turbidity (N.T.U.)	Ca (mg/l)	Cl (mg/l)	Fl (mg/l)	Mg (mg/l)
B12	14 APR	11.0	7.3	285	1000	378	696	5.0	120	-[a]	0.32	19
	27 OCT	11.0	7.4	233	370	1440	684	-[a]	400	56.5	1.2	110
C20	14 APR	11.0	6.8	224	1300	702	654	30	250	150	0.14	19
	27 OCT	-[b]	-	-	-	-	-	-	-	-	-	-
C49	14 APR	13.5	6.8	360	1100	560	765	1.5	160	56	0.21	39
	27 OCT	12.5	7.1	170	1100	439	720	-[a]	120	6075	1.4	35
D65	14 APR	13.5	6.5	180	5000	2360	344	10	730	-[a]	0.11	130
	27 OCT	12.5	6.6	41	4400	1780	2980	-[a]	550	6045	1.6	98

Location	Date	K (mg/l)	Na (mg/l)	SO_4 (mg/l)	$NO_3 + NO_2$ (mg/l-n)	NO_3 (mg/l-n)	NO_2 (μg/l-n)	P (μg/l)	Si (mg/l SiO_2)	Fe, total (mg/l)	Fe, soluble (μg/l)	Mn (μg/l)	Se (μg/l)
B12	14 APR	1.7	140	-[a]	-[a]	-[a]	4	74	9.3	0.97	15	-[a]	<2
	27 OCT	120	340	774	110	-[a]	-[a]	450	14.3	32	1600	0.47	-[a]
C20	14 APR	1.1	25	-[a]	-[a]	-[a]	7	9	10	5.8	46	-[a]	<2
	27 OCT	-[b]	-	-	-	-	-	-	-	-	-	-	-[a]
C49	14 APR	1.4	65	-[a]	-[a]	-[a]	2	100	14	-[a]	36	-[a]	<2
	27 OCT	0.87	70	151	6.7	-[a]	-[a]	60	11.7	-[a]	100	0.10	-[a]
D65	14 APR	2.1	300	-[a]	-[a]	-[a]	52	54	10	5.7	48	-[a]	<2
	20 OCT	1.4	230	30	420	-[a]	-[a]	24	12.9	3.0	200	0.47	-[a]

[a] Not analyzed.
[b] Pump malfunction.

2.2 RESULTS AND DISCUSSION

2.2.1 Surface Water Hydrology

Local precipitation and groundwater inflow play an important role in maintenance of instream flows, and consequently, water quality in the Neosho River and Wolf Creek. During 1980, 66 centimeters of precipitation were recorded at John Redmond Dam, 19 centimeters below the average annual precipitation level of 85 centimeters (NOAA, 1980). Total monthly precipitation levels were below normal throughout the year with the exception of March and December (Figure 2-1). Locally heavy rainfall events (>5 centimeters) were recorded in March and June of 1980. Flow in Wolf Creek at Locations 3 and 7 was essentially nonexistent during 1980 sampling periods due to low precipitation in the study area.

Neosho River flows near WCGS have been controlled by the operation of John Redmond Dam above Burlington, Kansas since 1963. Discharges into the river during 1980 were low for most of the year. Monthly mean flow ranged from 61 cfs in October to 6,025 cfs in April (Table 2-8). Peak discharges occurred in April and were similar in magnitude to peaks observed in June and July of 1979. Peak river discharge was 10,340 cfs recorded on 12 April 1980.

Water quality sampling dates in 1980 coincided with high flow in April and low flow in June, September, and December. Sampling in April was conducted the last day that flows exceeded 10,000 cfs; within 17 days, recorded flows were below 1,000 cfs and flows for the remainder of the year were generally below 500 cfs.

Flow data is unavailable for Wolf Creek as it is ungauged. Locations sampled during 1980 generally consisted of small pools which became progressively smaller throughout the year. Construction of the cooling lake site and dam controlled flows at Location 3 when precipitation events did occur and dam closure was essentially complete by September 30, 1980.

2.2.2 Neosho River

Water quality of the Neosho River was similar at all locations during 1980 with the exception of turbidity and total iron levels in June (Tables 2-2 through 2-6). No significant ($P > 0.05$) spatial differences were observed in the concentration of the parameters measured. Based on millequivalents per liter of the predominant cations and anions, water in the Neosho River can generally be classified as "calcium-sulfate water".

2.2.2.1 General Water Quality

Water temperature and dissolved oxygen (DO) levels exhibited normal seasonal trends. DO levels were generally higher at Location 1 as were oxygen saturation values (Table 2-2). Aeration of water as it passes through the control gates of John Redmond Dam and low water discharge account for this difference. Oxygen supersaturation was observed at Location 1 in October and Location 4 in April. Seasonal mean concentrations of total dissolved solids (TDS) and related dissolved constituents were generally highest in December at all locations (Table 2-3). Total suspended solids (TSS) and turbidity levels were highest in April as were total iron concentrations and color levels.

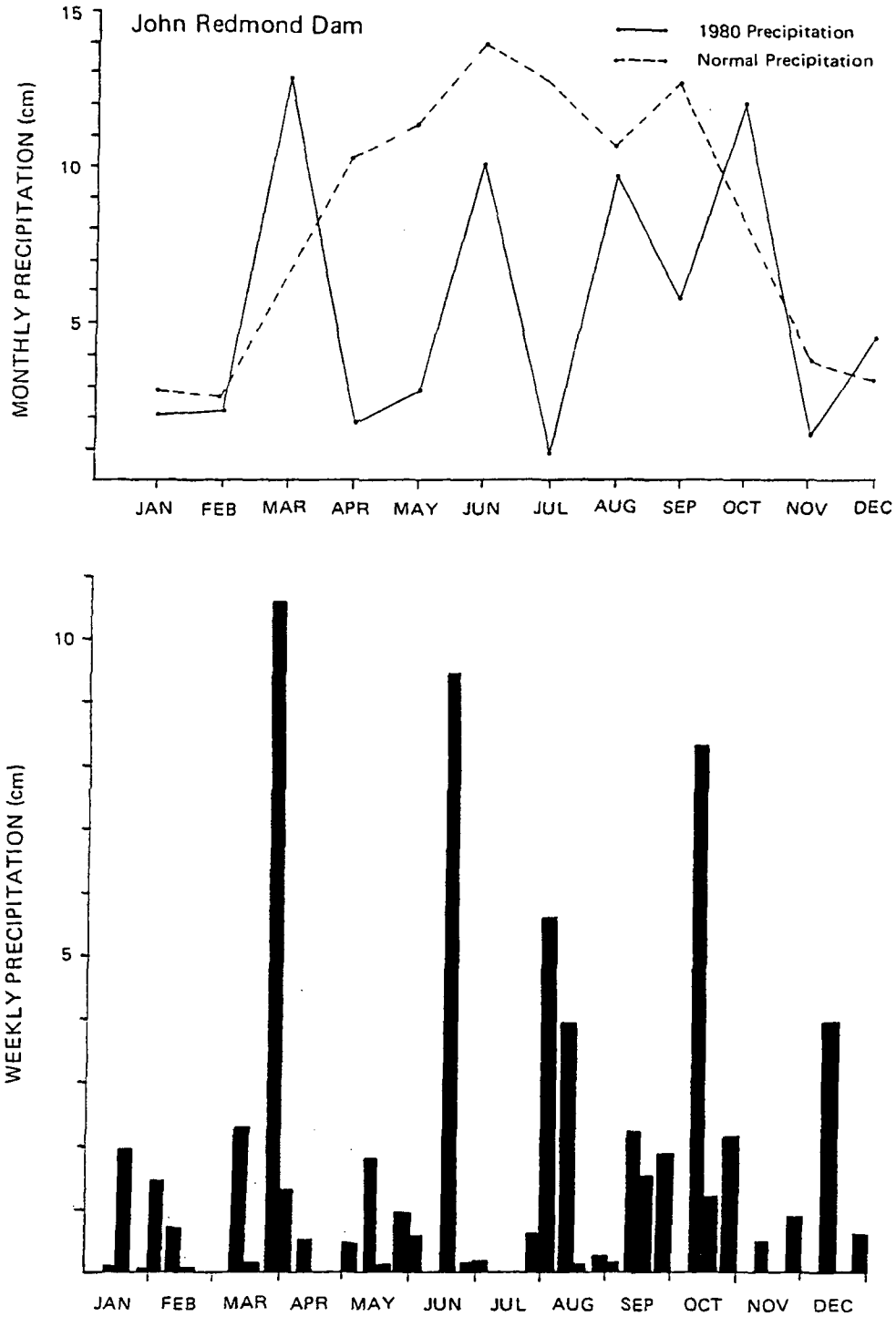

Figure 2-1 Precipitation at John Redmond Reservoir near the Wolf Creek Generating Station, 1980. (NOAA 1980).

Table 2-8 Mean daily river flow (cfs) in the Neosho River, 1980.

Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	140	140	1840	70	1770	175	285	64	64	64	140	156
2	140	140	1820	550	1266	202	285	64	265	64	140	83
3	140	140	1800	2777	820	260	285	64	64	64	140	130
4	140	140	1745	6925	820	265	225	64	64	64	140	156
5	140	140	1685	9065	600	235	200	64	64	64	122	156
6	140	140	1640	8980	410	175	200	64	64	52	85	156
7	140	140	1020	8655	410	175	200	64	64	52	85	156
8	140	140	150	8080	410	175	200	64	64	57	85	156
9	140	140	150	7820	258	175	200	64	64	59	85	156
10	140	140	150	8432	140	175	265	64	64	49	85	122
11	140	140	150	9585	140	180	325	64	64	49	85	130
12	140	140	1110	10340	140	180	325	64	64	49	85	148
13	140	140	1760	10220	160	180	325	64	64	49	155	148
14	140	140	1730	10245	160	180	325	64	64	49	169	148
15	140	570	1710	10088	165	180	300	64	64	49	156	148
16	140	915	1690	9710	425	180	275	64	64	49	156	148
17	140	915	1680	9330	640	180	275	64	64	49	156	118
18	270	915	1055	7730	640	180	193	64	64	49	156	94
19	450	915	710	7730	640	180	140	64	64	49	156	86
20	450	915	710	7730	640	180	140	64	64	49	156	86
21	450	903	710	7116	640	175	140	64	64	49	156	86
22	450	150	710	3777	640	180	117	64	64	49	156	43
23	960	160	710	1595	640	230	73	64	64	49	156	19
24	1360	170	725	2080	640	285	74	64	64	49	156	19
25	1100	2185	740	2390	640	285	77	64	64	49	156	19
26	900	4005	1725	2210	640	285	82	64	64	49	156	19
27	900	3900	2285	2010	395	285	89	64	64	73	156	19
28	575	3780	2340	1895	165	285	93	64	64	86	156	19
29	140	2535	2500	1835	165	285	103	64	64	110	156	19
30	140		285	1805	170	285	112	64	64	131	156	19
31	140		70		170		112	64		140	156	
Mean	344	858	1196	6025	501	213	194	64	70	61	136	96

High levels of suspended material and related constituents were attributed to the high discharge levels from John Redmond Dam, which included spring runoff water and suspended material, resulting from bottom and shoreline scouring.

2.2.2.2 Aquatic Nutrients

Seasonal mean concentrations of aquatic nutrients were highest in December with the exception of nitrate and soluble silica which was highest in April (Table 2-4). Annual mean concentrations of nitrogen species were slightly higher at Location 1 than Locations 10 and 4, however, no significant ($P > 0.05$) spatial differences were observed. Considerable temporal variability was apparent. Peak concentrations of most aquatic nutrients in December may be related to reduced primary productivity activity due to lower water temperature (Section 3.2). Aquatic nutrients were present in concentrations considered adequate to support aquatic species.

2.2.2.3 Indicators of Municipal and Industrial Contamination

Variability in concentrations of this group of water quality constituents over time was highly significant ($P \leq 0.05$), with the exception of total organic carbon (TOC). Seasonal mean concentrations of biochemical oxygen demand (BOD), fecal streptococcus bacteria, and oil-and-grease (hexane soluble material) were generally highest in October (Table 2-5). No significant ($P \geq 0.05$) spatial variability occurred during 1980. However, annual mean concentrations of fecal coliform, fecal streptococcus, and COD (457/100 ml, 119/100 ml, and 39 mg/l, respectively) were higher at Location 10. Fecal coliform densities were consistently higher at Locations 10 and 4, indicating a predominance of sewage-related organisms in the lower river which is downstream of the Burlington sewage treatment plant (Table 2-5).

2.2.2.4 Trace Metals

Trace metal concentrations exhibited spatial and temporal variability during 1980; however, differences among locations were not significant ($P \leq 0.05$). Copper concentrations were highest in April and ranged from 9 to 12.5 µg/l (Table 2-6). Annual mean concentrations were highest at Location 1 (7.6 µg/l). Lead concentrations ranged from <1 to 5.3 µg/l and were highest at Location 1 in December. Annual mean concentrations of lead, mercury and selenium were not calculated as values were generally below analytical detection limits. Peak concentrations of zinc were observed at Locations 1 and 4 in December and at Location 10 in June. Annual mean concentrations were highest at Location 4 (61 µg/l).

2.2.3 Wolf Creek

2.2.3.1 General Water Quality

Spatial and temporal variability of general water quality constituents were observed during 1980. Spatial differences were not significant ($P > 0.05$); however, the differences in seasonal means for water temperature, DO, pH, total alkalinity, sodium and soluble iron were significant ($P \leq 0.05$). Temperature, pH, total alkalinity, and specific conductance were highest in

June (Table 2-2). TDS, calcium, chloride, sodium and magnesium were highest at Location 7 in June and Location 3 in December (Tables 2-2 and 2-3). These differences reflect local variations in ground cover, bottom substrate and water volume as the locations were generally isolated from each other during the year. Low water temperatures recorded during October were attributed to low water levels and cool air temperatures at night. Annual mean concentrations of pH, (7.5 units), total alkalinity (134 mg/l), potassium (6.4 mg/l), soluble iron (419 μg/l), and color (37 units) were higher at Location 7 during 1980. The remaining general water quality constituents were highest at Location 3. Soluble iron and color levels are probably related to breakdown of leaf litter in the bottom of the pools sampled at Location 7. Hem (1970) reported that iron content of streams is often affected by decomposing leaf litter.

2.2.3.2 Aquatic Nutrients

Significant ($P \leq 0.05$) temporal variability of ammonia, total organic nitrogen, soluble orthophosphate and soluble silica concentrations was observed during 1980. Soluble silica was highest during June and soluble orthophosphate and total phosphate were higher in December (Table 2-4). Annual mean concentrations of ammonia (0.05 mg/l-N); total organic nitrogen (0.73 mg/l-N); soluble orthophosphate (88 μg/l-P), and total phosphorus (367 μg/l-P) were higher at Location 7, while annual mean concentrations of nitrate (2.73 mg/l-N), nitrite (0.015 mg/l-N), and soluble silica (4.9 mg/l-SiO_2) were higher at Location 3 (Table 2-4). The high annual mean concentration of nitrate at Location 3 resulted from high levels in April. The April concentration (10.0 mg/l-N) was ≈6 times higher than in previous studies and may represent fertilizer runoff.

2.2.3.3 Indicators of Municipal and Industrial Contamination

Differences in concentrations between locations of these indicator parameters reflect the isolation of the creek locations discussed in Section 2.2.3.1. Peak seasonal mean levels of BOD, TOC, fecal coliform, and fecal streptococcus at Location 7 and BOD, COD, and oil-and-grease at Location 3 were observed in October (Table 2-5). Annual mean concentrations of this group of parameters were highest at Location 7 with the exception of fecal streptococcus. Oxygen demand and TOC levels were probably higher at Location 7 due to greater levels of organic debris on the bottom of the creek bed as discussed in Section 2.2.3.1. BOD, COD, TOC, fecal coliform, and fecal streptococcus levels were generally higher in Wolf Creek than in the Neosho River. Oil-and-grease concentrations were below detection limits in Wolf Creek during April and October at Location 7 and in June at Location 3. High levels of oil-and-grease were observed at Location 7 in December and Location 3 in October (422 mg/l and 81 mg/l, respectively). High oil-and-grease values may be the result of natural oil products from the breakdown of plant material and/or variation in analytical methods.

2.2.3.4 Trace Metals

Concentrations of trace metals in Wolf Creek varied slightly among locations and with time; temporal variation observed in mercury concentrations were significant ($P \leq 0.05$). Seasonal concentrations of copper, lead, and zinc at Location 7 were highest in December whereas concentrations at Location 3 were higher in April and June (Table 2-6). Annual mean concentrations of

copper and zinc were highest at Location 3. Annual mean concentrations were not calculated for the remaining trace metals as levels were below detection limits.

2.2.4 Comparison to Previous Data

Water quality in the Neosho River is subject to variation in discharge rates from John Redmond Dam, inflow from Wolf Creek, groundwater inflow, and local precipitation runoff. Discharges from John Redmond and groundwater inflow were the main contributors to flow in the river due to the 1980 drought conditions. Water quality generally followed seasonal concentration patterns reported during previous studies. Seasonal mean manganese concentrations were higher throughout the year and copper, mercury, and zinc were higher for most seasons. Concentrations of nitrate and soluble orthophosphate were higher than previously reported in April and April, October, and December, respectively. Total organic nitrogen (April and June) and soluble silica (June, October, and December) concentrations were lower than values previously reported.

Organic demand parameters (BOD, COD) were generally higher than previously reported during October and December, while oil-and-grease values were higher during April 1980. Based on the aquatic ecology sampling conducted near the WCGS during 1980, there is no evidence that the variations in water quality parameters has had detrimental effects on endemic aquatic biota nor could changes be directly related to construction activities.

2.2.5 Comparison of Results to Kansas Water Quality Criteria

During 1980, water quality in the Neosho River was generally adequate to meet the assigned water quality criteria for all specific constituents except ammonia (Table 2-9). Ammonia concentrations exceeded the 0.15 mg/l allowable concentration at Locations 1 and 4 in December (Table 2-4). Water quality criteria are applicable to all assigned water bodies in the state unless the flow is below the seven day-ten year low flow. Based on discharge data (Table 2-8), the flows when these criteria were exceeded were in excess of the seven day-ten year low flow (15 cfs).

State water quality criteria do not provide limitations for several specific parameters that are discussed in The Quality Criteria for Water (U.S. EPA 1976). Review of these criteria indicated that the recommended criterion for phosphate (25 μg/liter) was exceeded at all locations in the Neosho River during 1980. Mercury (0.05 μg/liter) and iron (1.0 mg/liter) criteria were exceeded at most river locations.

Exceeding these criteria may not result in a detrimental effect on the biological populations in the Neosho River because the synergistic reactions of physical parameters (e.g., pH, temperature, and light penetration), river flow, and contact time with the various parameters have a role in determining the effect of the criteria exceeded.

Based on current and past chemical and biological data, exceeding the above criteria has not been detrimental to the overall biological integrity of the

Table 2-9 Water quality criteria for Kansas surface waters applicable to the Neosho River.[a]

Parameter	Criterion
Temperature, water	32.2 C (90 F)
Oxygen, dissolved	Not less than 5 mg/l
pH	6.5 to 8.5
Ammonia	0.15 mg/l-N maximum
Bacteria, fecal coliform	Not to exceed 2000 per 100 ml sample
Oil and grease	No evidence of visible oil or grease
Turbidity and total suspended solids	No increases from other than natural origin
Color	No man-made point source discharges of color producing substances
Taste and odor producing substances	No increases from man-made point discharges
Toxic substances	Man-made point discharges limited to concentrations in receiving water that will not harm human or aquatic life

[a] Kansas Department of Health and Environment (1977).

Neosho River. Since studies began near the WCGS, few violations of water quality criteria have occurred. During the present study, oil-and-grease levels exceeded the criteria for the first time. However, the results are not directly comparable to previous data because of differences in analytical methodology. The source of these higher levels could not be determined.

2.2.6 Groundwater

Variation in groundwater quality is related to many factors including water table fluctuation, well construction, surface water inflow, land use, and well and pump condition. Samples collected during the 1980 study indicated groundwater quality varied over time and among wells. Temporal variation was probably related to the dry conditions throughout the year which resulted in low recharge rates. Wells B-12 and C-20 were difficult to pump during 1980 and Well C-20 failed to produce water during the October study. With the exception of sodium, potassium, and sulfates, the concentration of major ionic constituents was highest in Well D-65 (Table 2-7).

The 1980 concentrations of calcium, phosphorus, silica, total iron, and manganese were generally higher than in 1979. Concentrations of these constituents were highest in Well B-12 in October and Wells C-49 and D-65 in April with the exception of silica in Well D-65 which was higher in October. Based on specific conductance, TDS and total hardness levels, Wells B-12 and D-65 appear to have higher levels of dissolved materials with Well D-65 having the highest. Concentrations of calcium, magnesium, potassium, sodium, sulfate, and total iron in Well B-12 were substantially higher in October and were in excess of previous data. This drastic increase is probably the result of poor well maintenance and concentration of constituents from low water levels. Well B-12 is no longer used on an active basis with the exception of groundwater monitoring. This low usage may also result in chemical changes in water quality resulting from reactions with the casing and water-bearing formations. Water quality in D-65 was slightly better overall and appeared to be less colored during 1980 compared to previous data. This may be attributed to casing modifications made during 1980.

National secondary drinking water criteria (U.S. EPA 1979b) for TDS, chlorides, sulfates, and total iron were exceeded in one or all the wells during 1980. Selenium concentrations, which have exceeded the EPA criteria in previous years were below detection limits in April and no data was available for October.

2.3 SUMMARY AND CONCLUSIONS

Water quality in the Neosho River and Wolf Creek during 1980 was affected by low flows, lack of local precipitation, and in the case of Wolf Creek, pooling of water at sampling locations. Neosho River water quality was generally good, with slightly lower quality at the lower river locations (10 and 4). Spatial differences were not significant with the exception of turbidity and total iron levels which were higher at Location 1.

Kansas water quality criteria for ammonia (0.15 mg/l) were exceeded at Locations 1 and 4 in the Neosho River. In addition, EPA-recomended criteria

for phosphate was exceeded in all samples and mercury and iron criteria were exceeded at most river locations. Oil-and-grease results indicated high levels of this material during October. However, due to a variation in analytical methods, results are inconclusive.

Selected nutrient concentrations were lower during 1980 than previously recorded, while oxygen demand parameters and several trace metals were higher than in past years. These differences reflect the lower precipitation levels and subsequent lower flows resulting in a concentrating effect on dissolved constituents, and the lack of heavy nutrient inflow during rainfall events.

Groundwater samples collected during 1980 varied in quality over time and among wells. Concentrations of calcium, phosphorus, total iron, and manganese were higher than in 1979. Temporal variation in concentration is probably due to the drought condition in the area resulting in low groundwater recharge and therefore higher ionic constituent concentration.

3. PHYTOPLANKTON

3.1 FIELD AND ANALYTICAL METHODS

Duplicate water samples for phytoplankton analyses were collected quarterly at Locations 1, 4, and 10 on the Neosho River. Subsamples were stored in prelabeled, 8-oz bottles containing five milliliters of M^3 preservative (Meyer 1971) for later algae identification, enumeration, and biovolume determination. Carbon fixation rate and chlorophyll a concentration were assessed from unpreserved portions of the samples and were used as indices of primary productivity.

The inverted microscope method (Lund et al. 1958; Weber 1973) was used to determine phytoplankton species composition and abundance. Identification and enumeration of phytoplankton were performed under oil immersion at 1,000X magnification. Approximately 400 reporting units per duplicate sample were identified to the lowest positive taxa and quantitatively reported using various reporting units:

Algal Form	Reporting Units (units/ml)
Diatoms	Each frustule
Unicellular	Each cell
Colonial	4 cells (50 cells for some blue-green algae)
Filamentous	100-μm lengths

Taxonomic keys used as identification aids included Hustedt (1930), Smith (1950), Cleve-Euler (1951), Tiffany and Britton (1952), Drouet and Daily (1956), Edmondson (1959), Prescott (1962, 1964), Patrick and Reimer (1966, 1975), Drouet (1968), Stoermer and Yang (1969), Weber (1971), and Whitford and Schumacher (1973).

Density data were used to calculate diversity and evenness (Shannon 1948 using natural logarithms; Pielou 1966; Zar 1968) at each location on each sampling date. Biovolume determinations were made following the procedures described by Cowell (1960) and Hohn (1969). Cell volumes were calculated using the geometrical configuration that best suited each taxon and expressed as microliters per liter (μl/liter).

The rate of carbon fixation was estimated with the light bottle/dark bottle C-14 method (Wetzel 1964; Parkos et al. 1969; Strickland and Parsons 1972). Six 50-ml light bottle subsamples (three per duplicate water sample) and one 50-ml dark bottle subsample per location were inoculated with 4-6 microcuries of aqueous C-14 bicarbonate solution. Dark bottle subsamples were wrapped in aluminum foil to exclude light, and all subsamples were incubated for 3 hours at a constant temperature (near ambient) and light intensity in an environmental chamber. Subsamples were filtered onto membrane filters (0.45-μm pore size), which then were air-dried under dark conditions. Upon return to the laboratory, the filters were dried further in a desiccator, fumed with concentrated HCl for 10 minutes (Wetzel 1965), and placed in low potassium scintillation

vials. After 17 milliliters of scintillation fluid were added to each vial, C-14 activity was measured with a refrigerated liquid scintillation counter. Primary productivity was expressed as carbon fixed per cubic meter of water per hour (mg $C/m^3/hr$) at each location.

Six 50-ml subsamples per location (three per duplicate water sample) were filtered through a thin layer of $MgCO_3$ on glass-fiber filters for chlorophyll a analysis. Filters were placed in centrifuge tubes and stored on ice under dark conditions, until further processing. The filters later were eluted in 10 milliliters of 90 percent aqueous acetone for 24 hours at 4 C under dark conditions, then subjected to ultrasonic disruption. After samples were clarified by centrifugation, their fluorescence was determined before and after the addition on 1N HCl (Lorenzen 1966). Standard equations (Strickland and Parsons 1972; APHA 1976) were used to calculate chlorophyll a concentrations. These concentrations, corrected for phàeopigments, were reported per cubic meter of water (mg Chl a/m^3) at each location.

3.2 RESULTS AND DISCUSSION

Phytoplankton collected in the Neosho River during 1980 consisted of 100 taxa representing 58 genera and 7 algal divisions (Table 3-1). The Chlorophyta (green algae) and Bacillariophyta (diatoms) were especially well represented (40 and 28 taxa, respectively). Density and biovolume for each taxon are presented by sampling date and location in Appendix B, along with summaries of phytoplankton data for 1973 through 1979.

During 1980, total phytoplankton densities ranged from 4,910 to 115,407/ml (Table 3-2). Densities were similar to respective values in previous years except in October when total densities were 3-10 times as great as previously observed. However, the 1980 results were not directly comparable to those of previous years because laboratory methods had been changed. A modified Lackey microtransect method (Lackey 1938; Mackenthun 1969) was used prior to 1980, but the inverted microscope method was used in 1980. In April and June, densities were similar at upstream (1) and downstream locations (4 and 10). Upstream densities were much greater than downstream densities in October and December.

Numerical dominance of the phytoplankton community in the Neosho River shifted among algal groups during the 1980 sampling season. Centric diatoms (Centrales) generally were dominant at all three locations on 15 April and 17 June, although green algae were slightly more abundant than centric diatoms at Location 1 near John Redmond Reservoir in June. In October the blue-green alga Merismopedia tenuissima was most important numerically at all locations. Different groups dominated the phytoplankton at upstream and downstream locations during December; diatoms were most abundant upstream while green algae dominated downstream. Green algae was always the second most important algal group numerically when diatoms were dominant. Previous studies have attributed the frequent importance of centric diatoms in this portion of the Neosho River to upstream discharges from the John Redmond Reservoir because large populations of these diatoms are generally characteristic of lentic (lake) habitats (Repsys 1979a; Bockelman 1980a).

Table 3-1 Algae identified in phytoplankton samples from the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.

BACILLARIOPHYTA (Diatoms)
- Centrales
  - Cyclotella atomus Hustedt
  - Cyclotella meneghiniana Kuetzing
  - Melosira ambigua (Grunow) O. Mueller
  - Melosira distans (Ehrenberg) Kuetzing
  - Melosira granulata (Ehrenberg) Ralfs
  - Skeletonema potamos (Weber) Hasle
  - Stephanodiscus astraea (Ehrenberg) Grunow
  - Stephanodiscus hantzschii Grunow
  - Stephanodiscus minutus Grunow ex Cleve and Moller
  - Thalassiosira fluviatilis Hustedt
  - Unidentified small centrics
- Pennales
  - Asterionella formosa Hassall
  - Cocconeis placentula Ehrenberg
  - Gomphonema parvulum (Kuetzing) Kuetzing
  - Navicula cryptocephala Kuetzing
  - Nitzschia acicularis (Kuetzing) W. Smith
  - Nitzschia apiculata (Gregory) Grunow
  - Nitzschia holsatica Hustedt
  - Nitzschia kutzingiana Hilse
  - Nitzschia linearis (Agardh) W. Smith
  - Nitzschia longissima (Brebisson ex Kuetzing) Grunow
  - Nitzschia palea (Kuetzing) W. Smith
  - Nitzschia tryblionella Hantzsch
  - Nitzschia spp.
  - Rhoicosphenia curvata (Kuetzing) Grunow ex Rabenhorst
  - Surirella ovalis Brebisson
  - Surirella ovata Kuetzing
  - Unidentified pennates

CHLOROPHYTA (Green Algae)
- Actinastrum hantzschii Lagerheim
- Ankistrodesmus convolutus Corda
- Ankistrodesmus falcatus (Corda) Ralfs
- Carteria cordiformis (Carter) Diesing
- Chlamydomonas spp.
- Coelastrum microporum Naegeli ex A. Braun
- Cosmarium spp.
- Crucigenia crucifera (Wolle) Collins
- Crucigenia fenestrata Schmidle
- Crucigenia quadrata Morren
- Crucigenia tetrapedia (Kirchner) West and West
- Dictyosphaerium ehrenbergianum Naegeli
- Dictyosphaerium pulchellum Wood
- Elakatothrix viridis (Snow) Printz
- Franceia ovalis (France) Lemmermann
- Gloeocystis gigas (Kuetzing) Lagerheim
- Golenkinia radiata (Chodat) Wille
- Kirchneriella subsolitaria G.S. West
- Lagerheimia quadriseta (Lemmermann) G.M. Smith
- Lagerheimia wratislawiensis (Schroeder) Ley
- Micractinium pusillum Fresenius
- Oocystis borgei Snow
- Oocystis pusilla Hansgirg
- Pediastrum duplex Meyen
- Pediastrum tetras (Ehrenberg) Ralfs
- Pteromonas spp.

CHLOROPHYTA (continued)
- Scenedesmus abundans (Kirschner) Chodat
- Scenedesmus acuminatus (Lagerheim) Chodat
- Scenedesmus bicellularis Chodat
- Scenedesmus bijuga (Turpin) Lagerheim
- Scenedesmus dimorphus (Turpin) Kuetzing
- Scenedesmus longus Meyen
- Scenedesmus quadricauda (Turpin) Brebisson
- Scenedesmus spp.
- Selenastrum minutum (Naegeli) Collins
- Selenastrum westii G.M. Smith
- Sphaerocystis schroeteri Chodat
- Tetraedron muticum (A. Braun) Hansgirg
- Tetrastrum staurogeniaeforme (Schroeder) Lemmermann
- Unidentified coccoid greens

CHRYSOPHYTA (Yellow-green Algae)
- Arachnochloris minor Pascher
- Chlorallanthus oblongus Pascher
- Chrysochromulina spp.
- Mallomonas tonsurata Teiling
- Ochromonas spp.
- Synuropsis globosa Schiller
- Trachychloron depauperatum Pascher

CRYPTOPHYTA (Cryptomonads)
- Chroomonas spp.
- Cryptomonas spp.
- Rhodomonas minuta (Skuja)

CYANOPHYTA (Blue-green Algae)
- Anabaena spp.
- Aphanocapsa delicatissima West and West
- Aphanocapsa elachista West and West
- Aphanothece nidulans P. Richter
- Chroococcus dispersus (Keissler) Lemmermann
- Merismopedia tenuissima Lemmermann
- Microcystis aeruginosa Kuetzing emend. Elenkin
- Unidentified coccoid blue-greens

EUGLENOPHYTA (Euglenoids)
- Euglena acus Ehrenberg
- Euglena gracilis Klebs
- Euglena polymorpha Dangeard
- Phacus caudatus Heubner
- Phacus helikoides Pochmann
- Phacus lemmermannii (Swirenko) Skvortzow
- Phacus pyrum (Ehrenberg) Stein
- Phacus spp.
- Trachelomonas crebea (Kellicott) DeFlandre
- Trachelomonas hispida (Perty) Stein
- Trachelomonas volvocina Ehrenberg

PYRRHOPHYTA (Dinoflagellates)
- Glenodinium spp.
- Gymnodinium spp.

Unidentified Microflagellates

Table 3-2 Mean density and biovolume of total phytoplankton and major algal groups in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.

		Density at Sampling Locations						Biovolume at Sampling Locations					
		1		10		4		1		10		4	
Date	Taxonomic Group	Units Per ml	%	Units Per ml	%	Units Per ml	%	µl per liter	%	µl per liter	%	µl per liter	%
15 April	Bacillariophyta	2604	51.17	2584	52.63	2614	51.75	2.368	85.90	2.164	80.36	2.299	80.54
	(Centrales)[a]	(2514)	(49.40)	(2494)	(50.80)	(2584)	(51.16)	(2.314)	(83.91)	(2.136)	(79.32)	(2.294)	(80.38)
	(Pennales)[a]	(90)	(1.76)	(90)	(1.83)	(30)	(0.59)	(0.055)	(1.99)	(0.028)	(1.04)	(0.005)	(0.16)
	Chlorophyta	1020	20.05	1235	25.15	1442	28.54	0.122	4.42	0.178	6.59	0.185	6.46
	Chrysophyta	0	0.00	10	0.20	42	0.84	0.000	0.00	<0.001	0.02	0.014	0.49
	Cryptophyta	309	6.08	369	7.51	419	8.29	0.154	5.59	0.101	3.74	0.232	8.11
	Cyanophyta	1006	19.77	532	10.84	384	7.60	0.015	0.55	0.028	1.05	0.007	0.27
	Euglenophyta	10	0.20	50	1.02	20	0.40	0.040	1.46	0.168	6.25	0.064	2.26
	Pyrrhophyta	0	0.00	0	0.00	0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	Total Phytoplankton	5089	100.00	4910	100.00	5051	100.00	2.757	100.00	2.692	100.00	2.854	100.00
17 June	Bacillariophyta	3711	34.56	4235	43.90	6637	49.95	2.251	65.34	1.699	36.84	2.753	63.10
	(Centrales)[a]	(3637)	(33.86)	(4071)	(42.20)	(6428)	(48.38)	(2.228)	(64.66)	(1.634)	(35.44)	(2.704)	(61.98)
	(Pennales)[a]	(75)	(0.69)	(165)	(1.71)	(210)	(1.58)	(0.023)	(0.67)	(0.064)	(1.41)	(0.049)	(1.12)
	Chlorophyta	3786	35.25	2750	28.51	4048	30.47	0.671	19.48	0.819	17.75	0.984	22.54
	Chrysophyta	15	0.14	3	0.03	45	0.34	0.002	0.04	<0.001	<0.01	0.004	0.09
	Cryptophyta	239	2.23	673	6.98	299	2.25	0.026	0.75	0.449	9.74	0.096	2.21
	Cyanophyta	2839	26.43	1656	17.17	1883	14.17	0.278	8.07	0.069	1.52	0.104	2.38
	Euglenophyta	30	0.28	75	0.77	90	0.67	0.208	6.05	1.542	33.43	0.379	8.68
	Pyrrhophyta	0	0.00	15	0.16	15	0.11	0.000	0.00	0.015	0.32	0.022	0.51
	Total Phytoplankton	10740	100.00	9647	100.00	13287	100.00	3.445	100.00	4.612	100.00	4.363	100.00
23 October	Bacillariophyta	16515	14.31	7111	22.73	5161	10.91	3.628	54.20	0.926	34.63	0.657	34.64
	(Centrales)[a]	(13189)	(11.43)	(6423)	(20.53)	(4473)	(9.45)	(2.135)	(31.89)	(0.825)	(30.85)	(0.583)	(30.74)
	(Pennales)[a]	(3326)	(2.88)	(688)	(2.20)	(688)	(1.45)	(1.493)	(22.30)	(0.101)	(3.78)	(0.074)	(3.90)
	Chlorophyta	18522	16.05	7570	24.20	11440	24.18	0.976	14.58	0.426	15.92	0.538	28.36
	Chrysophyta	344	0.30	688	2.20	688	1.45	0.023	0.35	0.030	1.11	0.063	3.33
	Cryptophyta	3899	3.38	3670	11.73	1835	3.88	0.793	11.84	1.062	39.70	0.454	23.95
	Cyanophyta	75552	65.47	12128	38.77	28185	59.58	0.404	6.04	0.074	2.79	0.184	9.71
	Euglenophyta	573	0.50	115	0.37	0	0.00	0.869	12.99	0.156	5.85	0.000	0.00
	Pyrrhophyta	0	0.00	0	0.00	0	0.00	0.000	0.00	0.000	0.00	0.000	0.00
	Total Phytoplankton	115407	100.00	31282	100.00	47310	100.00	6.694	100.00	2.675	100.00	1.897	100.00
16 December	Bacillariophyta	24341	39.73	3144	12.00	4023	14.72	7.498	53.93	1.033	22.76	1.410	28.97
	(Centrales)[a]	(21062)	(34.38)	(2637)	(10.06)	(3584)	(13.11)	(7.074)	(50.88)	(0.899)	(19.82)	(1.208)	(24.82)
	(Pennales)[a]	(3279)	(5.35)	(507)	(1.93)	(439)	(1.61)	(0.424)	(3.05)	(0.134)	(2.95)	(0.202)	(4.15)
	Chlorophyta	17664	28.83	13320	50.82	15289	55.95	2.574	18.51	1.864	41.07	1.882	38.67
	Chrysophyta	8046	13.13	1589	6.06	2231	8.16	0.590	4.24	0.125	2.75	0.174	3.58
	Cryptophyta	3245	5.30	2333	8.90	2840	10.39	1.685	12.12	0.742	16.36	1.051	21.60
	Cyanophyta	7497	12.24	5688	21.70	2907	10.64	0.212	1.53	0.131	2.88	0.030	0.62
	Euglenophyta	203	0.33	68	0.26	34	0.12	1.269	9.12	0.638	14.07	0.319	6.56
	Pyrrhophyta	135	0.22	0	0.00	0	0.00	0.064	0.47	0.000	0.00	0.000	0.00
	Total Phytoplankon	61266	100.00	26209	100.00	27324	100.00	13.903	100.00	4.538	100.00	4.866	100.00

[a] Values for centric and pennate diatoms are presented separately due to their relative importance in phytoplankton.

Total phytoplankton biovolume ranged from 2.68 to 13.90 µl/liter (Table 3-2). These 1980 values fall within the range of phytoplankton biovolumes (0.16-16.55 µl/liter) previously observed in the Neosho River (Table B-6). Centric diatoms, composing 30.7-83.9 percent of total biovolume, dominated phytoplankton biovolume upstream in the Neosho River on all dates and downstream in all but three instances. The other algal groups that dominated at downstream locations included cryptomonads (Cryptophyta) at Location 10 in October (39.7 percent) and green algae at Locations 10 and 4 in December (41.07 and 38.67 percent, respectively). Pennate diatoms (Pennales) and euglenoids (Euglenophyta) also occasionally made important contributions (>20 percent) to total biovolume.

Important centric diatoms observed in the Neosho River during 1980 included Cyclotella atomus, Cyclotella meneghiniana, Melosira granulata, Skeletonema potamos, Stephanodiscus astraea, Stephanodiscus minutus, and Thalassiosira fluviatilis (Table 3-3). Small centric diatoms (<5-µm diameter) that could not be positively identified by the analytical technique employed also were major components (≥5 percent of total density or biovolume) of the phytoplankton community except in April. These diatoms have all been important in the Neosho River during previous studies. Downstream declines in abundance reflecting probable origin in John Redmond Reservoir generally occurred for the Stephanodiscus species, M. granulata, and T. fluviatilis. In December the highest numbers of small unidentified centric diatoms also occurred upstream near the reservoir; however, in June and October, they were less abundant at Location 1 than at the downstream locations. The Cyclotella species and S. potamos were more abundant at downstream locations than upstream.

Taxa other than centric diatoms were also important in terms of density or biovolume, particularly in October and December. In October, M. tenuissima (Cyanophyta) dominated numerically at all locations while Nitzschia tryblionella (Pennales) and Rhodomonas minuta (Cryptophyta) made important contributions to total biovolume. At downstream locations in December, M. tenuissima and the green alga Ankistrodesmus falcatus were major taxa in terms of density; the green alga Chlamydomonas spp. and the cryptomonad Cryptomonas spp. were important in terms of biovolume. Earlier in the year, the euglenoid Euglena acus dominated biovolume at Location 10 on 17 June. Seasonal cycles of nondiatoms in the Neosho River were described by Repsys (1979a). All these important nondiatom taxa, except A. falcatus and E. acus, almost always occurred in highest numbers upstream at Location 1, suggesting their probable origin in John Redmond Reservoir. The greater downstream abundance and biovolumes of A. falcatus and E. acus possibly indicated these organisms are better adapted to, or originate in, the lotic (flowing) habitat of the Neosho River.

Annual maximum phytoplankton abundance has occurred in a different month during each year since 1973. The effects of physical factors such as water temperature, light intensity, and day length that normally control seasonal algal cycles were modified by seasonal differences in discharge rates from John Redmond Reservoir (Bockelman 1980a). Annual climatic differences in length and severity of winters, and the pattern and amount of yearly rainfall were factors that indirectly affected phytoplankton densities in the

Table 3-3 Mean density and biovolume of taxa composing at least 5 percent of total phytoplankton in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.

Date/Taxon	Mean Density (Units/ml) Location 1	10	4	Mean Biovolume (µl/liter) Location 1	10	4
15 April						
Bacillariophyta						
Centrales						
Cyclotella atomus	259	359	279	0.020	0.028	0.022
Stephanodiscus astraea	2125	1946	2055	2.240	2.051	2.166
Chlorophyta						
Ankistrodesmus falcatus	229	249	359	0.006	0.006	0.009
Selenastrum westii	190	247	264	0.005	0.006	0.006
Unidentified Coccoid green	264	239	232	0.027	0.024	0.023
Cryptophyta						
Cryptomonas spp.	80	40	120	0.134	0.066	0.201
Rhodomonas minuta	229	309	279	0.020	0.028	0.025
Cyanophyta						
Aphanocapsa delicatissima	555	151	180	0.009	0.003	0.003
Chroococcus dispersus	432	334	170	0.006	0.004	0.002
17 June						
Bacillariophyta						
Centrales						
Cyclotella atomus	180	658	958	0.017	0.061	0.089
Cyclotella meneghiniana	254	1227	1541	0.073	0.356	0.447
Melosira granulata	913	135	157	0.188	0.028	0.032
Stephanodiscus astraea	1961	1122	2110	1.935	1.108	2.083
Small unidentified Centrics	195	539	1332	0.004	0.012	0.031
Chlorophyta						
Chlamydomonas spp.	150	853	658	0.068	0.390	0.301
Crucigenia tetrapedia	782	322	430	0.030	0.012	0.016
Unidentified Coccoid green	636	483	748	0.172	0.131	0.203
Cryptophyta						
Cryptomonas spp.	0	329	45	0.000	0.407	0.055
Cyanophyta						
Aphanocapsa elachista	874	168	283	0.219	0.042	0.071
Chroococcus dispersus	991	550	696	0.041	0.023	0.029
Merismopedia tenuissima	614	849	831	0.002	0.003	0.002
Euglenophyta						
Euglena acus	0	30	0	0.000	1.298	0.000
Phacus spp.	15	0	15	0.179	0.000	0.179

Table 3-3 (continued)

Date/Taxon	Mean Density (Units/ml) Location 1	10	4	Mean Biovolume (µl/liter) Location 1	10	4
23 October						
Bacillariophyta						
Centrales						
Skeletonema potamos	0	2179	0	0.000	0.122	0.000
Stephanodiscus astraea	918	229	0	0.717	0.179	0.000
Stephanodiscus minutus	2179	1032	803	0.678	0.321	0.250
Small Unidentified Centrics	0	2867	1835	0.000	0.181	0.116
Pennales						
Nitzschia tryblionella	1147	0	0	0.801	0.000	0.000
Chlorophyta						
Selenastrum minutum	6967	2466	5821	0.237	0.083	0.198
Unidentified Coccoid green	0	0	1892	0.000	0.000	0.117
Cryptophyta						
Cryptomonas spp.	0	344	115	0.000	0.516	0.172
Rhodomonas minuta	3785	3326	1720	0.621	0.545	0.282
Cyanophyta						
Merismopedia tenuissima	72054	10551	26207	0.259	0.038	0.094
Euglenophyta						
Trachelomonas volvocina	344	115	0	0.469	0.156	0.000
16 December						
Bacillariophyta						
Centrales						
Thalassiosira fluviatilis	2738	0	338	2.139	0.000	0.264
Small unidentified Centrics	15585	1555	2603	4.161	0.415	0.695
Chlorophyta						
Ankistrodesmus falcatus	0	2637	3178	0.000	0.103	0.124
Chlamydomonas spp.	2738	1995	2299	0.958	0.698	0.805
Crucigenia crucifera	2865	2231	1073	0.751	0.585	0.281
Dictyosphaerium pulchellum	0	1462	3110	0.000	0.130	0.277
Unidentified Coccoid green	0	1927	1724	0.000	0.088	0.079
Chrysophyta						
Chrysochromulina spp.	7945	1487	2096	0.572	0.107	0.151
Cryptophyta						
Cryptomonas spp.	710	270	406	1.435	0.547	0.820
Rhodomonas minuta	0	2062	2434	0.000	0.196	0.231
Cyanophyta						
Merismopedia tenuissima	6356	4234	2434	0.023	0.015	0.008
Euglenophyta						
Euglena gracilis	101	68	34	0.958	0.638	0.319

Neosho River because they influence turbidity, retention time, and algal standing crops in the reservoir. Wilde and Reetz (1976) and Farrell (1978) associated increases in phytoplankton densities and chlorophyll a concentrations with concurrent declines in annual precipitation within the John Redmond Reservoir watershed from 1973 to 1976.

Diversity of phytoplankton in the Neosho River ranged from 1.70 to 3.03 during 1980 (Table 3-4). These values were in the range of values (0.91-3.34) reported in earlier years (Table B-7). Low phytoplankton diversity in October 1980 corresponded to the numerical dominance by the blue-green alga *M. tenuissima*. As in previous years, species indices were similar among Neosho River locations on most sampling dates. The greatest spatial difference occurred on 23 October when diversity ranged from 1.70 at Location 1 to 2.37 at Location 10. Maximum species diversity in 1980 occurred in June. Maximum diversity has occurred in October or December since 1975.

Carbon fixation rates ranged from 0.48 to 108.78 mg $C/m^3/hr$, and chlorophyll a concentrations ranged from 7.31 to 31.28 mg Chl a/m^3 in the Neosho River during 1980 (Table 3-5). Previous ranges in the Neosho River were 0.15-130.65 mg $C/m^3/hr$ and 0.70-50.96 mg Chl a/m^3 (Tables B-8 and B-9). Highest carbon fixation rates occurred in June and corresponded to relatively high chlorophyll a concentrations. Both parameters were highest downstream at Location 4 at this time. Water temperatures in the Neosho River in June were the highest (23.0-23.5 C) observed during sampling. Lowest carbon fixation rates occurred in December when river temperatures had dropped to 4.5-4.6 C. Carbon fixation rates in past years have generally shown summer depressions between spring and fall peaks.

As in previous years, no adverse effects of WCGS construction on phytoplankton composition, abundance, diversity, biovolume, chlorophyll a standing crop, or carbon fixation rate were evident in the Neosho River. Values for these parameters have generally been similar at all three river locations and especially at Locations 10 (upstream from Wolf Creek) and 4 (downstream from Wolf Creek). Wolf Creek, the drainage system through which most runoff from construction-related activities is carried to the Neosho River, has exhibited intermittent flow throughout the monitoring studies and has had only minor effects on flow regimes and phytoplankton in the river. Low or no flow was observed in Wolf Creek during 1980 when precipitation was low. In addition, the cooling lake dam was completed on 30 September, 1980. As previously stated, phytoplankton communities in this portion of the Neosho River have been influenced most directly by water releases from John Redmond Reservoir.

3.3 SUMMARY AND CONCLUSIONS

During 1980, numerical dominance of the phytoplankton community shifted among algal groups. Centric diatoms frequently were dominant although blue-green algae were the most abundant group in October. Green algae were often the second most abundant group. Centric diatoms also most often dominated the phytoplankton biovolume in the Neosho River. Other algal groups that were periodically important in terms of biovolume included green algae, cryptomonads, euglenoids, and pennate diatoms. Major taxa were the same as those in previous studies.

Table 3-4 Average diversity indices for phytoplankton collected from the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.

Date	Location	Species[a] Diversity	Evenness[b] Value	Number of Taxa
15 April	1	2.14	0.70	21
	10	2.37	0.71	28
	4	2.39	0.73	27
17 June	1	2.93	0.82	37
	10	3.03	0.83	40
	4	2.99	0.80	42
23 October	1	1.70	0.50	31
	10	2.37	0.77	22
	4	1.84	0.58	23
16 December	1	2.65	0.71	42
	10	2.84	0.81	34
	4	2.83	0.81	33

[a] Based on Shannon (1948) using natural logarithms.
[b] Zar (1968).

Table 3-5 Mean carbon fixation rates and chlorophyll a concentrations of phytoplankton samples collected from the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.

	Carbon Fixation Rate (mg C/m^3/hr)			Chlorophyll a Concentration (mg Chl*a*/m^3)		
	Location			Location		
Date	1	10	4	1	10	4
15 April	2.84	2.69	2.64	7.31	8.81	7.91
17 June	77.78	33.14	108.78	25.48	20.97	28.06
23 October	7.74	3.47	4.45	31.28	11.37	12.76
16 December	0.48	1.49	1.18	27.41	18.56	14.12

Values for phytoplankton biovolume, diversity, chlorophyll a, and carbon fixation rates observed in 1980 fell within the respective ranges previously reported for these parameters in the Neosho River. Maximum density in 1980 (115,407/ml at Location 1 in October) was much greater than the previous maximum (58,445/ml) reported for the Neosho River. However, 1980 density data were not directly comparable to previous density data because the analytical methods were changed in 1980.

Water releases from John Redmond Reservoir again exerted a controlling influence on phytoplankton in this portion of the Neosho River. Physical and climatic factors influenced phytoplankton in the river primarily because they affected discharge rates and phytoplankton development in the reservoir. No adverse effects of WCGS construction on phytoplankton in the Neosho River were noted during 1980. Data from locations immediately upstream and downstream from the confluence with Wolf Creek were similar, and there was no discharge from Wolf Creek into the Neosho River during most of 1980.

4. PERIPHYTON

4.1 FIELD AND ANALYTICAL PROCEDURES

Periphyton was sampled from plexiglass artificial substrates at Locations 10 and 4 in the Neosho River on 17 June, 12 August, 27 October, and 16 December. April collections were attempted, but the artificial substrate platforms were lost during a period of high flow, and the August collection was substituted. Periphytic algae were allowed to colonize and grow on the artificial substrates for ≈30 days prior to each collection. On each sampling date, duplicate samples were collected for identification, enumeration, and biovolume determinations and preserved with M^3 (Meyer 1971). Four replicate samples were taken for biomass and chlorophyll a measurements and stored on ice under dark conditions until further processing.

Periphytic algae were identified to the lowest positive taxon and enumerated. Diatoms were cleaned chemically (Hohn and Hellerman 1963) and analyzed from Hyrax mounts under oil immersion at 1250X magnification. Nondiatoms were analyzed from wet mounts at 500X magnification. Taxonomic references used for identifications were similar to those used for the phytoplankton (Section 3.1). Algal abundance was expressed as the number of units per square centimeter (No./cm^2) using reporting units similar to those used for phytoplankton (filamentous algae were reported in 10-μm lengths for periphyton). Biovolume was determined by methods described for phytoplankton and expressed as microliters per square decimeter (μl/dm^2). Shannon's (1948) diversity index and evenness indices (Zar 1968) were calculated using base 2 logarithms.

Biomass was used at each location as an index of the organic content of the periphyton community, and provided an index of the algal component. Biomass (ash-free dry weight, gravimetric method) and chlorophyll a (corrected for pheophytin, spectrophotometric method) were measured in accordance with Standard Methods for the Examination of Water and Wastewater (APHA 1976). Production rates were reported as milligrams per square decimeter per day (mg/dm^2/day) and micrograms per square decimeter per day (μg/dm^2/day) for biomass and chlorophyll a, respectively.

4.2 RESULTS AND DISCUSSION

Periphytic algae identified from the Neosho River during 1980 consisted of 167 taxa representing 52 genera and 6 taxonomic divisions (Table 4-1). As in previous years, most taxa (66 percent) were diatoms (Bacillariophyta). Density and biovolume for each taxon are presented by sampling date and location in Appendix C, along with summaries of periphyton data from natural substrates for 1973 through 1979.

Total densities observed at Locations 4 and 10 ranged from 541,826 to 3,056,249/cm^2 on artificial substrates in 1980 (Table 4-2) and from ≈40,000 to 84,250,000/cm^2 on natural substrates in previous years. Densities were similar (within 25 percent) at the two locations for August and October collections, but densities at Location 4 (below the confluence with Wolf Creek) were more than twice those at Location 10 during June and December. Total biovolume in 1980 ranged from 12.3 to 186.1 μl/dm^2; in previous years

Table 4-1 Algae identified in periphyton samples from artificial substrates in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.

BACILLARIOPHYTA (Diatoms)

- Achnanthes exigua Grunow
- A. lanceolata Brebisson
- A. lewisiana Patrick
- A. linearis W. Smith
- A. minutissima Kuetzing
- Amphora ovalis Kuetzing
- A. perpusilla Grunow
- A. veneta Kuetzing
- Caloneis bacillum (Grunow) Mereschowsky
- Cocconeis pediculus Ehrenberg
- C. placentula Ehrenberg
- Cyclotella atomus Hustedt
- C. meneghiniana Kuetzing
- C. pseudostelligera Hustedt
- Cymbella lunata W. Smith
- C. mexicana (Ehrenberg) Cleve
- C. minuta Hilse ex Rabenhorst
- C. sinuata Gregory
- C. tumida (Brebisson) VanHeurck
- Denticula elegans Kuetzing
- Diatoma vulgare Bory
- Fragilaria capucina DesMaziers
- F. construens var. venter (Ehrenberg) Grunow
- F. vaucheriae (Kuetzing) Petersen
- Gomphonema gracile Ehrenberg
- G. olivaceum (Lyngbye) Kuetzing
- G. parvulum Kuetzing
- G. subclavatum var. mexicanum (Grunow) Patrick
- G. tenellum Kuetzing
- G. tergestinum (Grunow) Fricke
- Gyrosigma obtusatum (Sullivan and Wormley) Boyer
- G. spencerii (W. Smith) Cleve
- Melosira distans (Ehrenberg) Kuetzing
- M. distans var. lirata (Ehrenberg) Bethge
- M. granulata (Ehrenberg) Ralfs
- M. granulata var. angustissima Muller
- M. varians C.A. Agardh
- Navicula accomoda Hustedt
- N. arvensis Hustedt
- N. auriculata Hustedt
- N. capitata Ehrenberg
- N. capitata var. hungarica (Grunow) Ross
- N. cincta (Ehrenberg) Ralfs
- N. cryptocephala Kuetzing
- N. cryptocephala var. veneta (Kuetzing) Grunow
- N. decussis Ostrup
- N. demissa Hustedt
- N. gottlandica Grunow
- N. graciloides A. Mayer
- N. gregaria Donkin
- N. heufleri Grunow
- N. heufleri var. leptocephala (Brebisson ex Grunow) Patrick
- N. menisculus Schumann
- N. menisculus var. upsaliensis (Grunow) Grunow
- N. minima Grunow
- N. minuscula Grunow
- N. muralis Grunow
- N. notha Wallace
- N. pupula Kuetzing

BACILLARIOPHYTA (continued)

- N. pygmaea Kuetzing
- N. radiosa Kuetzing
- N. rhynchocephala Kuetzing
- N. rhynchocephala var. germainii (Wallace) Patrick
- N. schonfeldii Hustedt
- N. symmetrica Patrick
- N. tripunctata (O.F. Muller) Bory
- N. tripunctata var. schizonemoides (VanHeurck) Patrick
- N. vaucheriae Petersen
- Navicula spp.
- Nitzschia accomodata Hustedt
- N. acicularis W. Smith
- N. acicularis var. adelos Hohn and Hellerman
- N. acicularoides Hustedt
- N. adapta Hustedt
- N. amphibia Grunow
- N. angustata (W. Smith) Grunow
- N. apiculata (Gregory) Grunow
- N. capitellata Hustedt
- N. clausii Hantzsch
- N. dissipata (Kuetzing) Grunow
- N. filiformis (W. Smith) Hustedt
- N. fonticola Grunow
- N. frustulum Kuetzing
- N. frustulum var. perminuta Grunow
- N. hantzschiana Rabenhorst
- N. hungarica Grunow
- N. kutzingiana Hilse
- N. linearis W. Smith
- N. longissima (Brebisson) Ralfs
- N. microcephala Grunow
- N. palea (Kuetzing) W. Smith
- N. pertica Hohn and Hellerman
- N. subacicularis Hustedt
- N. subcapitellata Hustedt
- N. sublinearis Hustedt
- N. tryblionella var. debilis (Arnott) A. Mayer
- N. tryblionella var. victoriae Grunow
- Nitzschia spp.
- Pleurosigma delicatulum W. Smith
- Rhoicosphenia curvata (Kuetzing) Grunow
- Stephanodiscus astraea (Ehrenberg) Grunow
- S. astraea var. minutula (Kuetzing) Grunow
- S. invisitatus Hohn and Hellerman
- Surirella ovata Kuetzing
- S. ovata var. africana Cholnoky
- S. suecica Grunow
- Synedra acus Kuetzing
- S. fasciculata var. truncata (Greville) Patrick
- S. minuscula Grunow
- Thalassiosira fluviatilis Hustedt

CHLOROPHYTA (Green Algae)

- Ankistrodesmus falcatus (Corda) Ralfs
- A. spiralis (Turner) Lemmermann
- Characium ambiguum Hermann
- Chlamydomonas spp.
- Cladophora glomerata (Linnaeas) Kuetzing
- Cosmarium spp.
- Crucigenia crucifera (Wolle) Collins

Table 4-1 (continued)

CHLOROPHYTA (continued)
- Gonium pectorale Meuller
- Kirchneriella subsolitaria G.S. West
- Lagerheimia quadriseta G.M. Smith
- Micractinium pusillum Fresenius
- Mougeotia spp.
- Oedogonium spp.
- Oocystis lacustris Chodat
- O. pusilla Hansgirg
- Pediastrum tetras (Ehrenberg) Ralfs
- Quadrigula lacustris (Chodat) G.M. Smith
- Scenedesmus abundans (Kirchner) Chodat
- S. bijuga (Turpin) Lagerheim
- S. dimorphus (Turpin) Kuetzing
- S. longus Meyen
- S. quadricauda (Turpin) Brebisson
- Selenastrum minutum (Naegeli) Collins
- S. westii G.M. Smith
- Stigeoclonium tenue (C.A. Agardh) Kuetzing
- Tetrastrum staurogeniaeforme (Schroeder) Lemmermann
- Unidentified coccoid green
- Unidentified filamentous green

CHRYSOPHYTA (Yellow-green Algae)
- Tribonema bombycinum (C.A. Agardh) Derbes and Solier
- Unidentified chrysophyte

CRYPTOPHYTA (Cryptomonads)
- Cryptomonas spp.

CYANOPHYTA (Blue-green Algae)
- Anabaena spp.
- Calothrix epiphytica West and West
- Chroococcus limneticus Lemmermann
- C. minimus (Keisser) Lemmermann
- C. minutus (Kuetzing) Naegeli
- Chroococcus spp.
- Lyngbya aerugineo-caerulea (Kuetzing) Gomont
- L. diguetii Gomont ex Hariot
- L. epiphytica Hieronymus ex Engler and Prantl
- L. limnetica Lemmermann
- L. nordgaardii Wille
- Merismopedia tenuissima Lemmermann
- Oscillatoria angusta Koppe
- O. limnetica Lemmermann
- Oscillatoria spp.
- Phormidium tenue (Meneghini) Gomont
- Spirulina laxa G.M. Smith

EUGLENOPHYTA (Euglenoids)
- Euglena gracilis Klebs
- E. minuta Prescott
- E. proxima Daneard
- Euglena spp.
- Phacus acuminatus Stokes
- P. lemmermannii (Swirenko) Skvortzow
- P. pyrum (Ehrenberg) Stein
- Trachelomonas volvocina
- Trachelomonas spp.

Table 4-2 Mean density, biovolume, and percent composition of major taxonomic groups in periphyton samples collected from artificial substrates in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.

		Density at Sampling Locations				Biovolume at Sampling Locations			
		10		4		10		4	
Exposure Period	Taxon	No./cm^2	%	No./cm^2	%	µl/dm^2	%	µl/dm^2	%
19 May-27 Jun	Bacillariophyta	662,858	51.0	1,789,463	58.6	16.8	62.5	34.7	18.6
	Chlorophyta	216,424	16.6	194,650	6.4	7.7	28.4	145.3	78.1
	Chrysophyta	0	--	7,724	0.3	0	--	0.2	0.1
	Cyanophyta	415,611	32.0	1,062,863	34.8	1.8	6.6	5.7	3.1
	Miscellaneous	5,745	0.4	1,544	0.1	0.7	2.5	0.2	0.1
	Total periphyton	1,300,641	100.0	3,056,249	100.0	27.0	100.0	186.1	100.0
08 Jul-12 Aug	Bacillariophyta	2,070,474	75.8	1,295,847	59.6	51.3	71.8	21.6	29.9
	Chlorophyta	148,497	5.4	154,483	7.1	14.8	20.7	45.4	63.1
	Chrysophyta	0	--	21,628	1.0	0	--	1.7	2.4
	Cyanophyta	512,623	18.8	701,364	32.3	5.4	7.6	3.4	4.7
	Total periphyton	2,731,598	100.0	2,173,328	100.0	71.5	100.0	72.1	100.0
26 Sep-27 Oct	Bacillariophyta	473,456	87.4	354,667	52.9	10.1	82.1	6.5	11.8
	Chlorophyta	17,236	3.2	216,039	32.2	1.1	8.9	48.1	87.1
	Cyanophyta	44,240	8.2	97,676	14.6	0.2	2.0	0.5	0.8
	Miscellaneous	6,894	1.3	1,723	0.3	0.9	7.1	0.1	0.2
	Total periphyton	541,826	100.0	670,107	100.0	12.3	100.0	55.2	100.0
12 Nov-16 Dec	Bacillariophyta	747,579	87.3	1,858,913	98.8	19.4	82.0	22.8	86.3
	Chlorophyta	47,110	5.5	71,240	3.5	1.4	5.7	2.4	9.2
	Cyanophyta	38,838	4.5	80,667	4.0	0.2	0.9	0.3	1.1
	Miscellaneous	23,210	2.7	13,558	0.7	2.7	11.4	0.9	3.3
	Total periphyton	856,738	100.0	2,024,379	100.0	23.7	100.0	26.4	100.0

the biovolume observed on natural substrates ranged from 0.7 to 10,903.2 $\mu l/dm^2$. Total biovolume was much higher at Location 4 than at Location 10 during June and October.

As often occurred with previous collections from natural substrates, diatoms numerically dominated the periphyton on artificial substrates at both locations throughout 1980 (Table 4-2). In terms of biovolume, diatoms were always dominant at Location 10, but at Location 4 they dominated biovolume only during the November - December exposure period. The major diatom collected from the May - June exposure was Cocconeis placentula (Table 4-3), which comprised 15.1 and 28.9 percent of total numbers at Locations 4 and 10, respectively (Appendix C). This species remained the dominant diatom at Location 10 during the July - August and September - October exposure periods; the dominant diatoms at Location 4 during these periods were Nitzschia frustulum and Gomphonema parvulum, respectively. The most abundant diatom at both locations during the November - December period was Nitzschia acicularis.

Green algae (Chlorophyta) dominated biovolume at Location 4 during the first three exposure periods, and composed more than 20 percent of total biovolume at Location 10 during the first two periods (Table 4-2). Important green algae were Cladophora glomerata (Location 4 only), Oedogonium spp., and Stigeoclonium tenue. Cladophora was a major component of periphyton in earlier studies but was not observed in 1979 (Bockelman 1980b). Blue-green algae (Cyanophyta) were observed at both locations during all four collection periods; Lyngbya epiphytica, Lyngbya limnetica, and Lyngbya diguetii were the major species observed in this group. These taxa were more important numerically than in terms of biovolume. Yellow-green algae (Chrysophyta), cryptomonads (Cryptophyta), and euglenoids (Euglenophyta) were observed in the artificial substrate samples, but only the euglenoid Euglena gracilis composed at least 5 percent of total density or biovolume.

Biomass and chlorophyll a production in 1980 ranged from 0.65 to 3.92 $mg/dm^2/day$ and 6.63 to 38.56 $\mu g/dm^2/day$, respectively (Table 4-4). Biomass production was higher at Location 4 than at Location 10 in the May - June, July - August, and November - December exposure periods. Maximum chlorophyll a production occurred at Location 4 in the first sampling period. Autotrophic Index values indicated that, with the possible exception of August collections from Location 4, periphyton was dominated by photosynthetic organisms (algae). Periphyton diversity (H') in 1980 ranged from 3.30 to 4.99, as compared to a range of 1.11-4.67 observed on natural substrates in previous years. In 1980, diversity ranges at Location 10 and Location 4 were comparable (3.39-4.99 and 3.30-4.25, respectively), and values were not consistently higher at either location. Evenness also was similar at Locations 10 and 4 in 1980, and followed the same trend as diversity.

There was no indication of construction effects on periphyton in the Neosho River evident from the results of artificial substrate sampling. There was little or no flow in Wolf Creek during the period of 1980 periphyton studies. Some spatial differences during the early exposure periods may have resulted from differences in physical characteristics (e.g., water velocity, reduced intensity of incident sunlight due to shading) at the two locations.

Table 4-3 Algal taxa composing at least 5 percent of total density of biovolume in periphyton collected from artificial substrates in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.

Exposure Period	Sampling Location 10	Sampling Location 4
19 May-17 Jun	Cocconeis placentula Stigeoclonium tenue Unidentified green coccoid Lyngbya epiphytica Lyngbya limnetica	Cocconeis placentula Nitzschia frustulum Navicula cryptocephala Gomphonema parvulum Cladophora glomerata Lyngbya epiphytica
08 Jul-12 Aug	Cocconeis placentula Nitzschia frustulum Stephanodiscus invisitatus Navicula heufleri Nitzschia subacicularis Oedogonium spp. Unidentified green coccoid Lyngbya epiphytica Lyngbya limnetica	Nitzschia frustulum Cocconeis placentula Stephanodiscus invisitatus Stigeoclonium tenue Cladophora glomerata Lyngbya limnetica Lyngbya epiphytica
26 Sep-27 Oct	Cocconeis placentula Nitzschia frustulum Nitzschia palea Nitzschia frustulum var. perminuta Navicula graciloides Navicula rhynchocephala Cyclotella meneghiniana Pleurosigma delicatulum Unidentified green coccoid	Gomphonema parvulum Navicula graciloides Nitzschia frustulum Nitzschia palea Oedogonium spp. Unidentified green coccoid Lyngbya diguetii
12 Nov-16 Dec	Nitzschia acicularis Nitzschia palea Navicula cryptocephala Surirella suecica Nitzschia dissipata Nitzschia hungarica Euglena gracilis	Nitzschia acicularis Surirella suecica Nitzschia palea Nitzschia acicularis var. adelos Navicula cryptocephala

Table 4-4 Mean biomass and chlorophyll a production, Autotrophic Index, and diversity measures for periphyton collected from artificial substrates in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.

Parameter	Exposure Period	Sampling Location 10	Sampling Location 4
Biomass production[a] (mg/dm^2 per day)	19 May-17 Jun	2.25	3.92
	08 Jul-12 Aug	1.96	3.56
	26 Sep-27 Oct	1.11	0.68
	12 Nov-16 Dec	0.65	1.26
Chlorophyll a production[b] ($\mu g/dm^2$ per day)	19 May-17 Jun	19.73	38.56
	08 Jul-12 Aug	18.02	15.34
	26 Sep-27 Oct	14.95	9.51
	12 Nov-16 Dec	6.63	18.11
Autotrophic Index[c]	19 May-17 Jun	114	102
	08 Jul-12 Aug	109	232
	26 Sep-27 Oct	74	71
	12 Nov-16 Dec	98	70
Number of taxa	19 May-17 Jun	33	47
	08 Jul-12 Aug	43	47
	26 Sep-27 Oct	73	69
	12 Nov-16 Dec	67	67
Diversity (H')[d]	19 May-17 Jun	3.39	3.79
	08 Jul-12 Aug	3.57	3.87
	26 Sep-27 Oct	4.99	4.25
	12 Nov-16 Dec	4.55	3.30
Evenness (J')[e]	19 May-17 Jun	0.67	0.68
	08 Jul-12 Aug	0.66	0.70
	26 Sep-27 Oct	0.81	0.70
	12 Nov-16 Dec	0.75	0.54

[a] Ash-free dry weight.
[b] Corrected for pheophytin.
[c] Weber 1973.
[d] Shannon 1948 using base 2 logarithms.
[e] Zar 1968.

4.3 SUMMARY AND CONCLUSIONS

These studies represented the first year that artificial substrate samplers were used to collect periphyton. In previous years periphyton was sampled from natural substrates. In addition, periphyton sampling in 1980 was limited to Locations 4 and 10 in the Neosho River. However, both total density and total biovolume in 1980 were within respective ranges previously reported in the Neosho River. Total density and total biovolume were generally similar at both locations or higher at Location 4 than at Location 10. Diatoms continued to be the most important numerical component of the periphyton in the Neosho River, while green algae often were important in terms of biovolume.

Neither biomass production nor chlorophyll a production indicated construction effects on periphyton in the Neosho River below the confluence with Wolf Creek. However, there was little or no flow from Wolf Creek during the 1980 periphyton studies.

5. ZOOPLANKTON

5.1 FIELD AND ANALYTICAL PROCEDURES

Duplicate zooplankton samples were collected quarterly from the Neosho River at Locations 1, 10, and 4 (Figure 1-1). Each replicate consisted of a stationary horizontal sample of 1-3 minutes duration with a metered No. 25 mesh (64-μm aperture) plankton net with a 437-cm^2 aperture. When flow was minimal or absent, the net was towed at a speed sufficient to provide reliable flowmeter readings. Each sample was placed in an appropriately labeled glass jar containing menthol crystals to relax the body structure of the rotifers to facilitate identification. Within one hour of collection, samples were preserved with 5 percent formalin, then transported to the laboratory for analysis.

In the laboratory, samples were concentrated or diluted to a workable density of organisms, and thoroughly mixed to obtain a representative subsample, which was withdrawn and placed in a Bogorov counting chamber. Stratified counts of zooplankton in the subsample were made using a binocular dissecting microscope at 10-70X magnification. Difficult specimens were identified at 100-1000X with a compound microscope. All organisms were counted in the first two subsamples. As progressively larger aliquots were withdrawn, abundant taxa were eliminated from consideration. Subsampling was continued until a sufficient number of organisms was enumerated to estimate population densities, usually after counting at least 5 percent of the total sample. Microcrustacea were identified to species with the exception of taxonomically indistinct immature copepods and cladocerans which were identified to the lowest positive taxon. Rotifers were identified to genus, except certain littoral benthic genera in the order Bdelloidea. Identifications were made using appropriate taxonomic keys, including Brooks (1957, 1959), Ruttner-Kolisko (1972), Smirnov (1974), and Pennak (1978).

5.2 RESULTS AND DISCUSSION

The zooplankton community in the Neosho River was dominated (>5 percent) by four copepod, one cladoceran, and seven rotifer taxa (Table 5-1). Rotifers constituted the majority of the plankton in most months and comprised 48-88 percent of the total assemblage (Table 5-2). Predominant rotifer taxa collected included Brachionus, Keratella, Polyarthra, and Synchaeta. During the study, immature copepods, Diaptomus siciloides, and Pleuroxus hamulatus were the only dominant crustaceans. In total, 58 taxa were encountered during the 1980 study (Table 5-3).

Mean zooplankton density in the tailwaters of John Redmond Reservoir (Location 1) was highest during June and October (156,334 and 159,391 organisms/m^3, respectively) and lowest in April (44,063 organisms/m^3) (Table 5-1). April and June zooplankton assemblages were relatively balanced, with copepods and rotifers each comprising approximately half of the total community. In April, immature copepods and Keratella together accounted for nearly 77 percent of the total zooplankton. Immature copepods continued to be important in June. Diaptomus siciloides was the only adult copepod to represent over 5 percent of the total zooplankton, and reached a maximum

Table 5-1 Mean density (No./m^3) of dominant zooplankton identified from samples collected in the Neosho River near Wolf Creek Generating Station, April through December 1980.

Taxa	14 April 1980			17 June 1980			27 October 1980			16 December 1980		
	1	10	4	1	10	4	1	10	4	1	10	4
Copepoda	21352	23053	24932	71887	15314	-[a]	43836	312	1482	25568	6133	12670
Nauplii	13209	15226	1[illegible]66	48644	13364	-	23716	276	1386	18748	5084	11229
Calanoid copepodites	32	26	30	5556	394	-	8088	0	0	778	103	151
Cyclopoid copepodites	7428	7273	7212	3041	1154	-	3955	25	76	2545	422	872
Diaptomus siciloides	19	26	34	9672	158	-	5557	9	0	2869	517	323
Cladocera	492	908	1010	2800	80	-	751	205	755	703	82	291
Pleuroxus hamulatus	0	0	0	0	0	-	0	47	321	0	26	76
Rotifera	22219	22055	33592	81647	101314	-	114804	3635	3763	89451	39739	82543
Bdelloid Rotifera	0	90	72	2384	375	-	1425	810	357	556	262	444
Brachionus spp.	2506	2651	2910	61106	45496	-	1908	861	1158	1271	1698	5773
Cephalodella spp.	0	0	0	238	4	-	115	342	629	159	241	323
Filinia spp.	2510	3073	2950	144	75	-	0	53	0	0	13	0
Keratella spp.	13110	13420	24592	12131	8859	-	1755	325	100	37496	11279	24312
Polyarthra spp.	2487	1548	1672	5112	35586	-	1513	47	10	36702	19619	26017
Synchaeta spp.	671	826	935	0	10661	-	108098	515	863	13028	6116	14725
Total Zooplankton	44063	46016	59534	156334	117208	-	159391	4152	6000	115722	46017	95504

[a] Samples collected but not preserved.

Table 5-2 Percent composition of dominant zooplankton identified from samples collected in the Neosho River near Wolf Creek Generating Station, April through December, 1980.

Taxa	14 April 1980			17 June 1980			27 October 1980			16 December 1980		
	1	10	4	1	10	4	1	10	4	1	10	4
Copepoda	48.5	50.1	41.9	46.0	13.1	-[a]	27.5	7.5	24.7	22.1	13.5	13.3
Nauplii	30.0	33.1	28.3	31.1	11.4	-	14.9	6.6	23.1	16.2	11.0	11.8
Calanoid copepodites	0.1	0.1	0.1	3.6	0.3	-	5.1	0	0	0.7	0.2	0.2
Cyclopoid copepodites	16.9	15.8	12.1	1.9	1.0	-	2.5	0.6	1.3	2.2	0.9	0.9
Diaptomus siciloides	<0.1	0.1	0.1	6.2	0.1	-	3.5	0.2	0	2.5	1.1	0.3
Cladocera	1.1	2.0	1.7	1.8	0.1	-	0.5	4.9	12.6	0.6	0.2	0.3
Pleuroxus hamulatus	0	0	0	0	0	-	0	1.1	5.4	0	0.1	0.1
Rotifera	50.4	47.9	56.4	52.2	86.9	-	72.0	87.5	62.7	77.3	86.4	86.4
Bdelloid Rotifera	0	0.2	0.1	1.5	0.3	-	0.9	19.5	6.0	0.5	0.6	0.5
Brachionus spp.	5.7	5.8	4.9	39.1	38.8	-	1.2	20.7	19.3	1.1	3.7	6.0
Cephalodella spp.	0	0	0	0.2	<0.1	-	0.1	8.2	10.5	0.1	0.5	0.3
Filinia spp.	5.7	6.7	5.0	0.1	0.1	-	0	1.3	0	0	<0.1	0
Keratella spp.	30.0	29.2	41.3	7.8	7.6	-	1.1	7.8	1.7	32.4	24.5	25.5
Polyarthra spp.	5.6	3.4	2.8	3.3	30.4	-	0.9	1.1	0.2	31.7	42.6	37.7
Synchaeta spp.	1.5	1.8	1.6	0	9.1	-	67.8	12.4	14.4	11.3	13.3	15.4

[a] Samples collected but not preserved.

Table 5-3 Zooplankton taxa collected in the Neosho River near Wolf Creek Generating Station, Kansas 1980.

COPEPODA
- Cyclops bicuspidatus thomasi Forbes
- Cyclops varicans rubellus Lilljeborg
- Cyclops vernalis Fischer
- Diaptomus clavipes Schacht
- Diaptomus pallidus Herrick
- Diaptomus siciloides Lilljeborg
- Ergasilus chautauquaensis Fellows
- Ergasilus megaceros Wilson
- Eucyclops agilis (Koch)
- Eucyclops speratus (Lilljeborg)
- Mesocyclops edax (Forbes)
- Harpacticoida

CLADOCERA
- Alona circumfimbriata Megard
- Alona pulchella King
- Alona sp. Baird
- Bosmina longirostris (O.F. Muller)
- Ceriodaphnia quadrangula (O.F. Muller)
- Chydorus sphaericus (O.F. Muller)
- Daphnia galeata mendotae Birge
- Daphnia parvula Fordyce
- Daphnia pulex Leydig
- Daphnia retrocurva Forbes
- Diaphanosoma brachyurum (Lieven)
- Diaphanosoma leuchtenbergianum Fischer
- Disparalona rostrata (Koch)
- Kurzia latissima (Kurz)
- Leptodora kindtii (Focke)
- Macrothrix laticornis (Jurine)
- Pleuroxus denticulatus Birge
- Pleuroxus hamulatus Birge
- Simocephalus vetulus (O.F. Muller)

ROTIFERA
- Asplanchna spp. Gosse
- Bdelloid Rotifera spp.
- Brachionus spp. Pallas
- Cephalodella spp. Bory de St. Vincent
- Colurella spp. Bory de St. Vincent
- Conochiloides spp. Hlava
- Dicranophorus spp. Nitzsch
- Euchlanis spp. Ehrenberg
- Filinia spp. Bory de St. Vincent
- Hexarthra spp. Schmarda
- Kellicottia spp. Ahlstrom
- Keratella spp. Bory de St. Vincent
- Lecane spp. Nitzsch
- Lepadella spp. Bory de St. Vincent
- Lophocharis spp. Ehrenberg
- Monostyla spp. Ehrenberg
- Notholca spp. Gosse
- Notommata spp. Ehrenberg
- Notommatid Rotifera spp.
- Platyias spp. Harring
- Polyarthra spp. Ehrenberg
- Rotaria spp. Scopoli
- Scaridium spp. Ehrenberg
- Synchaeta spp. Enrenberg
- Testudinella spp. Bory de St. Vincent
- Trichocerca spp. Lamark
- Trichotria spp. Bory de St. Vincent

density of 9,672 organisms/m^3 during June. Keratella was succeeded in abundance in June by Brachionus which comprised nearly 40 percent of the plankton. Synchaeta attained maximum densities at Location 1 in October (108,088 organisms/m^3). Other rotifer taxa were encountered in densities <2,000 organisms/m^3. Keratella and Polyarthra dominated the tailwater community (Location 1) in December when peak densities were recorded (37,496 and 36,702 organisms/m^3, respectively) (Table 5-1). Immature copepods remained important in December.

Cladoceran densities, especially B. longirostris, were extremely low in 1980 compared to previous annual means (Table 5-4). Diaptomus siciloides, numerically important during 1979 (Rogers 1980), was only dominant at Location 1 in June 1980. The decline in microcrustacean abundance in 1980 may be related to low reservoir discharges and selective predation by fish, especially gizzard shad. Based on fishery catch data (Section 7.2), gizzard shad apparently developed a strong year class in John Redmond Reservoir in 1980 due to low seasonal reservoir discharges which resulted in reduced losses of larval and juvenile gizzard shad. Although no food-habit data for gizzard shad in the reservoir were collected, selective predation by fish can alter species composition and abundance of zooplankton in lakes and reservoirs (Hrbacek et al. 1961; Brooks and Dodson 1965; Brooks 1968). Young gizzard shad in Tuttle Creek Reservoir, Kansas selectively fed on Cyclops, Bosmina, and Daphnia which may have caused a change in zooplankton species composition and abundance (Cramer and Marzolf 1970). Bosmina longirostris, Cyclops bicuspidatus, and Daphnia pulex were important food items in the diet of young-of-the-year gizzard shad in North Twin Lake, Iowa (Kutkuhn 1957). These preferences for crustacean zooplankton may partially account for the 21-fold decrease in cladocerans and an overall 4-fold decrease in total microcrustaceans relative to densities in 1979.

Zooplankton populations in the lower Neosho River (Locations 10 and 4) exhibited species composition and seasonal trends similar to that noted at Location 1. Nauplii reached maximum densities in April (16,800 organisms/m^3) at Location 4 (Table 5-1). Rotifer abundance was greatest in June at Location 10 when Brachionus and Polyarthra combined to represent nearly 70 percent of the total community. In October, the cladoceran Pleuroxus hamulatus, absent in April and June, comprised >5 percent of the total zooplankton at Location 4. Pleuroxus hamulatus and other littoral cladocerans including Chydorus sphaericus, Disparalona rostrata, Kurzia latissima, Alonids, and several littoral rotifer taxa were collected only at the downstream locations, suggesting autochthonus production. Seasonal autochthonus production in the Neosho River has been generally noted in past studies during low river flows (Repsys 1979b; Rogers 1980). Minimum densities at Locations 10 and 4 (4,152 and 6,000 organisms/m^3, respectively) occurred in October (Table 5-1).

Mean total zooplankton at Location 4 in October and December was greater than mean densities at Location 10 (Table 5-2). Habitat differences between Locations 10 and 4 may account for the higher densities at Location 4. Samples at Location 10 are collected below a riffle inimical to zooplankton production whereas Location 4 consists of a large sluggish pool conducive to zooplankton production. Higher zooplankton density at Location 4 has been noted in past studies in the Neosho River (Rogers 1980). Higher

Table 5-4 Annual mean densities (No./m^3) of selected major microcrustacean taxa from John Redmond Reservoir (Location 1), 1973 through 1980.

Taxa	Year							
	1973	1974	1975	1976	1977	1978	1979	1980
Copepoda								
Calanoid (*Diaptomus*) copepodites	2635	6948	8963	1698	4903	5447	6376	3614
Cyclopoid copepodites	2546	6558	9006	13182	16978	21601	23220	4242
Cyclops vernalis	284	597	443	976	1106	1432	1750	1400
Diaptomus pallidus	17[a]	1006	48	316	266	390	878	339
Diaptomus siciloides	1418[a]	1171	3458	1014	2502	5110	6772	4529
All adult *Diaptomus* spp.	2591	2177	3508	1330	2810	5501	7650	4879
Ergasilus chautauquaensis	133	39	756	282	217	154	97	110
Total Copepoda[b]	8188	16319	22676	17468	26014	34135	39093	14245
Cladocera								
Bosmina longirostris	4509	4247	10580	20980	14923	30484	7584	129
Ceriodaphnia spp.[c]	1022	2483	130	11	28	17	53	0
Daphnia parvula	1271	2095	2870	3547	3333	1134	3889	190
All *Daphnia* spp.[d] (juveniles and adults)	14413	5089	3994	3579	3343	1857	7955	979
Diaphanosoma leuchtenbergianum	3032	2759	8418	3344	4877	1391	3952	14
Moina spp.[e]	163	205	7484	259	1102	1921	649	0
Total Cladocera[b]	23139	14783	30943	28173	24273	35670	24082	1122
Total microcrustaceans[b]	31327	31102	53619	45641	50287	69805	63175	15367

[a] Males only. Females not identified to species in 1973.
[b] Includes the above selected taxa only.
[c] Mainly *C. lacustris*.
[d] Mainly juveniles and adults of *D. parvula*.
[e] Mainly *M. micrura*.

densities in December reflected increases in nauplii and the rotifers Keratella and Polyarthra.

Although dominant taxa were similar among locations, densities were generally lower downstream. Zooplankton abundance was apparently affected by water releases from John Redmond Reservoir. A correlation between reservoir discharge and mean microcrustacean density at Location 10 ($r = +0.81$) and Location 4 ($r = +0.89$) was apparent although not significant ($P > 0.05$). Beach (1960) reported that lakes and impoundments in the Ocqueoc River system of Michigan were the major locations of plankton development. In general, most plankton derived from lakes and artificial impoundments decreased in quantity downstream (Hynes 1970). The removal rate of the plankton is related to length of stream segment, current, depth of water, turbulence, and amount of vegetation or other objects in the channel which support a periphyton assemblage. Vegetation and periphyton display a pronounced filtering effect on the plankton during low flow (Chandler 1937). The abundance of plankton in the Neosho River in April was similar between Location 1 near John Redmond Reservoir and Locations 10 and 4, approximately 16-19 km downstream ($F_{(2,3)} = 3.591$, $P > 0.05$). The flow rate in April was at the annual maximum (Figure 1-2) and probably caused rapid transport of reservoir plankton to the downstream locations. Densities in April ranged from 44,000 organisms/m^3 at Location 1 to 59,000 organisms/m^3 at Location 4 (Table 5-1).

Differences between the tailwaters and downstream locations were pronounced during periods of low flow. Although data was not available from Location 4 in June, densities at Location 10 were lower than those near the reservoir. River flow in June was less than 300 cfs. Lower flow (<150 cfs) in October resulted in densities at least 26 times higher at Location 1 than Locations 10 and 4. Data collected in December also reflected a downstream decrease in abundance when releases were 148 cfs. The correlation between reservoir discharge flow and percentage zooplankton remaining at Location 10 was statistically significant ($r = +0.98$, $P \leq 0.05$) indicating that higher flows promote greater downstream transport of zooplankton. A similar relationship between reservoir discharge and percentage zooplankton remaining at Location 4 was evident ($r = +0.93$) although the relationship was not significant ($P > 0.05$). Similar reductions of zooplankton densities in the Neosho River during periods of low flow have been reported (Repsys 1978, 1979b; Rogers 1980) and documented by Ward (1975) and Armitage and Capper (1976) for river-reservoir systems in Wales and Colorado. Both authors speculated that these decreases in numbers were mainly attributed to the filtering effect of extensive growth of periphytic algae covering the stream-bottom substrates.

The data collected during the present study indicated that the construction of Wolf Creek Generating Station had no apparent effects on the zooplankton community in the Neosho River. Species composition was not significantly affected by construction activities. Any consistent differences or variability noted between locations were due to natural phenomena that were innate to the study area and to the Neosho River.

5.3 SUMMARY AND CONCLUSIONS

Predominant zooplankton taxa collected during the study included immature copepods, Brachionus, Keratella, Polyarthra, and Synchaeta. Rotifers dominated at all locations and comprised from 48 to 88 percent of the total assemblage. Mean microcrustacean density in the tailwaters of John Redmond Reservoir (Location 1) was 4-fold less than mean density in 1979. Reduced microcrustacean abundance may be related to low reservoir discharges and selective removal of zooplankton by young gizzard shad.

Maximum zooplankton density at Location 1 occurred in June (156,334 organisms/m^3) and October (159,391 organisms/m^3). Zooplankton abundance downstream was highest in June (Location 10) and December (Location 4). Mean zooplankton density generally decreased downstream. During periods of low flow differences between the upstream (Location 1) and downstream locations (Locations 10 and 4) were more pronounced. A correlation between river flow and zooplankton density at downstream locations was apparent although not statistically significant. A significant correlation between river flow and percentage zooplankton remaining from the tailwaters to downstream Location 10 was present. Production of littoral zooplankters was evident at downstream locations during periods of low flow. Densities increased from Locations 10 to 4 which was attributed to autochthonus production resulting from more favorable habitat at Location 4.

Construction of Wolf Creek Generating Station had no apparent effects on the zooplankton community in the Neosho River during the 1980 study period.

6. MACROINVERTEBRATES

6.1 FIELD AND ANALYTICAL PROCEDURES

Two replicate samples of drifting benthic macroinvertebrates were collected at night from the tailwaters of John Redmond Reservoir (Location 1; Figure 1-1) on 18 April, 16 June, 27 October, and 15 December 1980. Collections were made using a 0.75-m diameter plankton net of No. 0 mesh Nitex (0.571-mm), equipped with an internally mounted flowmeter (General Oceanics, Inc. Model 2030). Two replicate grab samples were collected with a Ponar dredge (area samples = 530 cm^2) on 15 April, 17 June, 28 October, and 16 December 1980 from Locations 10 and 4 in the Neosho River and Locations 7 and 3 in Wolf Creek (Figure 1-1). Qualitative samples were obtained by seining and handpicking at each of these five locations concurrent with Ponar sampling. Flooding precluded qualitative and Ponar sampling in the Neosho River in April.

All samples were sieved using U.S. Standard No. 30 mesh (0.595-mm) screen. The sieve residue was transferred to appropriately labeled containers fixed with 10 percent formalin with rose bengal stain (Mason and Yevich 1967). After exposure to the stain solution for a minimum of 24 hours, samples were rewashed in the laboratory in a No. 30 mesh sieve and preserved in 70 percent ethanol. Macroinvertebrates were manually separated from the debris with the aid of a stereozoom microscope and identified to the lowest possible taxonomic level using appropriate taxonomic references. Aerial and terrestrial specimens collected in drift samples were not identified or enumerated.

Diversty indices were calculated for all quantitative samples using Shannon's (1948) equation (log base 2). Student's "t" test (Steel and Torrie 1960) was used to test for significant differences ($P \leq 0.05$) in densities and diversity values among locations during each sampling period.

6.2 RESULTS AND DISCUSSION

6.2.1 Neosho River

6.2.1.1 Macroinvertebrate Drift

Drift samples from Location 1 in the Neosho River yielded 35 macroinvertebrate taxa in 1980 (Table 6-1). The drift was composed primarily of aquatic insects with Hydropsychidae (net-spinning caddisflies), Chaoboridae (phantom midges), and Chironomidae (midge flies) exhibiting the greatest densities (Table 6-2). Chironomidae were the most diverse group of organisms present. The lowest and greatest density and diversity was observed in December and June, respectively.

Chaoborus punctipennis was the dominant species during April and June when it comprised 79 and 41 percent, respectively, of the total drift assemblage. This species was also dominant in most of the 1979 drift collections at this site (Table 6-3). Considering the preference of *C. punctipennis* for a lentic habitat (Merritt and Cummins 1978), the individuals collected in the drift at Location 1 probably originated from John Redmond Reservoir and not the

Table 6-1 Summary of macroinvertebrate occurrence in quantitative collections near Wolf Creek Generating Station, Burlington, Kansas, 1980.

Taxon	Neosho River 1	Neosho River 10	Neosho River 4	Wolf Creek 7	Wolf Creek 3
Platyhelminthes					
Turbellaria					
Tricladida					
Planariidae					
Dugesia sp. Girard		+	+		
Nematoda					
Unidentified Nematoda			+		+
Entoprocta					
Urnatellidae					
Urnatella gracilis Leidy	+				
Annelida					
Oligochaeta					
Plesiopora					
Enchytraeidae					
Unidentified Enchytraeidae			+		+
Naididae					
Dero digitata (Muller)	+				
Nais sp. (Muller)			+	+	+
Nais behningi Michaelsen					+
Nais bretscheri Michaelsen					+
Tubificidae					
Branchiura sowerbyi Beddard		+	+		+
Ilyodrilus templetoni (Southern)				+	
Limnodrilus cervix Brinkhurst		+		+	+
Limnodrilus claparedianus Ratzel				+	
Limnodrilus hoffmeisteri Claparede				+	+
Immature w/o cap. chaetae		+	+	+	+
Immature w/ cap. chaetae		+	+	+	+
Hirudinea					
Rhynchobdellida					
Glossiphoniidae					
Actinobdella sp. Moore		+	+		
Actinobdella inequiannulata Moore			+		
Placobdella sp. Blanchard		+	+		
Pharyngobdellida					
Erpobdellidae					
Dina microstoma Moore					+
Arthropoda					
Crustacea					
Amphipoda					
Talitridae					
Hyalella azteca (Saussure)				+	
Decapoda					
Astacidae					
Unidentified Astacidae	+			+	
Insecta					
Ephemeroptera					
Ephemeridae					
Ephoron leukon Williamson		+	+		+
Hexagenia limbata (Serville)	+				
Potamanthus sp. Pictet		+	+		+

Table 6-1 (continued)

Taxon	Neosho River 1	Neosho River 10	Neosho River 4	Wolf Creek 7	Wolf Creek 3
Caenidae					
Caenis sp. Stephens	+	+	+		
Tricorythodes sp. Ulmer		+	+	+	+
Heptageniidae					
Unidentified Heptageniidae	+	+	+	+	
Heptagenia diabasia Burks		+			
Stenacron interpunctatum (Say)	+	+	+		
Stenonema sp. Traver	+				
Stenonema terminatum (Banks)		+			
Stenonema tripunctatum (Banks)	+	+	+		
Baetidae					
Unidentified Baetidae		+			+
Isonychia sp. Eaton		+			
Paracloeodes minutus		+			
Baetis sp. Leach		+			
Odonata					
Gomphidae					
Gomphus sp. Leach		+	+		
Coenagrionidae					
Argia sp. Rambur		+	+		
Plecoptera					
Perlidae					
Neoperla clymene (Newman)		+	+	+	+
Trichoptera					
Psychomyiidae					
Cyrnellus sp. Banks	+				
Hydropsychidae					
Unidentified Hydropsychidae	+	+	+	+	+
Cheumatopsyche sp. Wallengren	+	+		+	+
Hydropsyche frisoni Ross	+	+			
Hydropsyche orris Ross		+			
Potamyia flava (Hagen)	+	+	+	+	
Hydroptilidae					
Hydroptila sp. Dalman		+			
Leptoceridae					
Nectopsyche sp. (Muller)			+		
Oecetis sp. Mc Lachlan		+			
Coleoptera					
Unidentified Coleoptera					+
Elmidae					
Unidentified Elmidae					+
Stenelmis sp. Dufour		+	+	+	+
Diptera					
Chaoboridae					
Chaoborus punctipennis (Say)	+		+		+
Simuliidae					
Unidentified Simuliidae	+	+			
Chironomidae					
Ablabesmyia sp. Johannsen	+		+		
Chironomus sp. (Meigen)	+	+	+	+	+
Cladotanytarsus sp. Kieffer			+		
Coelotanypus sp. Kieffer	+				
Cricotopus sp. van der Wulp	+	+			+
Cricotopus bicinctus group (Meigen)		+	+		
Cricotopus fuscus group Kieffer	+				+
Cricotopus tremulus group	+	+			
Cricotopus vierriensis Goetghebuer	+	+	+		
Cryptochironomus sp. (Kieffer)		+	+	+	+

Table 6-1 (continued)

Taxon	Neosho River 1	Neosho River 10	Neosho River 4	Wolf Creek 7	Wolf Creek 3
Dicrotendipes sp. Kieffer	+	+	+	+	+
Eukiefferiella sp. Thienemann		+			
Glyptotendipes sp. Kieffer	+	+	+		
Glyptotendipes (Phytotendipes) sp. Goetghebuer	+			+	
Hydrobaenus sp. Brundin		+	+		+
Larsia sp. Fittkau		+	+		
Nanocladius sp. Kieffer	+	+	+		+
Paralauterborniella sp. Lenz		+			
Polypedilum (ss) sp. Kieffer	+	+		+	
Polypedilum (ss) convictum type (Walker)		+	+		
Polypedilum (ss) simulans type Townes		+	+		+
Procladius (Psilotanypus) sp. (Kieffer)	+			+	+
Procladius (ss) sp. Skuse	+			+	
Pseudochironomus sp. Malloch		+	+		
Rheotanytarsus sp. Bause	+	+			
Stictochironomus sp. Kieffer			+	+	+
Tanypus sp. Meigen	+				
Tanytarsus sp. van der Wulp		+	+		
Thienemanniella sp. Kieffer	+	+			
Thienemannimyia group Fittkau		+	+	+	+
Xenochironomus (Anceus) sp. Roback	+				
Ceratopogonidae					
Unidentified Ceratopogonidae			+		+
Empididae					
Hemerodromia sp. Meigen		+			
Dolichopodidae					
Unidentified Dolichopodidae					
Tipulidae					
Unidentified Tipulidae		+			+
Lepidoptera					
Pyralidae					
Parargyractis sp. Lange		+			
Mollusca					
Gastropoda					
Pulmonata					
Physidae					
Physa sp. Draparnaud		+	+	+	+
Planorbidae					
Ancylidae					
Ferrissia rivularis (Say)		+	+		
Ferrissia sp.			+		
Pelecypoda					
Heterodonta					
Sphaeriidae					
Sphaerium sp. Scopoli		+			+
Sphaerium transversum (Say)	+				
Eulamellibranchia					
Unionidae					
Unidentified Unionidae		+			
TOTAL TAXA	35	60	46	26	37

Table 6-2 Dominant groups[a] and diversity indices of the macroinvertebrate drift collected from the tailwaters of John Redmond Reservoir on the Neosho River (Location 1) near Wolf Creek Generating Station, Burlington, Kansas, 1980.

Taxon	18 April		16 June		27 October		15 December	
	No./100m^3	%	No./100m^3	%	No./100m^3	%	No./100m^3	%
Ephemeroptera								
Heptageniidae	276.6[b]	4.5	336.4	3.0	0		0	
Trichoptera								
Hydropsychidae	41.3	0.7	1302.8	11.0	19.8	32.3	2	100.0
Diptera								
Chaoboridae	4842.0	78.6	4920.5	41.4	5.4	8.8	0	
Simuliidae	0		463.6	3.9	23.4	38.3	0	
Chironomidae	982.4	15.9	4302.5	36.2	7.2	11.7	0	
Total Macroinvertebrates	6162.9		11875.1		61.3		2	
Total Taxa[c]	13		27		13		1	
Species Diversity Index[c]	1.68		3.57		3.09		0.00	

[a] Group composing > 5% of the total macroinvertebrates during any sampling period.
[b] Mean of two replicates.
[c] Total of two replicates.

Table 6-3 Drift densities (No./100m^3) of selected macroinvertebrate families in the tailwaters of John Redmond Reservoir on the Neosho River (Location 1) near Wolf Creek Generating Station, Burlington, Kansas, 1976-1980.

Taxonomic Group	Year	Month							
		April		June		October		December	
		Day	Night	Day	Night	Day	Night	Day	Night
Hydridae	1976	-[a]	110	19	-	-	2118	161	-
	1977	4	-	-	39	-	267	-	35
	1978	32	6	6	2	2980	9697	6719	4740
	1979	-	0	-	37	-	821	-	0
	1980	-	0	-	0	-	0	-	0
Naididae	1976	-	5	4	-	-	34	10	-
	1977	1407	-	-	1	-	-	-	-
	1978	27	-	-	2	26	109	681	736
	1979	-	16	-	0	-	5	-	2
	1980	-	21	-	0	-	0	-	0
Hydropsychidae	1976	-	33	46	-	-	108	30	-
	1977	98	-	-	3	-	56	-	39
	1978	26	54	306	709	21	9	244	115
	1979	-	0	-	2	-	546	-	4
	1980	-	41	-	1303	-	20	-	2
Chaoboridae	1976	-	169	159	-	-	35	6	-
	1977	23	-	-	247	-	208	-	-
	1978	25	105	32	27	-	51	5	-
	1979	-	125	-	500	-	966	-	0
	1980	-	4842	-	4920	-	5	-	0
Simuliidae	1976	-	55	83	-	-	29	58	-
	1977	5	-	-	-	-	-	-	-
	1978	-	11	15	13	-	-	124	16
	1979	-	0	-	7	-	55	-	0
	1980	-	0	-	464	-	23	-	0
Chironomidae	1976	-	41	419	-	-	242	45	-
	1977	217	-	-	108	-	8	-	-
	1978	240	173	263	74	111	838	275	222
	1979	-	44	-	231	-	468	-	0
	1980	-	982	-	4302	-	7	-	0
Total Density	1976	-	436	750	-	-	2702	375	-
	1977	1869	-	-	404	-	549	-	74
	1978	395	372	893	1006	3174	10815	8479	5879
	1979	-	186	-	973	-	2972	-	43
	1980	-	6163	-	11875	-	61	-	2

[a]Sample not taken.

riverine habitat at Location 1. This species is known to migrate to surface waters a short time after sunset and return to the hypolimnion or sediments a short time before sunrise (LaRow 1968). During its diel vertical migration, large numbers of Chaoborus were discharged from the reservoir and subsequently collected downstream at Location 1.

Chironomidae were also common in the April and June collections from the Neosho River (Table 6-2). Pupae and larvae of Procladius spp. dominated the diverse chironomid assemblage during these two months. Chironomus sp., Glyptotendipes sp., Cricotopus spp., Nanocladius sp., and Dicrotendipes sp. were other abundant midge taxa. Procladius spp. and Chironomus sp. probably originated from John Redmond Reservoir, where they have been commonly collected (Andersen 1976). Immature stages of these organisms were probably entrained in the discharge from the reservoir during their pre-emergence ascent to the surface. The other dominant taxa in the drift likely originated from the substrate in the tailwaters of the dam.

Hydropsychid caddisflies (primarily Cheumatopsyche sp.) were abundant in the June collection. Cheumatopsyche sp. was also a dominant taxon in October and the only organism in the December sampling. Hydropsychidae are lotic species which require a stable silt-free substrate with a constant current. The tailwaters of the John Redmond Reservoir dam provides an ideal habitat for net-spinning caddisflies.

Simuliidae (black flies) were commonly collected in June and dominated the drift in October. Similar to the hydropsychids, the Simuliidae are riverine species requiring a continuous current to supply a food source.

Heptageniid mayflies (primarily species of Stenonema) were numerically abundant in April and June but did not compose a large percent of the drift assemblage.

Drift densities were highest in April and June then declined in October and December (Table 6-2). Drift densities in the Neosho River since 1976 have generally been lowest in the winter (Table 6-3). Waters (1962) also reported higher macroinvertebrate drift rates in summer than in winter. He indicated that the seasonal difference in drift corresponded to a similar seasonal difference in production rates.

6.2.1.2 Benthic Samples

Ponar grab samples from the Neosho River during 1980 yielded 71 benthic macroinvertebrate taxa (Table 6-1). Tubificidae (aquatic segmented worms), Hydropsychidae (net-spinning caddisflies), and Chironomidae (midge flies) were the predominant groups collected (Table 6-4).

The October samples contained the greatest diversity and density of organisms during this study. As was reported in 1979 (Table 6-5), the lowest densities occurred in December. Grab samples could not be collected in April because of the flooding conditions. Hydropsychidae (primarily Potamyia flava and unidentified immature individuals) and a varied assemblage of Chironomidae dominated the benthic community in June. The mayfly Caenis sp. was also

Table 6-4 Dominant groups[a] and diversity index of benthic macroinvertebrates collected in Ponar grab samples from the Neosho River (Locations 10 and 4) near Wolf Creek Generating Station, Burlington, Kansas, 1980.

	17 June				28 October				16 December			
	10		4		10		4		10		4	
Taxon	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Oligochaeta												
Tubificidae	0[b]		0		330.8	1.9	463.0	11.3	226.8	52.2	396.9	70.0
Ephemeroptera												
Ephemeridae	283.5	6.4	122.8	8.8	2343.6	13.5	387.5	9.4	18.9	4.3	37.8	6.7
Caenidae	94.5	2.1	226.8	16.2	2371.9	13.7	198.5	4.8	18.9	4.3	9.4	1.7
Heptageniidae	18.9	0.4	0		1247.4	7.2	245.8	5.9	0		0	
Baetidae	0		0		1209.6	7.0	0		0		0	
Plecoptera												
Perlodidae	264.6	6.0	47.3	3.4	1209.6	7.0	66.2	1.6	47.3	10.9	0	
Trichoptera												
Hydropsychidae	1530.9	34.6	444.2	31.8	4999.0	28.8	0		9.4	2.2	0	
Coleoptera												
Elmidae	264.6	6.0	18.9	1.4	708.8	4.1	557.5	13.6	18.9	4.3	0	
Diptera												
Chironomidae	1908.9	43.3	519.8	37.2	1682.1	9.7	1918.3	46.7	28.4	6.5	94.5	16.7
Tipulidae	0		0		0		0		37.8	8.7	0	
Total Benthos	4413.1		1398.6		17359.7		4110.8		434.7		567.0	
Total Taxa	30[c]		17		48		34		15		14	
Species Diversity Index	3.98[c]		3.23		4.19		4.07		3.25		2.38	

[a] Group composing $\geq$ 5% of the benthos at a location during any sampling period.
[b] Mean of two replicates.
[c] Total of two replicates.

Table 6-5 Benthic macroinvertebrate data from the Neosho River (Locations 10 and 4) near Wolf Creek Generating Station, Burlington, Kansas, 1973-1980.

Sampling Date		Mean Density (No./m^2)[a]													
		Naididae		Tubificidae		Ephemeroptera		Plecoptera		Trichoptera		Chironomidae		Total Benthos	
		10	4	10	4	10	4	10	4	10	4	10	4	10	4
17 April	1975	0	10	218	28	0	19	0	0	0	114	86	104	340	388
6 April	1976	2873	2618	19	57	142	160	775	671	1105	19	6709	4593	13098	8496
4 April	1977	3194	1134	180	208	396	37	9	9	56	0	11000	3884	15498	5746
25 April	1978	9	0	28	19	19	104	57	66	584	208	463	208	1606	1002
10 April	1979	85	113	47	38	47	28	0	0	0	9	472	274	775	633
15 April	1980	-[b]	-	-	-	-	-	-	-	-	-	-	-	-	-
11 June	1974	0	0	9	0	0	38	0	0	0	0	9	38	38	142
10 June	1975	28	0	0	10	264	567	19	0	1200	1163	1012	369	2646	2174
15 June	1976	0	0	28	0	151	1200	0	66	66	321	57	255	350	1890
8 June	1977	9	28	104	132	9	95	0	0	9	28	57	113	265	605
27 June	1978	0	19	94	293	1029	916	19	19	7862	0	803	576	9894	2022
12 June	1979	19	47	0	491	47	0	0	0	0	0	170	180	576	983
17 June	1980	0	0	0	0	397	350	265	47	1531	444	1909	519	4413	1399
5 October	1976	85	9	0	397	2930	312	225	38	3496	0	8533	3393	16282	4328
4 October	1977	9	9	47	132	302	841	246	208	12786	12748	652	756	14317	14723
10 October	1978	123	142	255	387	1143	1143	151	0	28	19	2693	2164	4536	3449
8 October	1979	0	9	19	76	435	179	66	142	1370	189	5358	2665	7532	3307
28 October	1980	0	9	331	463	7173	832	1210	66	5320	19	1682	1918	17360	4111
10 December	1973	-	0	-	76	-	20	-	0	-	38	-	19	-	143
10 December	1974	0	9	19	728	19	19	0	0	19	19	94	576	189	1370
3 December	1975	19	57	19	180	57	227	10	10	19	57	246	1664	567	2438
14 December	1976	94	104	293	718	3827	672	1011	9	4403	75	4876	7475	16084	9941
13 December	1977	19	0	66	38	9	37	9	76	1427	1228	539	217	2485	1852
12 December	1978	444	9	47	0	321	132	9	813	28	18	10140	1673	11179	3081
10 December	1979	0	19	9	0	0	9	0	0	9	19	28	47	57	94
16 December	1980	0	0	227	397	38	47	47	0	9	0	28	95	435	567

[a] Mean of two replicates.
[b] Location not sampled.

abundant at Location 4. Although Location 10 had a greater density of organisms than Location 4, there were no significant differences ($P \leq 0.05$) between locations in any of the dominant groups or in species diversity (Table 6-6). The greater density and diversity at Location 10 compared with Location 4 may be attributed to the more productive riffle habitat at Location 10 in comparison to the predominantly pool habitat at Location 4.

The benthos community increased at both locations from June to October (Table 6-4). The predominant organisms in October included Hydropsychidae (primarily Cheumatopsyche sp. and unidentified immature individuals) at Location 10 and Chironomidae (primarily Dicrotendipes sp., Pseudochironomus sp., and Glyptotendipes sp.) at Location 4. The riffle habitat at Location 10 provided a steady current and silt-free substrate required by Hydropsychidae (Fremling 1960). Similar to the June collections, the benthic community at Location 10 was more diverse and densely populated than at Location 4. Of the major groups compared, the only significant difference between locations was in the total benthos (Table 6-6). The mayflies Potamanthus sp. and Tricorythodes sp. were also abundant at Location 10 in October.

The benthic fauna declined in abundance and number of taxa from October to December. The communities at Location 4 and 10 were dominated by Tubificidae (primarily Branchiura sowerbyi and unidentifiable immature tubificids, respectively). There were no significant differences in the density of the dominant groups or species diversity values between Locations 4 and 10 (Table 6-6).

A varied insect assemblage dominated the qualitative samples (Table 6-7). Hydropsychid caddisflies were the prominent organisms collected in June. During October and December, Location 10 yielded more taxa than Location 4 which was probably related to the diverse pool and riffle habitat at this site. Location 1, which was situated in the tailwaters of John Redmond Reservoir, was characterized by fewer taxa and a lower relative abundance of organisms than either Location 10 or 4. Variable reservoir discharges apparently limited benthic fauna at this sampling site. Previous qualitative samplings in the Neosho River also indicated a restricted macroinvertebrate community at Location 1.

6.2.2 Wolf Creek

Quantitative sampling of the Wolf Creek benthos in 1980 yielded 46 macroinvertebrate taxa (Table 6-1). Aquatic oligochaetes (Naididae and Tubificidae) and midges (Chironomidae) were the predominant organisms collected in the grab samples. Total densities were lowest in December when the creek had been reduced to isolated pools.

Tubificidae and Chironomidae dominated the Wolf Creek benthos in April (Table 6-8). Tubificids (primarily unidentifiable immature individuals without capilliform chaetae and Limnodrilus cervix) composed approximately 96 percent of the benthos at Location 7. The dominant organisms at Location 3 were the tubificid Branchiura sowerbyi and the chironomid Cryptochironomus sp. Although the total community density was greater at Location 7 in April,

Table 6-6 Significant differences ($P \leq 0.05$) in species diversity and density of the dominant benthic macroinvertebrates collected from the Neosho River (Locations 4 and 10) near Wolf Creek Generating Station, Burlington, Kansas, 1980.

	Statistical Comparisons		
Sampling Date	Dominant Taxa[a]	Density	Diversity
17 June	*Ephoron leukon*	NS[b]	NS
	Total Caenidae	NS	
	Total Hydropsychidae	NS	
	Total Chironomidae	NS	
	Total Benthos	NS	
28 October	*Potamanthus* sp.	NS	NS
	Total Caenidae	NS	
	Total Heptageniidae	NS	
	Stenelmis sp.	NS	
	Total Tubificidae	NS	
	Total Chironomidae	NS	
	Total Benthos	10 > 4	
16 December	*Potamanthus* sp.	NS	NS
	Total Tubificidae	NS	
	Total Chironomidae	NS	
	Total Benthos	NS	

[a] Taxa or groups composing ≥ 5% of the total benthos.
[b] Non-significant difference.

Table 6-7 Benthic macroinvertebrate occurrence in qualitative collections near Wolf Creek Generating Station, Burlington, Kansas, 1980.

	Sampling Date/Location									
	15 April 80					16 June 80				
Taxon	1[a]	10[a]	4[a]	7	3	1	10	4	7	3
Platyhelminthes										
Turbellaria										
Tricladida										
Planariidae										
Dugeia sp.								R		
Arthropoda										
Crustacea										
Decapoda										
Astacidae				R	R	0	R	R		0
Insecta										
Ephemeroptera										
Ephemeridae										
Ephoron leukon							R			
Heptageniidae										
Stenacron interpunctatum						R				0
Stenonema integrum							R			
S. tripunctatum					R	R			R	R
Odonata										
Gomphidae										
Gomphus sp.							R			
Coenagrionidae										
Argia sp.						R				
Libellulidae										
Didymops transversa								R		
Plecoptera										
Perlidae										
Neoperla clymene							R			
Megaloptera										
Corydalidae										
Corydalus cornutus								R		
Trichoptera										
Hydropsychidae										
Cheumatopsyche sp.						0	0	0		
Hydropsyche frisoni							R	R		
H. orris							R	R		
Potamyia flava							R	R		
Hydroptilidae										
Hydroptila sp.								R		
Hemiptera										
Gerridae										
Gerris sp.				R					0	R
Rheumatobates sp.				R					0	R
Veliidae										
Rhagovelia sp.							0			
Coleoptera										
Gyrinidae										
Dineutus sp.								0	R	
Mollusca										
Gastropoda										
Pulmonata										
Physidae										
Physa sp.				R	R				0	R
Planorbidae										
Helisoma sp.					R				R	
Pelecypoda										
Sphaeriidae										
Sphaerium transversum								R		
Number of Taxa				3	4	5	11	11	5	5

Table 6-7 (continued)

Taxon	Sampling Date/Location									
	28 October 80					12 December 80				
	1[a]	10[a]	4[a]	7	3	1	10	4	7	3
Annelida										
Oligochaeta										
Plesiopora										
Naididae										
Nais bretscheri							R			
Arthropoda										
Crustacea										
Decapoda										
Astacidae	R									
Insecta										
Ephemeroptera										
Ephemeridae										
Potamanthus sp.		R					R	R		
Heptageniidae										
Stenonema terminatum		R					O			
S. tripunctatum							R			
Baetidae										
Isonychia sp.		R					R			
Odonata										
Gomphidae										
Gomphus sp.		R						R		
Coenagrionidae										
Argia sp.	R	O	R			R	R			
Plecoptera										
Perlidae										
Acroneuria sp.							R			
Hemiptera										
Corixidae		R				R	R			
Trichoptera										
Hydropsychidae										
Unidentified Hydropsychidae							R			
Cheumatopsyche sp.	R						O			
Potamyia flava		R					R			
Coleoptera										
Elmidae										
Stenelmis sp.							R			
Gyrinidae										
Dincutus sp.			R							
Diptera										
Simuliidae							C			
Chironomidae										
Cricotopus fuscus							R			
Hydrobaenus sp.							R			
Ceratopogonidae							R			
Tipulidae							R			
Mollusca										
Gastropoda										
Basomatophora										
Physidae										
Physa sp.			O	O		R	R			
Pelecypoda										
Heterodonta										
Sphaeridae										
Sphaerium transversum	R	O					O			
Unionidae										
Lampsilis anodontoides			R							
Number of Taxa	4	9	4	0	0	3	19	2	0	0

R = Rare (1-4), O = Occasional (5-25), C = Common (26+).

[a] Not taken due to flooding.

Table 6-8 Dominant groups[a] and diversity indices of the benthic macroinvertebrates collected from Wolf Creek near Wolf Creek Generating Station, Burlington, Kansas, 1980.

	15 April				17 June				28 October				16 December			
	7		3		7		3		7		3		7		3	
Taxon	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Oligochaeta																
Naididae	0[b]		0		9.4	0.8	434.7	36.8	0		66.2	5.0	0		0	
Tubificidae	1285.2	95.8	198.4	34.4	869.4	76.0	151.2	12.8	113.4	66.7	1067.8	81.3	9.4	12.5	293.0	88.6
Ephemeroptera																
Caenidae	0		0		0		0		0		18.9	1.4	9.4	12.5	9.4	2.9
Ephemeridae	0		0		0		9.4	0.8	0		9.4	0.7	0		0	
Heptageniidae	0		0		0		0		0		0		9.4	12.5	0	
Plecoptera																
Perlodidae	0		0		0		0		0		0		9.4	12.5	9.4	2.9
Trichoptera																
Hydropsychidae	0		9.4	1.6	9.4	0.8	0		0		0		28.3	37.5	9.4	2.9
Coleoptera																
Elmidae	0		37.8	6.6	9.4	0.8	9.4	0.8	0		0		9.4	12.5	0	
Diptera																
Chironomidae	56.7	4.2	264.6	45.9	226.8	19.8	538.7	45.6	47.3	27.8	47.3	3.6	0		0	
Ceratopogonidae	0		28.4	4.9	0		9.4	0.8	0		9.4	0.7	0		0	
Gastropoda																
Physidae	0		9.4	1.6	0		0		9.4	5.6	0		0		0	
Total Benthos	1341.9		576.5		1143.4		1181.3		170.1		1313.6		75.6		330.8	
Total Taxa	8[c]		15		14		16		6		13		7		7	
Species Diversity Index	1.05[c]		3.34		2.24		3.17		1.88		1.73		2.75		1.87	

[a] Groups composing $\geq$ 5% of the total benthos at a location during any sampling period.
[b] Mean of two replicates.
[c] Total of two replicates.

more taxa were collected at Location 3. The significantly higher species diversity value at Location 3 reflected these community differences between locations (Table 6-9).

The June collections at Location 7 revealed a Tubificidae-dominated community similar to the fauna recorded in April. Tubificids and chironomids continued to be predominant families at Location 3 in June; however, the dominant taxon was the naidid oligochaete Nais sp. There were no significant differences between Locations 7 and 3 in June in species diversity values or in mean densities of the dominant groups (Table 6-9).

Tubificidae (primarily unidentifiable immature individuals) dominated the Wolf Creek benthos in October. From June to October the total benthos and total taxa decreased at Location 7 but remained the same at Location 3. The decline in the benthos community at Location 7 was attributed to the low flow and heavy leaf litter at this sampling site. Total Tubificidae and total benthos were significantly greater at Location 3 than at Location 7 in October.

The total benthos decreased at both locations in Wolf Creek from October to December. Low flow had reduced the aquatic habitats in Wolf Creek to isolated pools. Hydropsychid caddisflies (especially Cheumatopsyche sp.) and tubificids (predominantly unidentifiable immature individuals) were the most abundant families at Locations 7 and 3, respectively, in December.

Qualitative collections in Wolf Creek yielded few taxa in 1980 (Table 6-7). The sparse fauna was probably related to the intermittent nature of this stream and the extended reduced flow during 1980. Crayfish (Astacidae), water striders (Gerris sp.), and the snail, Physa sp., were the most abundant organisms collected in April and June; however, no macroinvertebrates were found during October and December.

Quantitative and qualitative sampling of Wolf Creek revealed variations in community composition and structure typical of intermittent streams. During 1980, the fauna of Wolf Creek had lower density and diversity values than the community of the Neosho River. Comparisons of Wolf Creek benthos densities from 1974 through 1980 revealed no consistent spatial or temporal fluctuations (Table 6-10). There were no indications that station construction had altered the macroinvertebrate community of Wolf Creek.

6.3 SUMMARY AND CONCLUSIONS

Drift samples collected from the Neosho River (Location 1) during 1980 yielded 35 macroinvertebrate taxa. The drift assemblage was dominated by Hydropsychidae (net-spinning caddisflies), Chaoboridae (phantom-midges), and Chironomidae (midge-flies). As in previous years, the composition of the drift in 1980 exhibited seasonal variations in density and diversity.

Ponar grab samples from the Neosho River (Locations 10 and 4) during 1980 contained 71 benthic macroinvertebrate taxa. Aquatic oligochaetes (Tubificidae), net-spinning caddisflies, and midge-flies were the dominant organisms. The diversity and density of benthic organisms were generally greater at

Table 6-9 Significant differences ($P \leq 0.05$) in species diversity and density of the dominant benthic macroinvertebrates collected from Wolf Creek (Locations 3 and 7) near Wolf Creek Generating Station, Burlington, Kansas, 1980.

	Statistical Comparisons		
Sampling Date	Dominant Groups[a]	Density	Diversity
15 April	Total Tubificidae	NS[b]	3 > 7
	Total Chironomidae	NS	
	Total Benthos	NS	
17 June	Total Tubificidae	NS	NS
	Total Chironomidae	NS	
	Total Naididae	NS	
	Total Benthos	NS	
28 October	Total Tubificidae	3 > 7	NS
	Total Chironomidae	NS	
	Total Benthos	3 > 7	
16 December	Total Tubificidae	NS	NS
	Total Benthos	NS	

[a] Selected groups composing $\geq$ 5% of the total benthos at a location.
[b] Non-significant difference.

Table 6-10 Macroinvertebrate densities (No./m^2) from Wolf Creek (Locations 7, 3, and 5) near Wolf Creek Generating Station, Burlington, Kansas, 1974-1980.

Sampling Date		Sampling Location 7	3	5
26 March	1974	-[a]	526[b]	359
17 April	1975	445	5680	265
6 April	1976	964	2807	1266
5 April	1977	57	463	dry
25 April	1978	728	1578	586
10 April	1979	1739	142	85
15 April	1980	1342	577	-
11 June	1974	-	898	161
10 June	1975	2098	435	19
15 June	1976	7437	1635	1805
8 June	1977	406	170	548
27 June	1978	2533	964	255
12 June	1979	2816	331	558
17 June	1980	1143	1181	-
5 October	1976	20667	dry	dry
3-4 October	1977	387	576	123
10 October	1978	1484	1427	dry
8 October	1979	529	822	dry
28 October	1980	170	1314	-
10 December	1974	-	4763	5481
3 December	1975	463	1323	303
14 December	1976	4319	dry	dry
12-13 December	1977	6587	643	1238
12 December	1978	917	1654	558
10 December	1979	246	1210	227
16 December	1980	76	331	-

[a] Location not sampled.
[b] Mean of two replicates.

Location 10 than at Location 4. These differences in the aquatic community were attributed to the more productive riffle habitat at Location 10 in comparison to the pool habitat sampled at Location 4.

A total of 46 macroinvertebrate taxa was collected in the Ponar grab samples from Wolf Creek in 1980. Tubificidae and Chironomidae were the predominant macroinvertebrate families collected from Wolf Creek. Naididae were also occasionally abundant components of the benthic fauna. Intermittent flow of Wolf Creek was the probable reason for lower abundance and diversity of macroinvertebrates in comparison with the Neosho River fauna.

Data collected in 1980 paralleled that reported in previous years of monitoring in Wolf Creek and the Neosho River. No long-term patterns, empirical, or statistical differences were found in the macroinvertebrate data that suggested any alterations attributed to construction of Wolf Creek Generating Station.

7. FISHERIES

7.1 FIELD AND ANALYTICAL PROCEDURES

7.1.1 Sampling Locations

Four locations in the Neosho River and two in Wolf Creek were sampled to characterize the resident fish community of each system (Figure 1-1). A description of the physical characteristics associated with each location is presented in Section 1.3.

Adult and juvenile fish were collected monthly April through July, October, and December 1980. Larval fish were collected biweekly April through July 1980.

7.1.2 Sampling Methods

7.1.2.1 Electroshocking

A single-phase 230-volt AC boat-mounted boom shocker was used to collect fish in the Neosho River at Locations 1, 10, and 4. Sampling at each location was conducted for approximately 30 minutes and encompassed approximately 800 meters of shoreline. Electroshocking was conducted at each location once during April, June, October, and December 1980 at Location 1 in May and July.

7.1.2.2 Seining

A seine, 4.6 meters long, 1.8 meters deep, with 0.3 centimeter Ace mesh was used to collect forage-size fish from the shallow areas at all locations. When physical conditions permitted, 2-4 seine hauls were taken per location during each sampling period. Seining was conducted at each location once during April, June, October, and December 1980. In addition, Location 1 was seined in May and July. High water conditions during April prevented seining in the Neosho River.

7.1.2.3 Larval Fish Sampling

Larval fish were collected at Location 1 by placing a stationary 0.75-m diameter No. 0 mesh Nitex plankton net in the flowing water for 2-3 minutes. The net was equipped with a flowmeter (General Oceanics Model 2030) to quantify the volume of water sampled. Duplicate diurnal and nocturnal samples were taken on all sampling dates by Kansas Gas and Electric Company personnel; each sample was preserved separately in 10 percent formalin.

7.1.3 Data Analysis

Fish collected by electroshocking were identified, measured (total length in mm), and weighed (g) in the field. Forage-sized fish collected by seining were identified and measured either in the field or laboratory depending on the number of individuals collected. Fish to be identified and measured in the laboratory were preserved in 10 percent formalin.

Catch per unit effort (CPE), defined as the number of fish collected per 30 minutes of electroshocking, was determined for all species collected by this method. Spatial and temporal comparisons were based on CPE.

Scale samples were obtained from all blue suckers collected. Scale impressions were made on cellulose acetate slides, and the number of annuli was determined with the aid of a microprojector. Age was determined for individual fish.

Fish larvae samples were returned to the laboratory where the larvae were separated from the debris and preserved in 10 percent formalin for later identification. Identifications were made to the lowest positive taxonomic level using available keys and current literature including Fish (1932), Mansueti and Hardy (1967), May and Gasaway (1967), and Taber (1969). Densities were expressed as the number of larvae per 100 cubic meters of water (no./100 m^3). Kansas Gas and Electric personnel sorted the samples, identified the larvae and provided the data for this report.

Surface water temperatures were measured during each fish collection with a calibrated thermometer.

7.2 RESULTS AND DISCUSSION

7.2.1 Physical Conditions

Flow in the Neosho River within the study area was dependent on water releases from John Redmond Reservoir. Drought conditions resulted in minimal discharges for most of the year. Low flow conditions existed in the Neosho River during all sampling periods except April when flows were high (Section 2.2). Wolf Creek had low or zero flow during all samplng periods.

Surface water temperatures were generally similar for all locations sampled (Table 7-1). Slight variation was noted among locations during the June sampling, which was attributed to solar heating at locations with low water levels.

7.2.2 Species Composition and Relative Abundance

7.2.2.1 General

Electroshocking and seining in the Neosho River and Wolf Creek resulted in the collection of 5,142 adult and juvenile fish representing 38 species from 11 families (Tables 7-2 and 7-3). Numerically dominant species included red shiner (77.2 percent), bullhead minnow (4.9 percent), river carpsucker (3.0 percent), and gizzard shad (2.5 percent). Red shiners have been the most abundant species collected for the past four years. Number and size distribution of fishes collected by electroshocking and seining during each sampling period are presented in Appendix E, Tables E-1 through E-3.

The 1980 collections included two species (gravel chub and freckled madtom) which were not reported in previous monitoring studies. Both species occur in larger streams of the Neosho River Basin in deep riffles with gravel

Table 7-1 Water temperature recorded at locations sampled by electroshocking and seining in the Neosho River and Wolf Creek near the Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.

Sampling Mode	Date	Sampling Location					
		1	10	11	4	7	3
Electroshocking	14 Apr	9.4	9.4	--[a]	9.4	-	-
	28 May	25.6	-	-	-	-	-
	17 Jun	23.0	25.6	-	25.6	-	-
	24 Jul	26.0	-	-	-	-	-
	29 Oct	8.9	9.4	-	8.9	-	-
	15 Dec	6.0	5.0	-	5.0	-	-
Seining	15 Apr	-	-	-	-	9.4	9.4
	28 May	25.6	-	-	-	-	-
	17 Jun	23.0	23.0	25.6	23.0	19.5	20.0
	24 Jul	27.0	-	-	-	-	-
	29 Oct	8.0	8.0	11.0	11.0	8.0	8.0
	15 Dec	5.0	5.0	5.0	5.0	4.5	4.5

[a] Not sampled.

Table 7-2 Checklist of fishes collected by seining and electrofishing near Wolf Creek Generating Station, Burlington, Kansas 1980.

Family and Scientific Name[a]	Common Name
Lepisosteidae (gars)	
Lepisosteus osseus	Longnose gar
Clupeidae (herrings)	
Dorosoma cepedianum	Gizzard shad
Cyprinidae (carps and minnows)	
Cyprinus carpio	Common carp
Campostoma anomalum	Central stoneroller
Hybopsis x-punctata	Gravel chub
Notemigonus chrysoleucas	Golden shiner
Notropis buchanani	Ghost shiner
Notropis lutrensis	Red shiner
Notropis stramineus	Sand shiner
Phenacobius mirabilis	Suckermouth minnow
Pimephales notatus	Bluntnose minnow
Pimephales promelas	Fathead minnow
Pimephales tenellus	Slim minnow
Pimephales vigilax	Bullhead minnow
Catostomidae (suckers)	
Carpiodes carpio	River carpsucker
Carpiodes cyprinus	Quillback
Ictiobus bubalus	Smallmouth buffalo
Ictiobus cyprinellus	Bigmouth buffalo
Ictiobus niger	Black buffalo
Moxostoma macrolepidotum	Shorthead redhorse
Cycleptus elongatus	Blue sucker
Ictaluridae (freshwater catfishes)	
Ictalurus melas	Black bullhead
Ictalurus punctatus	Channel catfish
Pylodictis olivaris	Flathead catfish
Noturus nocturnus	Freckled madtom
Noturus placidus	Neosho madtom
Poeciliidae (livebearers)	
Gambusia affinis	Mosquitofish
Atherinidae (silversides)	
Labidesthes sicculus	Brook silverside
Percichthyidae (temperate basses)	
Morone chrysops	White bass

Table 7-2 (continued)

Family and Scientific Name[a]	Common Name
Centrarchidae (sunfishes)	
Lepomis cyanellus	Green sunfish
Lepomis humilis	Orangespotted sunfish
Lepomis macrochirus	Bluegill
Lepomis megalotis	Longear sunfish
Micropterus salmoides	Largemouth bass
Micropterus punctulatus	Spotted bass
Pomoxis annularis	White crappie
Percidae (perches)	
Etheostoma spectabile	Orangethroat darter
Percina phoxocephala	Slenderhead darter
Stizostedion vitreum	Walleye
Scianidae (drums)	
Aplodinotus grunniens	Freshwater drum

[a] According to Robbins (1980).

Table 7-3 Number and relative abundance of fish collected by electroshocking and seining in the Neosho River and Wolf Creek near the Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.

Species	Sampling Date 14-15 Apr	28 May	17 Jun	24 Jul	28 Oct	15 Dec	Total	Relative Abundance
Longnose gar	6	0	6	0	0	0	12	0.2
Gizzard shad	4	24	69	2	18	11	128	2.5
Carp	8	1	5	0	23	3	40	0.8
Stoneroller	1	0	0	0	0	0	1	T[a]
Gravel chub	0	0	0	3	0	1	4	0.1
Golden shiner	19	3	22	1	6	0	51	1.0
Ghost shiner	0	3	2	1	13	3	22	0.4
Red shiner	16	94	383	6	1752	1718	3969	77.2
Sand shiner	0	1	7	0	0	0	8	0.2
Suckermouth minnow	6	0	3	0	1	5	15	0.3
Bluntnose minnow	0	0	0	0	3	0	3	0.1
Fathead minnow	1	0	3	0	0	0	4	0.1
Slim minnow	0	0	0	0	0	6	6	0.1
Bullhead minnow	0	0	18	5	189	42	254	4.9
UID Cyprinid	0	0	3	0	0	0	3	0.1
Carpiodes sp.	0	0	1	0	0	0	1	T
River carpsucker	2	26	48	15	19	42	152	3.0
Quillback	0	0	1	0	0	0	1	T
Ictiobus sp.	0	0	1	0	0	0	1	T
Smallmouth buffalo	3	5	30	11	11	3	63	1.2
Bigmouth buffalo	1	6	5	0	0	0	12	0.2
Black buffalo	1	1	0	0	0	0	2	T
Shorthead redhorse	0	0	5	0	2	0	7	0.1
Blue sucker	0	0	2	0	4	1	7	0.1
Black bullhead	1	0	4	0	0	0	5	0.1
Channel catfish	0	12	7	11	6	0	36	0.7
Flathead catfish	0	5	27	10	1	0	43	0.8
Freckled madtom	0	0	0	0	0	1	1	T
Neosho madtom	0	0	1	0	1	4	6	0.1
Mosquitofish	0	0	0	0	4	0	4	0.1
Brook silverside	0	0	0	32	14	0	46	0.9
White bass	7	1	13	1	3	0	25	0.5
Green sunfish	6	0	13	8	1	0	28	0.5
Orangespotted sunfish	3	2	6	11	3	2	27	0.5
Bluegill	0	0	2	0	1	0	3	0.1
Longear sunfish	0	0	2	3	1	0	6	0.1
Largemouth bass	0	0	0	1	0	0	1	T
Spotted bass	0	0	25	0	2	1	28	0.5
White crappie	2	7	13	11	0	2	35	0.7
Orangethroat darter	0	0	0	0	0	4	4	0.1
Slenderhead darter	0	0	0	0	10	4	14	0.3
Walleye	0	2	2	0	0	0	4	0.1
Freshwater drum	4	0	13	4	39	0	60	1.2
Total	91	193	742	136	2127	1853	5142	

bottoms (Cross 1967). Similar habitat was sampled in December at Location 10 where these species were collected. Cross (1967) found freckled madtoms to be scarce when encountered but they occurred most often in areas of slow current with leaves or other woody material. Gravel chubs were most abundant in the Neosho River when there was continuous low and clear flow (Cross 1967) which existed in 1980 following the high April flow. Consistently low flows made the riffles more accessible which may have made these species more susceptible to collection. Gravel chub has been classified as endangered in Kansas because of its narrow range in the Neosho and Spring rivers (Platt et al. 1974). Recommendations for protecting this species include control of nutrient loading and protection of gravel substrates.

Blue sucker, which are listed as rare in Kansas (Platt et al. 1974) were again collected in 1980. A total of nine blue suckers was collected. The total length (TL, mm) - weight (W,g) relationship of these fish was $\log_{10}W = 3.49 \log_{10} TL - 6.44$ $r = 0.94$ (Figure 7-1). Ages ranged from III+ to VI+, with no representatives of the IV+ age group. Condition factors (Carlander 1969) ranged from 0.72 to 0.96 for all fish collected. Age was highly correlated with both $\log_{10}$ total length and $\log_{10}$ weight, with $r = 0.98$ and $r = 0.95$, respectively. A comparison of the bio-characteristics of the blue suckers collected in the Neosho River in 1980 and other populations is presented in Table 7-4. Coefficients of condition and length-weight relationship determined for blue suckers collected in the Neosho River were similar to those determined by Swingle (1965) and Rupprecht and Jahn (1980).

The Neosho madtom, listed as endangered in Kansas (Platt et al. 1974), was collected in 1980. Six Neosho madtom were collected at Location 10 and 11 (Table 7-3). Slenderhead darters were collected at Locations 10, 11, and 4. Slenderhead darters and Neosho madtoms require shallow gravel riffles swept by swift current as habitat (Cross 1967, Deacon 1961). Location 10 appeared to be the preferred habitat for both the Neosho madtom and slenderhead darter. Although Locations 11 and 4 were also utilized, higher numbers at Location 10 may be due to differences in bottom substrates. Location 10 has coarser gravel and less silt than Locations 4 and 11 following high reservoir discharges in April.

Gizzard shad were collected in lower numbers than in previous years. Lower catches were probably due to the low discharges from the John Redmond Reservoir for most of the year. It is suspected that most gizzard shad present in the river originate from the reservoir.

7.2.2.2 Neosho River

7.2.2.2.1 Electroshocking

Electroshocking in the Neosho River yielded 546 fish representing 23 species (Table 7-5). The most abundant species collected included river carpsucker (27.8 percent), gizzard shad (11.4 percent), freshwater drum (11.0 percent), smallmouth buffalo (8.4 percent), carp (7.9 percent), flathead catfish (7.7 percent), channel catfish (6.4 percent), and white crappie (5.5 percent). These eight species comprised 86.1 percent of the total collected by electroshocking. CPE was greatest at Location 1 throughout the year except in October (Figure 7-2).

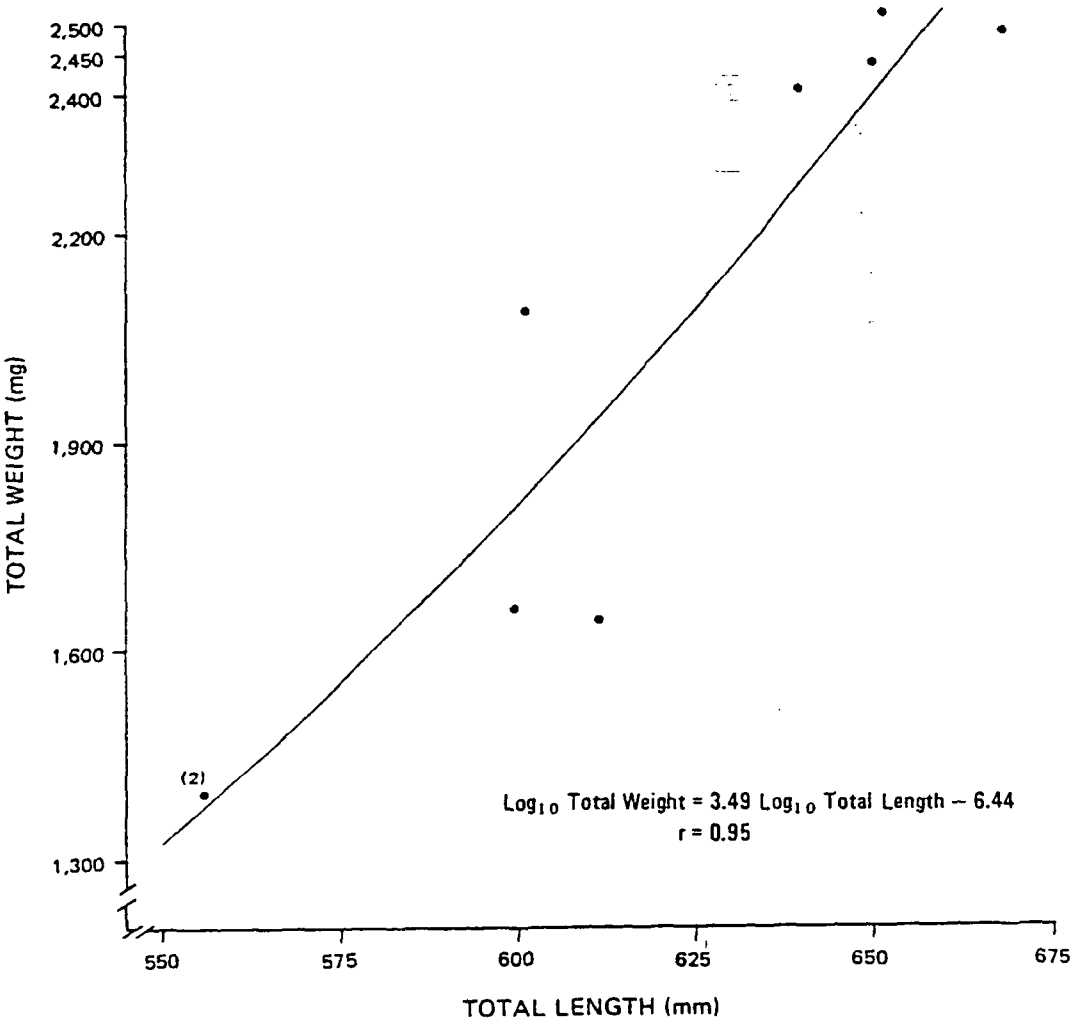

Figure 7-1 Length-weight relationship of blue suckers collected by electroshocking in the Neosho River near the Wolf Creek Generating Station, Burlington, Kansas, 1980.

Table 7-4 Comparison of blue suckers collected in the Neosho River in 1980 with other populations.

Biostatistic	Neosho River Kansas	Mississippi River Iowa[a]	Alabama[b]
Number Examined	9	153	6
Total Length (TL) - Weight (W) Relationship	$\log_{10}W = 3.49(\log_{10}TL) - 6.44$ $r = 0.94$	$\log_{10}W = 3.59(\log_{10}TL) - 6.69$ $r = 0.96$	$\log_{10}W = 3.19(\log_{10}TL) - 5.57$ $r = 0.95$
Condition "K"			
range	0.72 - 0.96	0.74 - 1.10	0.73 - 1.04
mean	0.85	0.87	0.89
Length Range (mm)	556-668	503-817	457-635
Weight Range (g)	1390-2510	-	703-2246

[a] Rupprecht and Jahn 1980.
[b] Swingle 1965.

Table 7-5 Number and relative abundance of fish collected by electroshocking in the Neosho River near the Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.

Species	Sampling Date						Total	Relative Abundance
	14 Apr	28 May[a]	17 Jun	24 Jul[a]	28 Oct	15 Dec		
Longnose gar	6	0	1	0	0	0	7	1.3
Gizzard shad	4	24	5	0	18	11	62	11.4
Carp	8	1	5	3	23	3	43	7.9
Ghost shiner	0	0	0	1	0	0	1	0.2
Red shiner	0	0	0	1	0	0	1	0.2
River carpsucker	2	26	48	15	19	42	152	27.8
Quillback	0	0	1	0	0	0	1	0.2
Smallmouth buffalo	3	5	13	11	11	3	46	8.4
Bigmouth buffalo	1	6	1	0	0	0	8	1.5
Black buffalo	1	1	0	0	0	0	2	0.4
Shorthead redhorse	0	0	0	0	2	0	2	0.4
Blue sucker	0	0	2	0	4	1	7	1.3
Channel catfish	0	12	7	11	5	0	35	6.4
Flathead catfish	0	5	27	10	0	0	42	7.7
Brook silverside	0	0	0	1	1	0	2	0.4
White bass	7	1	3	1	3	0	15	2.7
Green sunfish	0	0	6	8	1	0	15	2.7
Longear sunfish	0	0	2	3	0	0	5	0.9
Largemouth bass	0	0	0	1	0	0	1	0.2
Spotted bass	0	0	2	0	2	1	5	0.9
White crappie	2	7	8	11	0	2	30	5.5
Walleye	0	2	2	0	0	0	4	0.7
Freshwater drum	4	0	13	4	39	0	60	11.0
Total	38	90	146	81	128	63	546	

[a] Only Location 1 sampled.

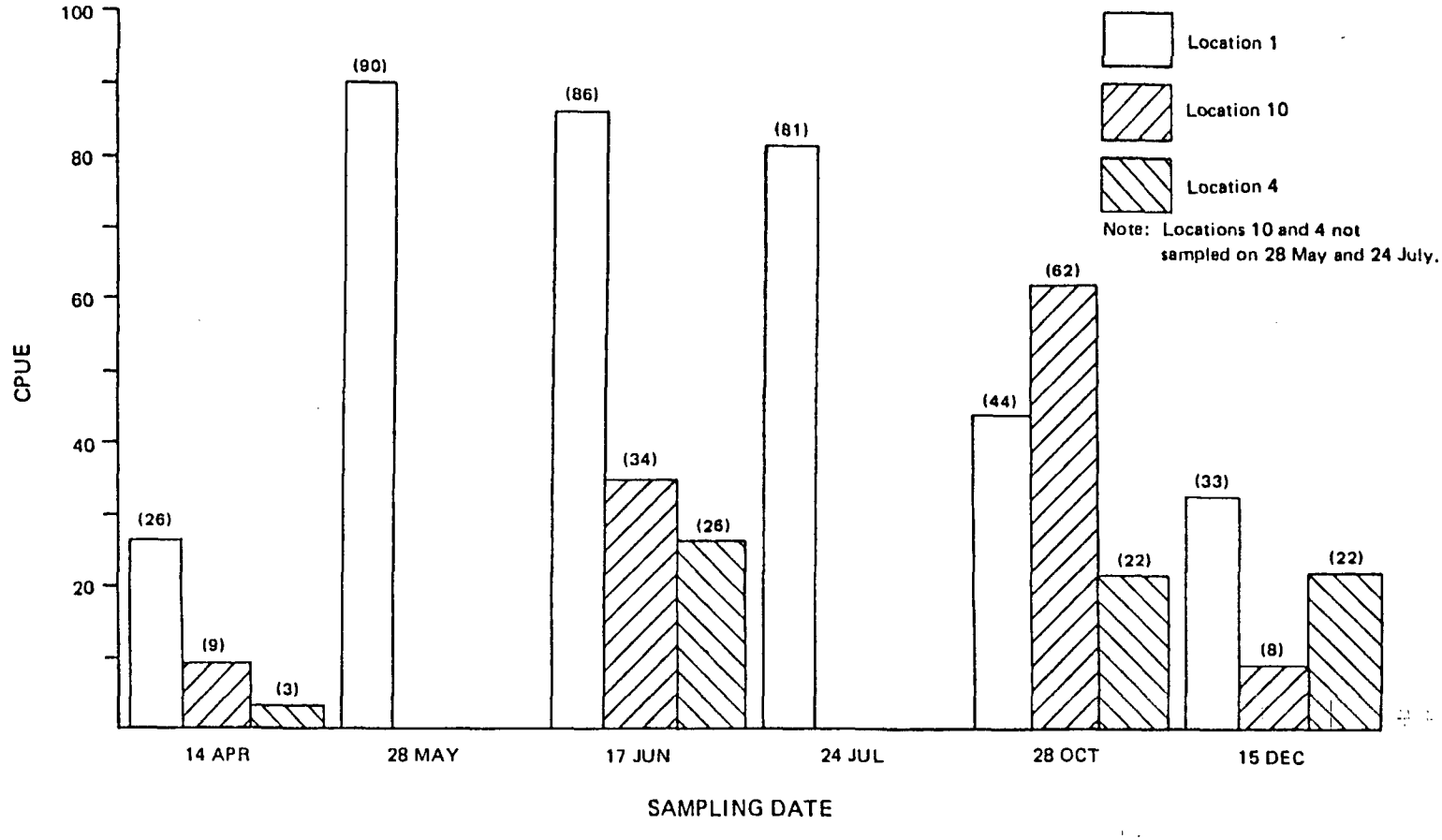

Figure 7-2 Catch-per-unit-effort of electrofishing at three locations (1, 10, and 4) in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.

Catch rates were greatest for most species in the tailwaters (Location 1) of John Redmond Reservoir. River carpsucker were collected throughout the sampling season and were caught at rates that averaged approximately 5 times higher than at the downstream locations (Table 7-6). Consistent occurrence and large size of carpsuckers at Location 1 suggested a resident population in the tailwater area. The average CPE at Location 1 for river carpsucker was approximately 5 times greater than at the downstream locations.

Catch rates of gizzard shad were extremely low in 1980 (Table 7-6). The average CPE was only 4.4 compared to average CPE's of 15.0 to 28.1 recorded from 1977 through 1979. The lower rates in 1980 were due primarily to the near absence of juveniles in the tailwaters. Lower catches may be attributable to reduced discharges from the reservoir where most of the gizzard shad in the river are thought to originate. Low densities of larval gizzard shad (Section 7.2.3) support the apparent relationship between reservoir discharges and gizzard shad abundance. Catches of gizzard shad at Location 4 represented 43.6 percent of the catch at that location which was higher than previously reported. Gizzard shad CPE was highest in May at Location 1 when the catch was dominated by adults in spawning condition.

Smallmouth buffalo were taken throughout the year (Table 7-5) and based on CPE were most abundant at Location 10 (Table 7-6). Catch data collected from 1977 through 1980 for smallmouth buffalo and other commercial species (including carp, river carpsucker, and bigmouth buffalo) were examined to determine if commercial fishing operations during 1980 in the Neosho River had any impact on these species. The 1980 catch rates of these species were within ranges of previous CPE's except for bigmouth buffalo whose catch rates have declined since 1977 (Table 7-7). Data collected in 1981 will provide additional information on the impact of commercial fishing.

Freshwater drum represented 11.0 percent of the total catch and were abundant at Location 10 where the average CPE was 8.5 (Table 7-6). Thirty-five percent of the total catch was taken at Location 1. Most drum collected were small (average length 174 mm) and do not represent a commercial or sport value at this size (Appendix E, Table E-1). Freshwater drum represented between 12.9 and 14.4 percent of the electrofishing catch from 1977 through 1979 (Table 7-8).

Flathead catfish were collected in greater numbers than channel catfish for the first time in four years (Table 7-8). The greatest CPE for both species occurred in the tailwaters of the John Redmond Reservoir (Table 7-6). Most catfish (78 percent) were collected during the early summer (Table 7-5). Location 1 apparently provided the most suitable habitat for channel catfish based on CPE whereas the CPE for flathead catfish was similar at all three locations (Table 7-4). Both species were nearly absent during April and December indicating, as in 1979, a movement to deeper, more quiescent waters during the winter (Bliss 1980).

Other species which had higher CPE in the tailwaters included carp, white bass, green sunfish, and white crappie (Table 7-6). Catch rates of white bass and white crappie may have been affected by low discharges from the reservoir since some of these fishes are thought to be lost from the reservoir

Table 7-6 Number and average CPE of each fish species collected by electroshocking at sampling locations in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.[a]

Species	Location 1		Location 10		Location 4	
	No.	CPE	No.	CPE	No.	CPE
Longnose gar	0	0.0	7	1.8	0	0.0
Gizzard shad	32	5.3	3	0.8	27	6.8
Carp	33	5.5	9	2.2	1	0.2
Ghost shiner	1	0.2	0	0.0	0	0.0
Red shiner	1	0.2	0	0.0	0	0.0
River carpsucker	121	20.2	15	3.8	16	4.0
Quillback	0	0.0	1	0.2	0	0.0
Smallmouth buffalo	20	3.3	21	5.2	5	1.2
Bigmouth buffalo	8	1.3	0	0.0	0	0.0
Black buffalo	2	0.3	0	0.0	0	0.0
Shorthead redhorse	1	0.2	1	0.2	0	0.0
Blue sucker	1	0.2	4	1.0	2	0.5
Channel catfish	31	5.2	3	0.8	1	0.2
Flathead catfish	21	3.5	10	2.5	11	2.8
Brook silverside	2	0.3	0	0.0	0	0.0
White bass	14	2.3	0	0.0	1	0.2
Green sunfish	14	2.3	1	0.2	0	0.0
Longear sunfish	4	0.7	0	0.0	1	0.2
Largemouth bass	1	0.2	0	0.0	0	0.0
Spotted bass	0	0.0	2	0.5	3	0.8
White crappie	28	4.7	2	0.5	0	0.0
Walleye	4	0.7	0	0.0	0	0.0
Freshwater drum	21	3.5	34	8.5	5	1.2
Total	360	60.1	113	28.2	73	18.1

[a] CPE represents number of fish caught per 30 min. of effort.

Table 7-7 Average CPE (by electrofishing at Location 1) of commercial fishes in the Neosho River, Burlington, Kansas, 1977 through 1980.[a]

Species	Year			
	1977	1978	1979	1980
Carp	1.8	6.4	11.5	5.5
River carpsucker	18.1	13.2	35.8	20.2
Smallmouth buffalo	9.1	3.7	3.8	3.3
Bigmouth buffalo	5.4	3.1	2.0	1.3

[a] Number of fish caught per 30 min. of effort.

Table 7-8 Number and relative abundance of fish collected by electroshocking in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1977-1980.

	Year Collected							
	1977		1978		1979		1980[a]	
Species	No.	Relative Abundance	No.	Relative Abundance	No.	Relative Abundance	No.	Relative Abundance
Longnose gar	6	0.4	7	0.5	9	0.6	7	1.3
Shortnose gar	2	0.1	3	0.2	9	0.6	0	0.0
Gizzard shad	457	31.1	563	36.7	271	18.5	62	11.4
Carp	116	7.9	101	6.6	149	10.2	43	7.9
Goldfish	0	0.0	0	0.0	1	0.1	0	0.0
Red shiner	4	0.3	2	0.1	7	0.5	1	0.2
Sand shiner	1	0.1	0	0.0	0	0.0	0	0.0
Ghost shiner	1	0.1	0	0.0	0	0.0	1	0.2
Blue sucker	33	2.2	38	2.5	21	1.4	7	1.3
River carpsucker	199	13.5	139	9.1	323	22.1	152	27.8
Quillback	0	0.0	0	0.0	0	0.0	1	0.2
Bigmouth buffalo	73	5.0	28	1.8	36	2.5	8	1.5
Smallmouth buffalo	79	5.4	63	4.1	58	4.0	46	8.4
Black buffalo	1	0.1	5	0.3	9	0.6	2	0.4
Shorthead redhorse	1	0.1	3	0.2	1	0.1	2	0.4
Golden redhorse	3	0.2	1	0.1	1	0.1	0	0.0
Channel catfish	93	6.3	78	5.1	93	6.4	35	6.4
Flathead catfish	14	1.0	17	1.1	11	0.8	42	7.7
Brook silverside	15	1.0	0	0.0	0	0.0	2	0.4
Mosquitofish	0	0.0	1	0.1	0	0.0	0	0.0
White bass	48	3.3	54	3.5	120	8.2	15	2.7
Largemouth bass	1	0.1	1	0.1	2	0.1	1	0.2
Spotted bass	8	0.5	6	0.4	9	0.6	5	0.9
Bluegill	2	0.1	0	0.0	0	0.0	0	0.0
Green sunfish	26	1.8	153	10.0	52	3.6	15	2.7
Longear sunfish	11	0.7	9	0.6	4	0.3	5	0.9
Orangespotted sunfish	2	0.1	3	0.2	1	0.1	0	0.0
White crappie	83	5.7	31	2.0	75	5.1	30	5.5
Walleye	0	0.0	5	0.3	8	0.5	4	0.7
Freshwater drum	190	12.9	221	14.4	192	13.1	60	11.0
No. species	26		24		24		23	
Total No. Fish	1469		1532		1462		546	

[a] Sampling done on 6 dates; all other years represent 8 dates.

during higher flows than generally occurred in 1980. In contrast to 1979, white bass apparently remained in the tailwaters throughout the year (Appendix Table E-1).

Supplemental data collected by Kansas Gas and Electric at Location 1 during radiation monitoring collections indicated similar species composition to the environmental monitoring surveys. Dominant species included river carpsucker, channel catfish, flathead catfish, and freshwater drum. Gizzard shad were also collected in low numbers by KGE personnel. Two species (brook silversides and golden redhorse) were only taken during the radiation monitoring collections.

Synthesis of the environmental and radiation monitoring electroshocking data provided more complete seasonal catch data than did previous studies. The predominant species generally were more abundant in the tailwaters during the spawning season (May through July) and apparently dispersed in the summer (Table 7-9). Catch rates of gizzard shad, carp, river carpsucker, and freshwater drum generally increased in the fall whereas flathead catfish and white crappie were not encountered after the summer collections. The electroshocking CPE was moderate in December but the diversity of fishes was lowest of the study (Table 7-9). A relatively mild early winter resulted in water temperatures of 4.5 C during the December 1980 sampling. Previous studies found that fish were absent at Location 1 when water temperatures were below 2 C (Bliss 1980).

7.2.2.2.2 Seining

A total of 4,357 fish representing 28 species was collected during seining in the Neosho River (Tables 7-10 and 7-11). Species having relative abundance greater than 5 percent included only red shiner (87.4 percent) and bullhead minnow (5.4 percent). Of the remaining species, only gizzard shad (1.9 percent) had a relative abundance greater than 1 percent. Seine catches were highest in October and December (Figure 7-3) when juvenile red shiners dominated the samples (Table 7-11). Red shiners were most abundant at Locations 1 and 10 (Table 7-10).

Red shiners have become increasingly important in the Neosho River since 1976. This predominance may be attributed to the adaptability of red shiners to environmental variation and specifically to drought conditions (Cross 1967, Pflieger 1975). Drought conditions in 1980 resulted in low flow during most of the year which may have given red shiners a competitive advantage. Most other species in the river do not do as well under these conditions, thereby reducing competition.

Few game fish were collected by seining in the Neosho River. Channel catfish, flathead catfish, white bass, white crappie, and spotted bass represented less than 1 percent of the total catch (Table 7-10). Collection of adult and juvenile gizzard shad at Location 4 suggests the pool habitat was used as a spawning/nursery area during 1980.

The 1980 seine catch was higher than in previous years despite reduced effort (Table 7-12). Greater catches of red shiner and bullhead minnow were responsible for the increase. Annual catches of other major species were generally

Table 7-9 Catch rates (CPE) of selected species collected by electroshocking at the tailwaters of John Redmond Reservoir (Location 1) near Wolf Creek Generating Station, Burlington, Kansas, 1980.

Date	Gizzard shad	Carp	River carpsucker	Smallmouth buffalo	Channel catfish	Flathead catfish	White bass	White crappie	Freshwater drum	Total
14 Apr	3.0	7.0	2.0	0.0	1.0	0.0	7.0	2.0	3.0	26.0
14 May	18.0	2.0	8.0	0.0	4.0	2.0	4.0	12.0	2.0	70.0
28 May	24.0	1.0	26.0	5.0	12.0	5.0	1.0	7.0	0.0	90.0
11 Jun	0.0	8.3	21.7	1.7	3.3	11.7	1.7	6.7	5.0	68.4
17 Jun	0.0	3.0	39.0	3.0	7.0	6.0	3.0	8.0	7.0	86.0
9 Jul	2.0	1.0	18.0	1.0	13.0	11.0	0.0	2.0	2.0	55.0
24 Jul	0.0	3.0	15.0	11.0	11.0	10.0	1.0	11.0	4.0	81.0
29 Aug	0.0	0.0	4.0	7.0	7.0	4.0	2.0	0.0	1.0	30.0
18 Sep	0.0	1.0	8.0	3.0	2.0	0.0	0.0	5.0	2.0	23.0
30 Sep	3.0	4.0	8.0	6.0	7.0	0.0	3.0	1.0	7.0	42.0
21 Oct	12.0	0.0	24.0	4.5	12.0	0.0	10.5	0.0	16.5	84.0
28 Oct	1.0	17.0	12.0	1.0	1.0	0.0	2.0	0.0	7.0	44.0
20 Nov	0.0	1.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	23.0
15 Dec	4.0	2.0	27.0	0.0	0.0	0.0	0.0	0.0	0.0	33.0

Table 7-10 Number of fish collected by seining in the Neosho River near the Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.

Species	Sampling Location 1[a]	10[b]	11[b]	4[b]	Total	Relative Abundance
Longnose gar	-	1	-	5	6	0.1
Gizzard shad	29	-	-	37	66	1.5
Gravel chub	-	1	-	-	1	T[c]
Golden shiner	12	-	-	-	12	0.3
Ghost shiner	18	3	-	-	21	0.5
Red shiner	1184	1987	-	637	3808	87.4
Sand shiner	8	-	-	-	8	0.2
Suckermouth minnow	-	6	-	2	8	0.2
Bluntnose minnow	3	-	-	-	3	0.1
Slim minnow	-	5	-	1	6	0.1
Bullhead minnow	17	215	-	4	236	5.4
Carpiodes sp.	-	-	-	18	18	0.4
Ictiobus sp.	1	-	-	-	1	T
Smallmouth buffalo	-	-	-	17	17	0.4
Bigmouth buffalo	-	-	-	4	4	0.1
Shorthead redhorse	-	-	-	5	5	0.1
Freckled madtom	-	1	-	-	1	T
Neosho madtom	-	4	2	-	6	0.1
Channel catfish	-	1	-	-	1	T
Flathead catfish	-	1	-	-	1	T
Mosquitofish	4	-	-	-	4	0.1
Brook silverside	38	5	-	1	44	1.0
White bass	10	-	-	-	10	0.2
Orangespotted sunfish	18	-	-	1	19	0.4
Bluegill	2	-	-	1	3	0.1
Longear sunfish	1	-	-	-	1	T
Spotted bass	-	2	-	21	23	0.5
White crappie	5	-	-	-	5	0.1
Orangethroat darter	-	4	-	-	4	0.1
Slenderhead darter	-	13	1	1	15	0.3
Total	1350	2249	3	755	4357	
Percent of Total	31.0	51.6	0.1	17.3		

[a] Sampled on five dates.
[b] Sampled on three dates.
[c] Trace, < 0.1 percent.

Table 7-11 Number and relative abundance of fish collected by seining in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.

	Sampling Date									
	28 May[a]		17 Jun		24 Jul[a]		28 Oct		15 Dec	
Species	No.	Relative Abundance	No.	Relative Abundance	No.	Relative Abundance	No.	Relative Abundance	No.	Relative Abundance
Longnose gar	0	0.0	5	1.2	0	0.0	0	0.0	0	0.0
Gizzard shad	0	0.0	64	15.7	2	3.6	0	0.0	0	0.0
Gravel chub	0	0.0	0	0.0	0	0.0	0	0.0	1	0.1
Golden shiner	3	2.9	2	0.5	1	1.8	6	0.3	0	0.0
Ghost shiner	3	2.9	2	0.5	0	0.0	13	0.7	3	0.2
Red shiner	94	91.3	239	58.6	5	9.1	1752	87.6	1718	96.0
Sand shiner	1	1.0	7	1.7	0	0.0	0	0.0	0	0.0
Suckermouth minnow	0	0.0	2	0.5	0	0.0	1	0.1	5	0.3
Bluntnose minnow	0	0.0	0	0.0	0	0.0	3	0.2	0	0.0
Slim minnow	0	0.0	0	0.0	0	0.0	0	0.0	6	0.3
Bullhead minnow	0	0.0	0	0.0	5	9.1	189	9.5	42	2.3
Carpiodes sp.	0	0.0	18	4.4	0	0.0	0	0.0	0	0.0
Ictiobus sp.	0	0.0	1	0.2	0	0.0	0	0.0	0	0.0
Shorthead redhorse	0	0.0	5	1.2	0	0.0	0	0.0	0	0.0
Freckled madtom	0	0.0	0	0.0	0	0.0	0	0.0	1	0.1
Neosho madtom	0	0.0	1	0.2	0	0.0	1	0.1	4	0.2
Channel catfish	0	0.0	0	0.0	0	0.0	1	0.1	0	0.0
Flathead catfish	0	0.0	0	0.0	0	0.0	1	0.1	0	0.0
Mosquitofish	0	0.0	0	0.0	0	0.0	4	0.2	0	0.0
Brook silverside	0	0.0	0	0.0	31	56.4	13	0.7	0	0.0
White bass	0	0.0	10	2.5	0	0.0	0	0.0	0	0.0
Orangespotted sunfish	2	1.9	2	0.5	11	20.0	3	0.2	1	0.1
Bluegill	0	0.0	0	0.0	0	0.0	1	0.1	0	0.0
Longear sunfish	0	0.0	0	0.0	0	0.0	1	0.1	0	0.0
Spotted bass	0	0.0	23	5.6	0	0.0	0	0.0	0	0.0
White crappie	0	0.0	5	1.2	0	0.0	0	0.0	0	0.0
Orangethroat darter	0	0.0	0	0.0	0	0.0	0	0.0	4	0.2
Slenderhead darter	0	0.0	1	0.2	0	0.0	10	0.5	4	0.2
Total	103		408		55		1999		1789	

[a] Only Location 1 was sampled.

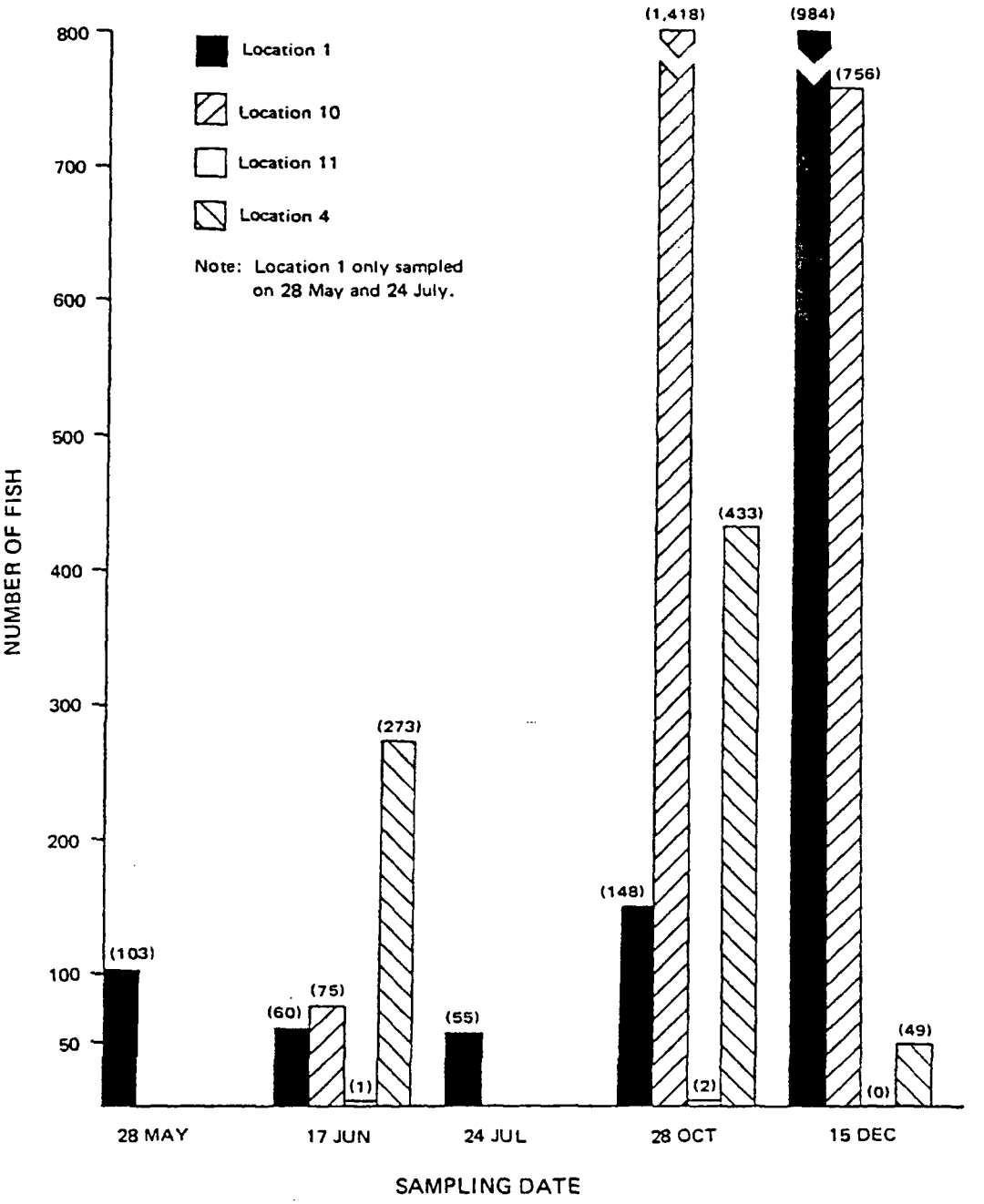

Figure 7-3 Number of fish collected during seining in the Neosho River (Locations 1, 10, 11, and 4) near the Wolf Creek Generating Station, Burlington, Kansas, 1980.

Table 7-12 Number of selected fishes collected by seining in the Neosho River near the Wolf Creek Generating Station, Burlington, Kansas, 1973 through 1980.

Species	Year							
	1973	1974	1975	1976	1977	1978	1979	1980
Gizzard shad	0	0	3	1669	41	1174	149	66
Ghost shiner	35	21	100	606	412	270	264	21
Red shiner	42	910	1558	2928	981	2381	2536	3808
Bluntnose minnow	0	2	3	43	31	11	29	3
Bullhead minnow	92	2	14	238	12	174	188	236
Slim minnow	0	7	64	32	6	0	22	6
Neosho madtom	0	0	0	12	19	46	12	6
Mosquitofish	0	24	108	54	49	69	2	4
Total fish	207	990	1920	5944	1626	4418	3491	4357
No. collections	8	8	8	26	26	28	25	14
No. fish per collection	26	124	240	229	63	158	140	311

within previous ranges although wide variations are evident. Gizzard shad catches exhibited the greatest variability. Schooling behavior of cyprinids and gizzard shad and fluctuating flows probably contributed to some of the annual variations. Variable flows affect the number of fish discharged from the reservoir (i.e. gizzard shad), affects selection of seining sites, and has potential effects on reproduction and recruitment and schooling results in patchy distribution. No trends are evident that suggest a decline in the abundance of any species collected by seining.

7.2.2.3 Wolf Creek

7.2.2.3.1 Seining

Seining in Wolf Creek resulted in the collection of only 242 fish represented by 9 species. The most abundant species was the red shiner with 98.8 percent collected at Location 3. Most fish occurred in the 17 June sample (Appendix E, Table E-3). No fish were taken on 28 October and only 1 was taken on 15 December. The only gamefish collected in 1980 in Wolf Creek was the black bullhead (Table 7-13). Orangespotted sunfish, which represented 28.1 percent in 1978 and 30.0 percent in 1979 of the total catch from Locations 7 and 3, were collected in low numbers in 1980 (n = 8) representing only 3.3 percent of the total catch. Only 38 fish were collected at Location 7. The extremely low catch in 1980 was probably due to several factors including drought conditions, closure of the cooling lake dam in September 1980, rerouting of the creek through borrow areas on the construction site, and renovaton of the watershed with rotenone from the dam to KGE's northern property boundary during the summer of 1980.

7.2.3 Larval Fish

Larval fish were present in the tailwaters (Location 1) from 30 April to 23 July 1980. Total densities ranged from 0.9 to 26.3/100 m^3 in the diurnal samples (Table 7-14) and from 2.2 to 100.4/100 m^3 in the nocturnal samples (Table 7-15). Peak abundance of ichthyoplankton occurred in June. Densities were similar to numbers recorded in 1979 which was considered a low abundance year attributed to either a poor spawn or missed spawning period of usually (1976-1978) abundant gizzard shad (Bliss 1980). Low densities in 1980 were probably the result of low discharges from John Redmond Reservoir. The major spawning site of gizzard shad is in the reservoir and water releases during spawning result in a population of larval shad entering the Neosho River. During 1980 water releases were very low, and few larvae apparently entered the Neosho River. Other common taxa included freshwater drum, channel catfish, *Lepomis* sp., and *Notropis* sp.

Larvae in nocturnal samples were more than four times as abundant as larvae in diurnal samples (Table 7-16). All larval taxa that were collected during the day were more abundant at night.

The average density of sucker larvae in 1980 (0.5/100 m^3) was low compared to the density recorded in 1979 (11.0/100 m^3). Higher abundance of

Table 7-13 Number of fish collected by seining in Wolf Creek near the Wolf Creek Generating Station, Burlington, Kansas, April through December 1980.

Species	Sampling Location 7	Sampling Location 3	Total	Relative Abundance
Stoneroller	0	1	1	0.4
Golden shiner	24	15	39	16.1
Red shiner	2	158	160	66.1
Suckermouth minnow	0	7	7	2.9
Fathead minnow	0	4	4	1.7
UID cyprinid	0	3	3	1.2
Black bullhead	1	4	5	2.1
Green sunfish	7	6	13	5.4
Orangespotted sunfish	4	4	8	3.3
Bluegill	0	2	2	0.8
Total	38	204	242	

Table 7-14 Number, density, and taxa of larval fish collected during diurnal sampling at Location 1 in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, April through July 1980.

Date	Volume of Water Sampled (m^3)	Water Temperature (°C)	Taxa	Number	Density (No./100m^3)
2 Apr	46.38	8.0	-	0	0.0
17 Apr	30.10	6.0	-	0	0.0
30 Apr	102.43	15.5	Gizzard shad	1	1.0
			Notropis sp.	3	2.9
			Total	4	3.9
14 May	82.58	17.5	-	0	0.0
28 May	226.26	22.0	Gizzard shad	2	0.9
			Total	2	0.9
11 Jun	134.14	23.5	Gizzard shad	28	20.9
			White bass	1	0.7
			Lepomis sp.	4	3.0
			Freshwater drum	2	1.5
			Total	35	26.1
25 Jun	184.66	24.0	Carp	1	0.5
			Notropis sp.	1	0.5
			Freshwater drum	48	25.3
			Total	50	26.3
9 Jul	220.47	29.0	*Notropis* sp.	13	5.9
			White bass	1	0.5
			Lepomis sp.	2	0.9
			Freshwater drum	1	0.5
			Unidentified	1	0.5
			Total	18	8.3
23 Jul	186.66	-	*Notropis* sp.	6	3.2
			Centrarchidae	2	1.1
			Lepomis sp.	4	2.1
			Freshwater drum	4	2.1
			Unidentified	1	0.5
			Total	17	9.0

Table 7-15 Number, density, and taxa of ichthyoplankton collected during nocturnal sampling at Location 1 in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, April through July 1980.

Date	Volume of Water Sampled (m^3)	Water Temperature (°C)	Taxa	Number	Density (No./$100m^3$)
2 Apr	58.38	8.0	-	0	-
17 Apr	82.96	6.0	-	0	-
30 Apr	137.91	15.0	Cyprinidae	2	1.5
			Ictiobus sp.	1	0.7
			Total	3	2.2
14 May	67.97	17.5	Gizzard shad	2	2.9
			Ictiobus sp.	1	1.5
			Total	3	4.4
28 May	165.41	22.0	Gizzard shad	19	11.5
			Percidae	1	0.6
			Total	20	12.1
11 Jun	129.31	23.5	Gizzard shad	92	71.1
			Ictiobus sp.	1	0.8
			White bass	3	2.3
			Lepomis sp.	2	1.5
			Freshwater drum	32	24.7
			Total	130	100.4
25 Jun	192.7	24.0	Gizzard shad	3	1.6
			Cyprinidae	1	0.5
			Channel catfish	7	3.6
			White bass	3	1.6
			Freshwater drum	54	28.0
			Total	68	35.3
9 Jul	222.47	28.0	Gizzard shad	6	2.7
			Cyprinidae	3	1.3
			Notropis sp.	29	13.0
			Channel catfish	9	4.0
			White bass	9	4.0
			Centrarchidae	8	3.6
			Lepomis sp.	103	46.3
			Pomoxis sp.	2	0.9
			Freshwater drum	4	1.8
			Total	173	77.6

Table 7-15 (continued)

Date	Volume of Water Sampled (m^3)	Water Temperature (°C)	Taxa	Number	Density (No./100m^3)
23 Jul	181.51	25.0	*Notropis* sp.	2	1.1
			Channel catfish	61	33.6
			Flathead catfish	1	0.5
			Centrarchidae	3	1.7
			Lepomis sp.	10	5.5
			Green sunfish	2	1.1
			Freshwater drum	6	3.3
			Unidentified	5	2.8
			Total	90	49.6

Table 7-16 Number, relative abundance, and average density of larval fish collected at Location 1 in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, April through July, 1980.

	Diurnal			Nocturnal			Total		
Taxa	No.	Relative Abundance (%)	Density (No./100m^3)[a]	No.	Relative Abundance (%)	Density (No./100m^3)[a]	No.	Relative Abundance (%)	Density (No./100m^3)[a]
Gizzard shad	31	24.6	2.4	122	25.1	9.9	153	25.0	6.1
Cyprinidae	0	0.0	0.0	6	1.2	0.5	6	1.0	0.2
Carp	1	0.8	0.1	0	0.0	0.0	1	0.2	0.0
Notropis sp.	23	18.3	1.8	31	6.4	2.5	54	8.8	2.2
Ictiobus sp.	0	0.0	0.0	3	0.6	0.2	3	0.5	0.1
Channel catfish	0	0.0	0.0	77	15.8	6.2	77	12.6	3.1
Flathead catfish	0	0.0	0.0	1	0.2	0.1	1	0.2	0.0
White bass	2	1.6	0.2	15	3.1	1.2	17	2.8	0.7
Centrarchidae	2	1.6	0.2	11	2.3	0.9	13	2.1	0.5
Lepomis sp.	10	7.9	0.8	115	23.6	9.3	125	20.4	5.0
Green sunfish	0	0.0	0.0	2	0.4	0.2	2	0.3	0.1
Pomoxis sp.	0	0.0	0.0	2	0.4	0.2	2	0.3	0.1
Percidae	0	0.0	0.0	1	0.2	0.1	1	0.2	0.0
Freshwater drum	55	43.7	4.3	96	19.7	7.8	151	24.6	6.0
Unidentified	2	1.6	0.2	5	1.0	0.4	7	1.1	0.3
Total	126		9.9	487		39.3	613		24.5

[a] Average of two replicates.

sucker larvae might have been expected in 1980 because adult river carpsucker were relatively abundant at Location 1 and were present throughout the larval sampling season (Table 7-5).

Centrarchids were collected in higher abundance in 1980 than in 1979. Lepomis sp. (sunfishes), which were not collected in 1979, had a density of 5.0/100 m^3 in 1980. Reduced flow out of the reservoir may have afforded Lepomis sp. with more suitable spawning habitat in 1980.

7.3 SUMMARY AND CONCLUSIONS

Fisheries sampling in the Neosho River and Wolf Creek in the vicinity of the Wolf Creek Generating Station resulted in collections similar to previous monitoring studies. Drought conditions in 1980 caused a substantial cutback in flow out of the John Redmond Reservoir for most of the year. This resulted in decreased electroshocking catches in the Neosho River, notably for gizzard shad and white bass which presumably enter the river from the reservoir.

Decreased flows apparently afforded red shiner and bullhead minnow suitable habitat in the river since numbers in seine collections were higher than in past years. Dominance of red shiner in the seine collections may be related to their ability to adapt to drought conditions.

Seine collections in Wolf Creek were dominated by red shiners. Total catches were extremely low, especially in September and December. Drought conditions, closure of the cooling lake dam, and renovation of the creek contributed to the low number of fish collected.

Ichthyoplankton collected at Location 1 were less abundant than in previous years due to lower densities of gizzard shad and nearly a total absence of catostomids. Low discharges from John Redmond Reservoir probably resulted in the low abundance of gizzard shad in the tailwaters since most of their larvae probably originate in the reservoir. Reduced flows may have benefited sunfishes since their larvae (Lepomis) exhibited increased abundance when compared to previous studies.

The 1980 data displayed characteristics of a drought year. Comparisons with previous data did not indicate any long term trends that suggested any construction effects on the Neosho River fish community. Construction activity, including rerouting of the creek channel and closure of the cooling lake dam in conjunction with drought conditions resulted in expected population reductions in Wolf Creek. Renovation of the creek with rotenone prior to lake filling was completed in 1980 and was done as part of the cooling lake management and stocking program.

Potential impacts of the makeup water pumphouse were not evident in 1980. Construction activity was completed in April 1980 and testing was initiated in October. Filling of the cooling lake started at the end of October and therefore pumping during the larval fish season was avoided. Removal of fish from the river through impingement processes apparently did not affect catch

rates. Potential effects of impingement losses on the abundance of fish in the tailwaters of John Redmond Reservoir should not be evident until after extended use of the makeup water pumphouse.

8. VEGETATION MONITORING

8.1 METHODS

Construction phase monitoring of vegetation in September 1980 near Wolf Creek Generating Station (WCGS), Burlington, Kansas, was conducted in three representative plant community types (Figure 1-2):

1. Community 1--north floodplain woods (upper Wolf Creek)
2. Community 2--abandoned railroad right-of-way
3. Community 8--south floodplain woods (lower Wolf Creek)

Community composition and structure in the two floodplain woods and an abandoned railroad right-of-way were determined; productivity was estimated for the railroad right-of-way.

8.1.1 Field Procedures

All vegetational strata within the three plant communities were sampled by the quadrat method (Oosting 1956; Wiegert 1962). Six permanent 400-m^2 circular plots were systematically distributed in each floodplain woods community to sample trees (stems >10 cm dbh) and saplings (stems 2.5-10.0 cm dbh). Five circular plots, each 10 m^2, were nested within the circumference of each 400-m^2 plot to sample the shrub stratum (Figure 8-1). Herbaceous vegetation and woody seedlings less than 30-cm tall were sampled with 1-m^2 plots centered within each 10-m^2 plot.

The ground layer in the abandoned railroad right-of-way was sampled using 25 0.1-m^2 circular plots distributed at 10-m intervals along one transect. The abandoned railroad right-of-way also was sampled using the point-quadrat method; 200 point-quadrats were used to determine cover by species (Mueller-Dombois and Ellenberg 1974). Productivity in the abandoned railroad right-of-way was determined by the harvest method (Ovington et al. 1963).

Site land-use disturbances were mapped through onsite inspection, aerial photo interpretation, and consultation with Kansas Gas and Electric personnel.

8.1.2 Analytical Procedures

Community composition and structure were quantified by community for each of the three sampling locations. Absolute and relative values of frequency, density, and dominance were computed for species in the overstory, understory, and shrub strata. Importance values were determined as the sum of the relative values (Curtis and McIntosh 1951). Absolute and relative frequency, and average community ground layer coverage were calculated for ground layer vegetation in each community sampled. In addition, percent coverage by species was calculated for the abandoned railroad right-of-way, based on point-quadrat sampling (Mueller-Dombois and Ellenberg 1974). Densities of trees and saplings were calculated for nine stem-diameter classes. All data summaries were performed on a Data General NOVA computer using standard

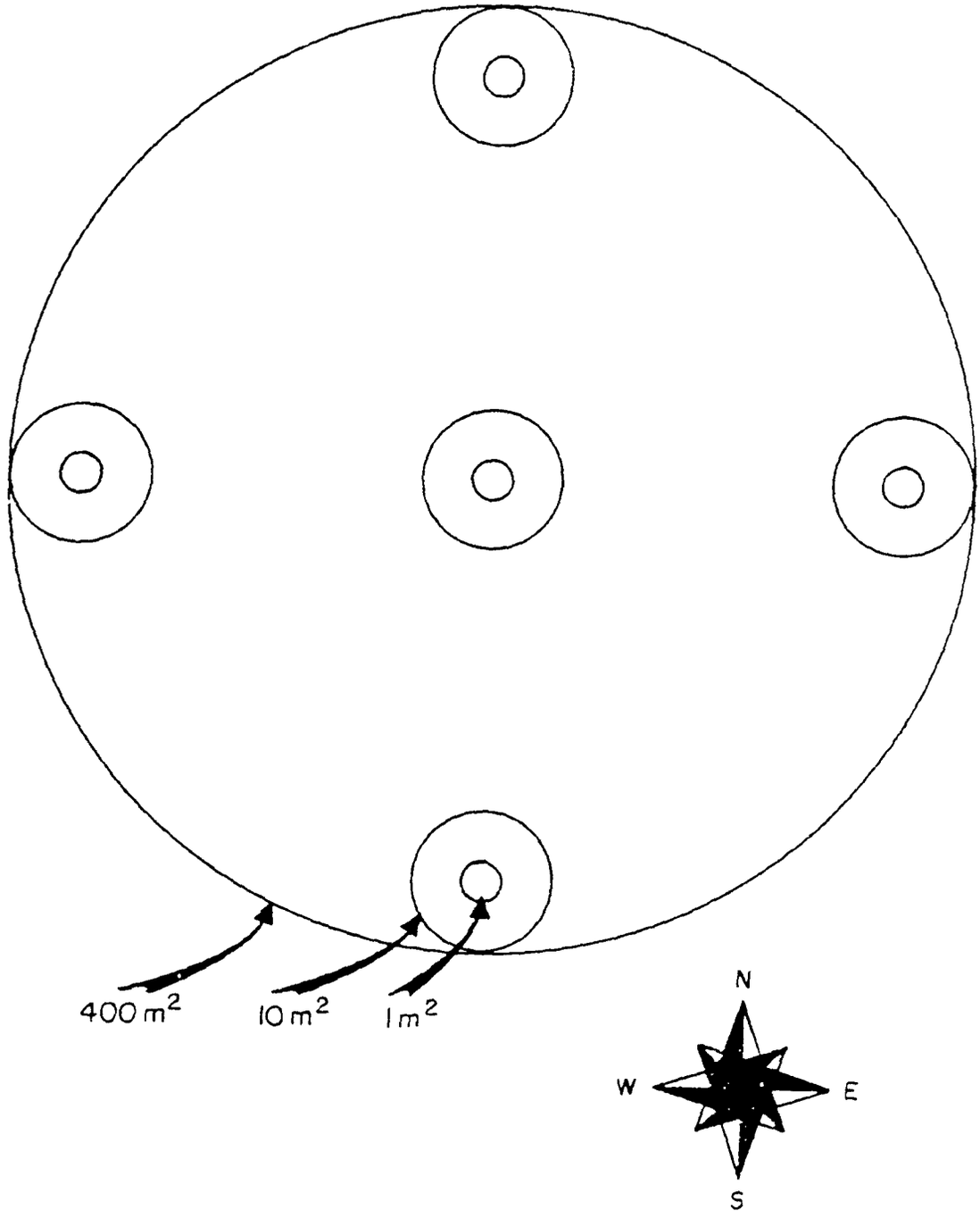

Figure 8-1 Schematic representation of nested quadrat layout for sampling floodplain woods vegetation near Wolf Creek Generating Station, Burlington, Kansas, 1980.

equations (Curtis and Cottam 1962). Tables were constructed from computer printouts. Numerals in the bodies of tables are rounded values, whereas the totals are sums of unrounded values.

Primary productivity of the abandoned railroad right-of-way was calculated using equations of Kelly et al. (1974).

Plant voucher specimens of previously unrecorded species were collected, dried, processed for permanent preservation, and deposited in the EA herbarium for future reference. Botanical nomenclature followed Gleason and Cronquist (1963). A phylogenetic list of species sampled during 1980 was compiled (Appendix G, Table G-1).

The coefficient of community was used to quantify similarity between 1980 community data and those of previous years. Because community change occurs most rapidly in the lower strata, only data from the ground layer and shrub stratum were used in computing coefficients. Values of absolute frequency were used for ground-layer comparisons, and importance values were used for shrub-stratum comparisons. The coefficient of community (Cox 1972) was computed as

$$\frac{2W}{a + b}$$

where

W = the sum of the lower of the two values of a species occurring in both years

a = the sum of species values for the 1980 sample

b = the sum of species values for the sample year compared

An index of shrub stratum flood susceptibility (Uhlemann 1979) was calculated for each of the floodplain woods. The index is the weighted average type (Whittaker 1973) and was calculated by multiplying species' importance values by species' flood suceptibility weights, summing the weighted values, and dividing the total weighted values by the sum of the importance values considered; species with importance values of 5 or less, and species that show no distributional affinities (e.g., *Smilax hispida*; Bell 1974a,b, 1975a,b) were not considered in the index calculation. Species weighting values are the same as those prescribed in the 1978-1979 WCGS monitoring report (Uhlemann 1979).

8.2 RESULTS AND DISCUSSION

8.2.1 North Floodplain Woods (Community 1)

8.2.1.1 Present Status

The north floodplain woods sampling area was located on the west bank of Wolf Creek, just to the north of the projected upstream edge of the WCGS cooling lake. A network of shallow ephemeral stream channels crossed the floodplain creating a gently rolling topography which sloped slightly to the south.

Rainfall was below normal during summer 1980 and drought conditions existed in September (Section 2.2). Ground-layer vegetation was very sparse, and Wolf Creek was completely dry.

The north floodplain woods contained floristic elements of both the northern floodplain forest and the oak-hickory forest of Kansas described by Kuchler (1974). Hackberry (Celtis occidentalis) and bur oak (Quercus macrocarpa) dominated the overstory (Table 8-1); both species occurred at 100 percent frequency. High relative density and relative dominance of hackberry and bur oak, respectively, accounted for their high community importance. Black walnut (Juglans nigra), bitternut hickory (Carya cordiformis), Shumard's oak (Quercus shumardii), and green ash (Fraxinus pennsylvanica) were of intermediate importance, and red bud (Cercis canadensis), Kentucky coffee tree (Gymnocladus dioica), American elm (Ulmus americana), red mulberry (Morus rubra), and osage orange (Maclura pomifera) were minor overstory components.

All overstory members, with the exception of black walnut, bur oak, and Shumard's oak, were present as saplings in the understory (Table 8-2). Slippery elm (Ulmus rubra) was the only species represented in the understory but not in the overstory. Hackberry was by far the most important species of the nine recorded with an importance value of 159.9. Red bud and green ash were the next two most important species.

Six tree, two shrub, and two vine species were recorded in the shrub stratum (Table 8-3). Coralberry (Symphoricarpos orbiculatus) was the obvious stratum dominant (importance value of 155.0). Missouri gooseberry (Ribes missouriense) was the only other shrub species recorded. Hackberry and green ash were the most important tree species recorded from the shrub stratum. With the exception of box elder (Acer negundo), all tree species represented reproduction of canopy species.

The ground layer in September was composed of 15 identifiable species and 3 genera (Table 8-4). Wild rye (Elymus virginicus) and an unidentified sedge (Carex sp.) were dominant species. Dead and dried mats of cleavers (Galium aparine) covered much of the ground. Apparently this species had been common earlier in the summer, but it was not alive in September and therefore does not appear in Table 8-4. Average ground cover was 28 percent.

Total basal area of the north floodplain woods canopy was 27.8m^2/ha (Tables 8-1 and 8-2). Canopy density was 750.0 saplings/ha and 287.6 trees/ha (Table 8-5); all sapling and tree size classes were represented.

The shrub stratum, with a density of 10,233 stems/ha, provided 9.3 percent ground cover (Table 8-3); coralberry provided the greatest density and cover.

Ground layer cover was 28 percent in September (Table 8-4).

8.2.1.2 Comparisons with Previous Studies

The north floodplain woods community has changed very little since 1975. Canopy composition has varied only slightly in species importance ranking. The shrub stratum in 1980 was very similar to previous years based on

Table 8-1 Phytosociological data summary of trees in the north floodplain woods, Community 1, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

Species	Frequency	Relative Frequency	Relative Density	Basal Area (m^2/ha)	Relative Dominance	Importance Value
Celtis occidentalis	100.0	20.7	47.8	3.0	11.9	80.4
Quercus macrocarpa	100.0	20.7	10.2	12.1	47.5	78.4
Juglans nigra	66.7	13.8	13.0	3.7	14.5	41.3
Carya cordiformis	66.7	13.8	13.0	2.7	10.6	37.4
Quercus shumardii	16.7	3.4	1.4	1.7	6.7	11.5
Fraxinus pennsylvanica	33.3	6.9	4.3	1.2	4.7	15.9
Morus rubra	33.3	6.9	2.9	0.1	0.4	10.2
Cercis canadensis	16.7	3.4	2.9	0.0	0.3	6.6
Gymnocladus dioica	16.7	3.4	1.5	0.5	2.0	6.9
Ulmus americana	16.7	3.4	1.5	0.3	1.2	6.2
Maclura pomifera	16.7	3.4	1.5	0.0	0.2	5.1
Total				25.5		

Table 8-2 Phytosociological data summary of saplings in the north floodplain woods, Community 1, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

Species	Frequency	Relative Frequency	Relative Density	Basal Area (m^2/ha)	Relative Dominance	Importance Value
Celtis occidentalis	100.0	20.7	67.2	1.6	72.0	159.9
Cercis canadensis	100.0	20.7	12.4	0.3	11.1	44.1
Fraxinus pennsylvanica	66.7	13.8	8.6	0.1	5.0	27.4
Ulmus americana	50.0	10.3	4.8	0.0	3.9	19.1
Carya cordiformis	50.0	10.3	2.7	0.0	4.0	17.1
Ulmus rubra	50.0	10.3	2.2	0.1	2.7	15.2
Morus rubra	33.3	6.9	1.1	0.0	0.6	8.5
Gymnocladus dioica	16.7	3.4	0.5	0.0	0.6	4.6
Maclura pomifera	16.7	3.4	0.5	0.0	0.1	4.1
Total				2.3		

Table 8-3 Phytosociological data summary of species in the shrub stratum of the north floodplain woods, Community 1, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

Species	Frequency	Relative Frequency	Stems/ Hectare	Relative Density	Ground Cover	Relative Dominance	Importance Value
Symphoricarpos orbiculatus	76.7	35.9	7267	71.0	4.5	48.1	155.0
Celtis occidentalis	56.7	26.6	1000	9.7	3.2	34.2	70.5
Fraxinus pennsylvanica	26.7	12.5	600	5.9	0.7	8.4	26.8
Ulmus rubra	13.3	6.2	533	5.2	0.5	5.7	17.2
Ribes missouriense	20.0	9.3	467	4.6	0.2	2.5	16.4
Rhus radicans	6.6	3.1	233	2.3	0.1	0.6	6.0
Carya cordiformis	3.3	1.6	33	0.3	0.0	0.2	2.1
Vitis sp.	3.3	1.6	33	0.3	0.0	0.1	2.0
Acer negundo	3.3	1.6	33	0.3	0.0	0.1	2.0
Quercus sp.	3.3	1.6	33	0.3	0.0	0.0	1.9
Total			10233		9.3		

Table 8-4 Frequency of species in the ground layer and average ground layer cover in the north floodplain woods, Community 1, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

Species	Frequency	Relative Frequency
Elymus virginicus	66.7	25.0
Carex sp.	56.7	21.2
Verbesina alternifolia	20.0	7.5
Parthenocissus quinquefolia	20.0	7.5
Sanicula gregaria	16.7	6.2
Phlox divaricata	16.7	6.2
Ribes missouriense	13.3	5.0
Laportea canadensis	10.0	3.8
Polygonum virginianum	6.6	2.5
Smilax hispida	6.6	2.5
Rhus radicans	6.6	2.5
Symphoricarpos orbiculatus	6.6	2.5
Ulmus rubra	3.3	1.2
Menispermum canadense	3.3	1.2
Ruellia strepens	3.3	1.2
Vitis sp.	3.3	1.2
Celtis occidentalis	3.3	1.2
Quercus sp.	3.3	1.2
Community Ground Layer Cover	28%	

Table 8-5 Density (stems/ha) of saplings and trees by diameter classes in the north floodplain woods (Community 1) near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

	Diameter Classes (centimeters D.B.H.)											
	Sapling Class			Tree Class								
Species	2.5-6.2	6.3-10.0	Sub-total	10.1-17.5	17.6-25.0	25.1-32.5	32.6-40.0	40.1-47.5	47.6-55.0	>55.1	Sub-total	Totals
Celtis occidentalis	275.0	245.8	520.8	108.3	16.7	8.3		4.2			137.5	658.3
Cercis canadensis	66.7	29.2	95.8	8.3							8.3	104.2
Fraxinus pennsylvanica	58.3	8.3	66.7	4.2	4.2				4.2		12.5	79.2
Carya cordiformis	8.3	12.5	20.8	8.3	8.3	12.5		4.2	4.2		37.5	58.3
Ulmus americana	25.0	12.5	37.5			4.2					4.2	41.7
Juglans nigra			0.0	4.2	12.5	4.2	4.2	8.3		4.2	37.5	37.5
Quercus macrocarpa			0.0		4.2		4.2			20.8	29.2	29.2
Morus rubra	8.3		8.3	8.3							8.3	16.7
Ulmus rubra	8.3	8.3	16.7								0.0	16.7
Gymnocladus dioica		4.2	4.2				4.2				4.2	8.3
Maclura pomifera	4.2		4.2	4.2							4.2	8.3
Quercus shumardii			0.0							4.2	4.2	4.2
Total	454.2	320.8	775.0	145.8	45.8	29.2	12.5	16.7	8.3	29.2	287.6	1052.5

similarity indices that were remarkably high (Table 8-6). Sample similarity for replicate samples in a plant community seldom exceed 85 percent (Cox 1972), and 60 percent is a more common value (Whittaker and Woodwell 1973). High similarities indicate the shrub stratum has changed little over the monitoring period, and that the flood of 1979 did not greatly affect the shrub-stratum composition.

In 1980, ground-layer data was collected only in September, and therefore comparisons were made with September data from previous years. Ground-layer similarity indices for 1980 were slightly lower than in previous years. This was caused by slight shifts in species composition and frequencies in 1980 which were attributed to the summer drought.

Moderate differences occurred between 1979 and 1980 structural data. The basal area of the overstory decreased 2.7 m^2/ha. The majority of the basal-area decrease was due to the death of a large-diameter (97.8-cm dbh) Shumard's oak. Also, 1979 dbh measurements were immediately after the June 1979 flood, when tree trunks may have been swollen from prolonged immersion in flood waters, whereas the 1980 measurements were taken in September after a protracted dry spell.

Shrub-stratum ground coverage in 1980 was roughly half that of the previous year, although stem density was relatively unchanged. Structural changes in shrub-stratum were attributed to the severe flooding of the community during 1979.

8.2.2 Abandoned Railroad Right-of-Way (Community 2)

8.2.2.1 Present Status

The vegetation of the abandoned railroad right-of-way was similar to the prairies of the Kansas Osage plains as described by Weaver (1968) and Kuchler (1974). Community 2 has been protected from grazing, mowing, and fire since 1975; such protection is unusual for prairie communities in the area, and has influenced community change.

Eleven identifiable species or genera were recorded during the September 1980 sampling (Table 8-7). Nonflowering or unidentifiable grasses were recorded as Gramineae. Dominant grasses included big bluestem (*Andropogon gerardi*), switchgrass (*Panicum virgatum*), Scribner's panicum (*P. scribnerianum*), and Indian grass (*Sorghastrum nutans*). Average ground cover was 79 percent.

Community ground-layer cover, as determined by the point-quadrat method, agreed closely with the ground-cover values estimated during plot sampling (83 and 79 percent, respectively). Six of the eight taxa recorded were grasses; big bluestem was the dominant species (Table 8-8). Litter was the only ground cover recorded at 16.5 percent of the points, and bare ground added 0.5 percent. Mean canopy height was 4.4 dm in September.

Productivity in the abandoned railroad right-of-way, as estimated by harvest of peak standing crop, was 2,550 kg/ha/yr. This was roughly half the average value (5,080 kg/ha/yr) reported by Koelling and Kucera (1965) for tall-grass prairie in southwestern Missouri.

Table 8-6 Year to year data comparisons expressed as percent similarity for three plant communities near Wolf Creek Generating Station, Burlington, Kansas.

Community/Stratum	Years Compared	Similarity (%)
North floodplain Woods		
Shrub stratum	1980-1979	92
	1980-1978	81
	1980-1977	86
	1980-1976	86
	1980-1975	90
Ground layer	1980-1979	52
	1980-1978	62
	1980-1977	49
	1980-1976	49
	1980-1975	58
Abandoned railroad right-of-way		
Ground layer	1980-1979	67
	1980-1978	50
	1980-1977	59
	1980-1976	39
	1980-1975	26
	1980-1974	20
South floodplain woods		
Shrub stratum	1980-1979	84
	1980-1978	83
	1980-1977	86
	1980-1976	84
Ground layer	1980-1979	67
	1980-1978	71
	1980-1977	54
	1980-1976	58

Table 8-7 Frequency of species in the ground layer and average ground layer cover in the abandoned railroad right-of-way, Community 2, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

Species	Frequency	Relative Frequency
Andropogon gerardi	64.0	31.4
Panicum virgatum	32.0	15.7
Panicum scribnerianum	32.0	15.7
Sorghastrum nutans	20.0	9.8
Andropogon scoparius	16.0	7.8
Solidago graminifolia	12.0	5.9
Gramineae	8.0	3.9
Salvia reflexa	4.0	2.0
Solidago canadensis	4.0	2.0
Cornus sp.	4.0	2.0
Carex sp.	4.0	2.0
Poa pratensis	4.0	2.0
Community Ground Layer Cover	79%	

Table 8-8 Percent cover of species in the ground layer, community ground layer cover, and mean canopy height in the abandoned railroad right-of-way, Community 2, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

Species	% Cover	Relative Dominance
Andropogon gerardi	59.5	71.7
Panicum virgatum	11.5	13.9
Panicum scribnerianum	6.0	7.2
Sorghastrum nutans	2.5	3.0
Solidago graminifolia	1.0	1.2
Poa pratensis	0.5	0.6
Carex sp.	0.5	0.6
Community Ground Layer Cover	83.0	
Mean Canopy Height	4.4 dm	

8.2.2.2 Comparison with Previous Studies

In 1980 data was collected only in September, and therefore comparisons were made with September data from previous years. Diversity decreased markedly from 1979 to 1980; 11 taxa were present in 1980 versus 16 in 1979. However, similarity was greater between 1980 and 1979 than between 1980 and previous years because the dominant species generally had similar frequencies (Table 8-6). In general, the percent similarity between 1980 and previous years decreased with time, reflecting the gradual domination of the community by prairie grasses. Prairie grasses were present in the community since the study was initiated, but have increased in frequency as other pasture and weed species have decreased.

Dense litter accumulation was evident in the ground layer and probably negatively affected diversity and productivity. In prairie communities which are not mowed, grazed, or burned, litter accumulation leads to delayed growth, reduction of diversity through loss of the midlevel grasses, decreased density, and the development of almost pure stands of taller grasses such as big bluestem and switchgrass (Weaver and Rowland 1952).

Ground cover was lower than in previous years (79 vs. 97.8 percent six-year average). Litter covered much of the remaining 21 percent of the ground (16.5 percent as measured by the point-quadrat method). The sharp reduction in ground cover probably resulted from the accumulation of litter and subsequent thinning of the community (Weaver and Rowland 1952) and low precipitation during summer 1980.

The average canopy height of 4.4 dm was below the 5.0 dm average of the previous five years. This low value was also probably a result of the summer drought.

Productivity estimates from the previous six years have averaged 5,416 kg/ha/yr and have ranged from 2,990 in 1978 to 7,446 in 1975. The 1980 estimate (2,550 kg/ha/yr) was the lowest annual estimate and probably reflects summer drought conditions and adverse effect of litter accumulation (Weaver and Rowland 1952).

8.2.3 South Floodplain Woods (Community 8)

8.2.3.1 Present Status

The south floodplain woods sampling area was located approximately 4 km downstream from the Wolf Creek cooling lake dam. The floodplain and adjacent terrace were dissected by several ephemeral stream channels and the resultant topography was irregularly rolling. Sampling plots were located on higher well-drained sites as well as the more frequently inundated depressions. Drought conditions prevailed in September and much of the vegetation, including hackberry trees, was wilted.

The community contained elements of both the northern floodplain forest and the oak-hickory forest of Kansas (Kuchler 1974). The overstory was dominated

by hackberry, American elm, silver maple (Acer saccharinum), Shumard's oak, and pin oak (Quercus palustris). Shellbark hickory (Carya laciniosa), green ash, and bur oak were frequent species, and red mulberry (Morus rubra), black walnut, honey locust (Gleditsia triacanthos), and Kentucky coffee tree occurred infrequently (Table 8-9). The distribution of these species in relation to community topography was discussed in previous reports (Uhlemann 1979; Uhlemann et al. 1978).

Hackberry and American elm dominated the understory of Community 8. Green ash and red bud were also important species (Table 8-10).

The shrub stratum was composed of 11 tree, 2 shrub, and 3 vine species (Table 8-11). Poison ivy (Rhus radicans), coralberry, and hackberry were the dominant species. With the exception of slippery elm, all the tree species in the shrub stratum represented reproduction of canopy species.

Sixteen species and two genera were present in the ground layer in September 1980 (Table 8-12). Virginia wild rye and sedge (Carex sp.) were dominant as in Community 1. Dried mats of cleavers were also present in Community 8.

The combined basal area of the trees and saplings forming the canopy of Community 8 was 29.0 m^2/ha (Tables 8-9 and 8-10); densities of trees and saplings were 329.4 and 500.0 stems/ha, respectively (Table 8-13).

Ground cover of the shrub stratum was 20.3 percent, and total shrub density was 15,667 stems/ha. Poison ivy and coralberry made up 69 percent of the shrub density (Table 8-11). Ground layer cover in September was 16 percent (Table 8-12).

8.2.3.2 Comparison with Previous Studies

Little compositional change has occurred in the south floodplain woods since the initial vegetation survey in 1976. The 1980 overstory and understory compositions were similar to those of previous surveys. Very high similarity values (83-86 percent) were calculated for the 1976 through 1980 shrub stratum data comparisons (Table 8-6). September ground layer data were also similar (71-54 percent, Table 8-6).

The structure of Community 8 changed slightly since 1979. In the canopy, total stem density increased slightly because of increases in tree and sapling density by hackberry and increases in sapling density by American elm. American elm tree density continued to decline because of Dutch elm disease. Elm mortality and the death of several tree size Shumard's oak and pin oak caused a 0.5 m^2/ha decrease in the total overstory basal area.

In the shrub stratum, a decrease in total stem density and percentage ground cover was largely due to the decreased frequency, density, and cover of poison ivy and coralberry. Extensive poison ivy stands located in low areas of the community were damaged by flooding in 1979.

Ground-layer coverage was less than in previous years, which was attributed to summer drought conditions.

Table 8-9 Phytosociological data summary of trees in the south floodplain woods, Community 8, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

Species	Frequency	Relative Frequency	Relative Density	Basal Area (m^2/ha)	Relative Dominance	Importance Value
Celtis occidentalis	83.3	16.1	19.0	2.0	7.3	42.4
Acer saccharinum	33.3	6.4	13.9	5.0	18.0	38.3
Ulmus americana	100.0	19.4	15.2	1.0	3.4	38.0
Quercus shumardii	33.3	6.4	12.7	5.0	18.1	37.2
Quercus palustris	33.3	6.4	8.9	4.0	14.3	29.6
Carya laciniosa	66.7	12.9	8.9	0.9	3.3	25.1
Fraxinus pennsylvanica	50.0	9.6	7.6	1.6	5.6	22.8
Quercus macrocarpa	33.3	6.4	7.6	2.3	8.1	22.1
Platanus occidentalis	16.7	3.2	1.3	3.9	14.1	18.6
Morus rubra	16.7	3.2	1.3	0.7	2.6	7.1
Juglans nigra	16.7	3.2	1.3	0.6	2.0	6.5
Gleditsia triacanthos	16.7	3.2	1.3	0.5	1.8	6.3
Gymocladus dioica	16.7	3.2	1.3	0.4	1.3	5.8
Total				27.7		

Table 8-10 Phytosociological data summary of saplings in the south floodplain woods, Community 8, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

Species	Frequency	Relative Frequency	Relative Density	Basal Area (m^2/ha)	Relative Dominance	Importance Value
Celtis occidentalis	100.0	21.4	40.8	0.5	41.6	103.8
Ulmus americana	100.0	21.4	29.2	0.4	32.2	82.8
Fraxinus pennsylvanica	66.7	14.3	12.5	0.1	8.8	35.6
Cercis canadensis	50.0	10.7	5.0	0.1	6.3	22.0
Carya laciniosa	33.3	7.1	2.5	0.1	4.0	13.6
Morus rubra	33.3	7.1	2.5	0.0	1.4	11.0
Acer saccharinum	16.7	3.6	1.7	0.0	2.3	7.6
Gymnocladus dioica	16.7	3.6	2.5	0.0	0.6	6.7
Ulmus rubra	16.7	3.6	0.8	0.0	1.9	6.3
Crataegus sp.	16.7	3.6	1.7	0.0	1.0	6.3
Quercus shumardii	16.7	3.6	0.8	0.0	0.2	4.6
Total				1.3		

Table 8-11 Phytosociological data summary of species in the shrub stratum of the south floodplain woods, Community 8, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

Species	Frequency	Relative Frequency	Stems/ Hectare	Relative Density	Ground Cover	Relative Dominance	Importance Value
Rhus radicans	46.7	15.4	5800	37.0	3.3	16.3	68.7
Symphoricarpos orbiculatus	26.7	8.7	5033	32.1	3.2	15.8	56.7
Celtis occidentalis	53.3	17.6	1500	9.5	5.6	27.6	54.7
Fraxinus pennsylvanica	40.0	13.2	1100	7.0	2.1	10.4	30.6
Ulmus americana	20.0	6.5	533	3.4	3.2	15.6	25.6
Smilax hispida	36.7	12.1	567	3.6	0.4	2.1	17.9
Euonymus atropurpureus	20.0	6.5	367	2.3	0.5	2.3	11.2
Gymnocladus dioica	13.3	4.4	167	1.1	0.9	4.7	10.2
Carya laciniosa	13.3	4.4	200	1.3	0.6	2.8	8.5
Ulmus rubra	6.6	2.2	67	0.4	0.2	0.9	3.6
Morus rubra	6.6	2.2	67	0.4	0.0	0.4	3.0
Gleditsia triacanthos	6.6	2.2	67	0.4	0.0	0.3	3.0
Quercus shumardii	3.3	1.1	100	0.6	0.1	0.5	2.2
Quercus macrocarpa	3.3	1.1	33	0.2	0.0	0.0	1.4
Quercus sp.	3.3	1.1	33	0.2	0.0	0.0	1.3
Menispermum canadense	3.3	1.1	33	0.2	0.0	0.0	1.3
Total			15667		20.3		

Table 8-12 Frequency of species in the ground layer and average ground layer cover in the south floodplain Woods, Community 8, near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

Species	Frequency	Relative Frequency
Elymus virginicus	66.7	28.2
Carex sp.	33.3	14.1
Rhus radicans	30.0	12.7
Parthenocissus quinquefolia	23.3	9.8
Ruellia strepens	20.0	8.4
Geum canadense	10.0	4.2
Laportea canadensis	10.0	4.2
Celtis occidentalis	6.6	2.8
Smilax hispida	6.6	2.8
Quercus sp.	3.3	1.4
Euonymus atropurpureus	3.3	1.4
Muhlenbergia frondosa	3.3	1.4
Symphoricarpos orbiculatus	3.3	1.4
Festuca obtusa	3.3	1.4
Leersia virginica	3.3	1.4
Ambrosia trifida	3.3	1.4
Menispermum canadense	3.3	1.4
Gleditsia triacanthos	3.3	1.4
Community Ground Layer Cover	16%	

Table 8-13 Density (stems/ha) of saplings and trees by diameter classes in the south floodplain woods (Community 8) near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

	Diameter Classes (centimeters D.B.H.)											
	Sapling Class			Tree Class								
Species	2.5-6.2	6.3-10.0	Sub-total	10.1-17.5	17.6-25.0	25.1-32.5	32.6-40.0	40.1-47.5	47.6-55.0	>55.1	Sub-total	Totals
Celtis occidentalis	129.2	75.0	204.2	41.7	8.3	8.3	4.2				62.5	266.7
Ulmus americana	83.3	62.5	145.8	45.8			4.2				50.0	195.8
Fraxinus pennsylvanica	45.8	16.7	62.5	8.3	8.3		4.2		4.2		25.0	87.5
Acer saccharinum	4.2	4.2	8.3	8.3		4.2	4.2	29.2			45.8	54.2
Quercus shumardii	4.2		4.2		4.2	12.5	4.2	12.5	8.3		41.7	45.8
Carya laciniosa	4.2	8.3	12.5	16.7	8.3		4.2				29.2	41.7
Quercus palustris			0.0			12.5	8.3		4.2	4.2	29.2	29.2
Quercus macrocarpa			0.0		4.2	8.3	8.3	4.2			25.0	25.0
Cercis canadensis	16.7	8.3	25.0								0.0	25.0
Morus rubra	8.3	4.2	12.5					4.2			4.2	16.7
Gymnocladus dioica	12.5		12.5				4.2				4.2	16.7
Crataegus sp.	8.3		8.3								0.0	8.3
Platanus occidentalis			0.0							4.2	4.2	4.2
Ulmus rubra		4.2	4.2								0.0	4.2
Gleditsia triacanthos			0.0				4.2				4.2	4.2
Juglans nigra			0.0					4.2			4.2	4.2
Totals	320.8	183.3	500.0	120.8	33.3	45.8	50.2	54.3	16.7	8.3	329.4	829.4

8.2.4 Flood Susceptibility Analysis

Flood susceptibility indices were calculated from the September 1980 shrub stratum data. The flood susceptibility indices are based on phytosociology of the shrub-stratum data and, as with the similarity indices, have changed little over the monitoring period. For the north floodplain woods, values ranged from 8.14 in 1975 to 8.84 in 1977 and averaged 8.51 (Table 8-14); the 1980 value was 8.48. South floodplain woods values have ranged from 6.19 in 1978 to 6.69 in 1980 and averaged 6.52. The high 1980 value is a result of the 1979 flood damage to the extensive stands of poison ivy present in the most heavily flooded locations of the community. Poison ivy has a low species weighting value in the flood susceptibility index calculation, and therefore, the decrease in density and cover of this species resulted in a higher flood susceptibility index.

8.2.5 Land Use Disturbance

Construction-related land-use disturbance on the WCGS site in 1980 affected approximately 160 acres. This was a sharp decrease from the 760 acres disturbed in 1979 and reflected the near completion of the project. The total disturbed acreage through 1980 was 2,330 acres or 24 percent of the 9,818-acre site.

The major land disturbance in 1980 was the clearing of approximately 110 acres of riparian woodland along Wolf Creek in the cooling lake basin. Quarrying for fill and riprap disturbed three smaller parcels of land totaling 50 acres.

The closure of the cooling lake dam will have a long term impact on the WCGS site and the downstream reach of Wolf Creek. The cooling lake will flood approximately 5,000 acres of riparian woodland, upland woodland, pasture and range, and abandoned agricultural land. The vegetation at the periphery of the lake will shift in composition to more mesic and hydric species. Mudflats, similar to those described for John Redmond Reservoir (Uhlemann et al. 1978) and other wetlands will develop along much of the lake shore.

Dam closure will alter the downstream flow regime probably causing a shift in species composition of the riparian woodlands. Wolf Creek is an intermittent stream with little or no base flow. Release of water from the cooling lake is expected to be minimal and consequently the lower reach of Wolf Creek between the dam and the confluence with the Neosho River will receive much less water and experience floods of much less magnitude than in the past. Upland species will gradually dominate the floodplain woodlands, and vegetation will probably invade much of the creek bed. In addition, farmers downstream of the dam, anticipating less flooding, are beginning to clear the floodplain in order to expand their fields. This trend could result in a substantial loss of wooded habitat in an area where woodlands are scarce.

The removal of vegetation and the filling of the cooling lake will displace numerous species of wildlife. Most bird species, deer, furbearers, and other large mammals may relocate to adjacent and outlying areas, although the

Table 8-14 Shrub stratum flood susceptibility index, for all years sampled, of the north and south floodplain woods (Communities 1 and 8, respectively), near Wolf Creek Generating Station, Burlington, Kansas.

Location/Year	Flood Susceptibility
North floodplain woods	
1975	8.14
1976	8.46
1977	8.84
1978	8.71
1979	8.42
1980	8.48
Average	8.51
South floodplain woods	
1976	6.54
1977	6.60
1978	6.19
1979	6.60
1980	6.69
Average	6.52

carrying capacity for these species will be reduced due to habitat loss. Most of the small mammals and reptiles in or adjacent to the cooling lake will probably be lost. However, amphibian populations should increase. Due to the limited amount of new habitat disturbed, additional wildlife losses during 1980 probably were not large.

8.3 SUMMARY AND CONCLUSIONS

Species representative of both the oak-hickory and northern floodplain forest types were present in the northern floodplain woods. Hackberry and bur oak were dominant in the tree strata which were only slightly changed from previous years. Ground coverage of the shrub stratum in 1980 was sharply reduced but stem density increased; these effects were attributed to the severe flooding of the community in 1979. Ground-layer data were similar to previous years.

Tall-grass prairie species dominated the abandoned railroad right-of-way, which was compositionally similar to the previous years, although diversity had declined. Prairie grasses have gradually attained complete dominance during the study period as weeds and pasture plants have decreased in abundance. Ground cover was lower than in 1979 and the productivity estimate was lower than all previous estimates. Decreases in diversity, ground cover, and productivity were attributed to a combination of litter accumulation in the community and the summer drought of 1980.

The south floodplain woods contained species common to the oak-hickory and northern floodplain forest types. The tree strata were virtually unchanged. Silver maple, hackberry, American elm, Shumard's oak, and pin oak were dominant species in the overstory, and hackberry and American elm dominated the understory. The shrub stratum was dominated by poison ivy, coralberry, and hackberry. Poison ivy stands had been severely damaged by flooding in 1979, and the stem density and percentage ground cover of this species were lower than 1978 and 1979 values. Ground-layer coverage was slightly reduced; this was attributed to the summer drought of 1980.

The 1980 shrub-stratum flood susceptibility indices changed little from those calculated in previous years.

No adverse construction-related effects on vegetation were inferred from the 1980 data from Communities 1, 2, or 8.

Construction-related land-use disturbances affected roughly 160 acres. This was the lowest annual disturbance observed during the monitoring period and reflects near completion of the project. The major portion of disturbed land was riparian woodland which is of limited extent in the area and important wildlife habitat. Closure of the cooling lake dam will have a long-term impact on the vegetation of the Wolf Creek drainage. Approximately 5000 acres of riparian woodland, upland woodland, pasture and range, and abandoned agricultural land will be flooded by the cooling lake. Mesic and hydric plant communities will develop at the periphery of the lake and wetlands will develop along the lake shore. Downstream of the dam the plant communities

will change in response to the cessation of flooding and the reduction of flow. Upland species should gradually dominate the old floodplain woods and vegetation will invade the creek bottom.

9. WILDLIFE

9.1 FIELD AND ANALYTICAL PROCEDURES

Wildlife populations were censused in two communities during the WCGS 1980 monitoring study (Figure 1-2). The north floodplain woods, Community 1 (NE 1/4, NW 1/4, Section 25, T20S, R15E), has been sampled since 1973. This wooded community, located along Wolf Creek has not been recently disturbed by logging.

The abandoned railroad right-of-way, Community 2 (NE 1/4, NE 1/4, Section 6, T21S, R16E), was selected for study in May 1974 and has been sampled during all subsequent monitoring studies. The community is typical of abandoned railroad rights-of-way habitat in that there are relatively low areas parallel to the former trackbed that are scattered with debris, and beyond which lies a generally flat sod of prairie grasses. The tenant of an adjacent farm pastured cattle up to the perimeter of this community and during 1976 removed a fence along one edge, thus reducing the extent of neighboring undisturbed habitat. Both communities were selected for their accessibility and value in monitoring potential biotic changes resulting from proposed construction, lake-filling, and station-operation activities.

9.1.1 Mammals

Mammals were quantitatively studied by small mammal trapping during September 1980 in the north floodplain woods and abandoned railroad right-of-way communities and qualitatively surveyed during May, June, and September 1980, and January 1981 along the 20-mile wildlife survey route and during habitat searches. Incidental mammal observations during 1980 terrestrial wildlife studies near WCGS were also recorded.

9.1.1.1 Small-mammal Trapping

Grids of 50 Sherman live traps (8 x 9 x 23 cm) were established during September in the abandoned railroad right-of-way and north floodplain woods communities to determine small mammal species composition and abundance. One trap was placed at each station, with stations spaced at 10-m intervals along lines 10 meters apart (abandoned railroad right-of-way: two rows, 12 traps each, two rows, 13 traps each; north floodplain woods: five rows, 10 traps each). Traps were baited with a mixture of rolled oats and peanut butter, set for four consecutive nights, and checked daily. Captured animals were toe-clipped, sexed, aged, weighed, and their reproductive condition recorded. In communities where sufficient capture data were available, the modified Peterson index (Seber 1973) was used to calculate population estimates. Density estimates were determined by dividing the population estimate by the trapping grid's area of influence. This area equals the area of the trapping grid, plus the area inside a line around the perimeter of the grid "n" meters from the grid boundary (where "n" equals the radius of a species' mean home range).

9.1.1.2 20-Mile Wildlife Survey Route

A 32-km (20-mi) wildlife survey route was established on roads throughout the monitoring area to study mammals, birds, reptiles, and amphibians (Figure 1-2). During each sampling month, the route was surveyed twice in the morning and once after sunset. Mammalian species observed were recorded by mile interval and their numbers indicated. Observations of eastern cottontail (*Sylvilagus floridanus*) during June and September were summarized and reported as the number observed per 20 miles.

9.1.1.3 Habitat Searches

Habitat searches were conducted in the north floodplain woods and abandoned railroad right-of-way communities during May, June, and September 1980 and January 1981. Information collected was used to determine species distribution, habitat preferences, and community composition. All mammal sign including sight and scent observations, dens, scats, tracks, and feeding signs were noted and reported by species, habitat, date, type, and number of observations.

9.1.1.4 Supplemental Data

In addition to species recorded during community and general area surveys, significant wildlife observations made during terrestrial studies near WCGS were noted, and these data contributed to completing the site species list.

9.1.1.5 Nomenclature

Field identification was aided by reference to Burt and Grossenheider (1964) and Murie (1954). Nomenclature followed Jones et al. (1975).

9.1.2 Avifauna

Avian surveys were conducted in May, June, and September 1980 and January 1981, to ensure that both summer and winter resident populations, as well as those using the area during migration were identified. Species lists and estimates of relative densities of game and nongame species that occur near WCGS were derived from the censuses. Seasons were represented by May (spring), June (summer), September (fall), and January (winter).

9.1.2.1 Transect Counts

Avian transects using Kendeigh's (1944) census technique were conducted in the north floodplain woods and abandoned railroad right-of-way to determine avian population density, relative abundance, and species composition. Transect widths and lengths were delineated in 1973 using aerial photographs and ground inspection. Trained observers walked the transects in the morning or evening on three days during each sampling month (May, June, and September 1980, and January 1981). All auditory and visual cues of avian species that were actually using the habitat at the time of censusing were recorded and the duration of the count noted; species flying overhead or outside the transect boundaries were not used to determine avian community composition, but were noted for inclusion on the site species list. Data were reported

by community, day, species, and number of observations and converted to number of birds per hour to provide a basis for direct comparison. Relative frequencies were also calculated for each species.

The bird species diversity index (BSD), a derivative of information theory (Shannon and Weaver 1949) and a measure of biotic diversity (MacArthur 1965), was calculated for each community. The equation

$$BSD = 1/N \left(N \log_e N - \sum_{i=1}^{s} n_i \log_e n_i\right)$$

(Lloyd et al. 1968), where

N = total population
n_i = number of species observations
s = total number of species in the aggregation

was used to calculate diversity.

9.1.2.2 20-Mile Wildlife Survey Route

The 20-mile wildlife survey route was driven between sunrise and 1200 hours during two days within each sampling period. Species observed during May and September 1980, and January 1981 surveys were counted and their numbers recorded by mile interval as the observer drove along the route. Methodology for collecting data along the route during the June 1980 survey differed from other months and previous studies by including species observed at 3-minute stopping/counting periods at 0.8-km (0.5-mi) intervals along the route. Data collected at the stops was included in the survey and reported on a per-mile basis. The difference in methodology does not compromise the data, however, avian information collected during the June 1980 wildlife survey is not numerically comparable to previous year's data.

Data on avian game species also were collected along the survey route. Bobwhite (*Colinus virginianus*) call count surveys were conducted in May and June. The number of bobwhite calls heard during a 2-minute counting period at stops located at one-mile intervals along the route was recorded. Data were summarized and reported by mile interval along the route. Mourning dove (*Zenaida macroura*) observations along the 20-mile wildlife survey route during May and June also were summarized and reported by mile interval.

9.1.2.3 John Redmond Reservoir and Dam

Birds were qualitatively assessed during May, June, and September 1980, and January 1981 at John Redmond Reservoir and Dam. All avian observations during two counting periods in each month were recorded and a separate annotated species list was compiled for this area.

9.1.2.4 Supplemental Data

In addition to species recorded during community and general area surveys, significant avian observations made during terrestrial studies near WCGS were noted and these data contributed to completing the site species list.

9.1.2.5 Nomenclature

Field identification was aided by reference to Peterson (1947) and Robbins et al. (1966). Nomenclature followed the American Ornithologist's Union (1957, 1973, 1976).

9.1.3 Herpetofauna

Reptiles and amphibians were qualitatively surveyed in May, June, and September 1980, and January 1981. Data collected during habitat searches and along the 20-mile wildlife survey route provided information on herpetofauna community composition, relative abundance, and distribution.

9.1.3.1 20-Mile Wildlife Survey Route

The 20-mile wildlife survey route was driven twice in the morning and once after sunset during May, June, and September 1980. Reptile and amphibian observations were recorded by mile interval and their numbers indicated.

9.1.3.2 Habitat Searches

Habitat searches were conducted in the north floodplain woods and abandoned railroad right-of-way communities during all sampling months. Searches included investigations of wet areas and dead tree stumps, turning over logs and stones, raking through debris and leaf litter, and looking in other likely places. Herpetofauna observations were recorded by species, habitat, date, type, and number of observations.

9.1.3.3 Supplemental Data

In addition to species recorded during community and general area surveys, significant herpetofauna observations made during terrestrial wildlife studies near WCGS were noted and data contributed in completing the site species list.

9.1.3.4 Nomenclature

Identification was aided by reference to Conant (1975). Nomenclature followed Collins et al. (1978).

9.1.4 Endangered and Threatened Species

All species lists were checked against official lists of endangered and threatened species (Kansas Fish and Game Commission 1978; United States Department of the Interior (USDI) 1979).

9.2 RESULTS AND DISCUSSION

9.2.1 Mammals

Twelve mammal species were observed in two sampling communities, along the 20-mile wildlife survey route, and at John Redmond Reservoir during the 1980 monitoring program (Table 9-1). Four mammals, eastern woodrat (*Neotoma floridana*), fox (*Vulpes* or *Urocyon* sp.), long-tailed weasel (*Mustela frenata*), and muskrat (*Ondatra zibethicus*), were recorded for the first time near WCGS. Since the monitoring program began in 1974, a total of 23 species has been observed.

9.2.1.1 Small Mammals

Small mammal capture data from the 1973 baseline study are not directly comparable to data collected during subsequent monitoring studies because of changes in sampling technique and locations. There were additional alterations in study sites and sampling schedules after the 1974 monitoring study that made comparisons between portions of the 1974 and later monitoring studies invalid. However, comparisons between subsequent studies are feasible.

White-footed mouse (*Peromyscus leucopus*) was the only mammal captured during live-trapping studies in two communities during September 1980 (Table 9-2). Eight individuals were captured in the north floodplain woods and one in the abandoned railroad right-of-way. Density estimates were 8.0 and 0.9/ha in the north floodplain woods and abandoned railroad right-of-way, respectively.

In contrast to previous years, white-footed mice were not abundant in the north floodplain woods. The September 1980, white-footed mouse density was 53 percent lower than reported in 1979, 61 percent lower than the previous five-year average (20.4/ha), and the lowest density since September 1975 when 7.0/ha were recorded (Table 9-3).

Density estimates of the white-footed mouse also were low in the abandoned railroad right-of-way, however concentrations in this area have never been high (Table 9-3). Although only one mouse was captured during September 1980, the September density estimate was equal to or was higher than all previous September estimates except 1978 (1.8/ha). Data collected in this community from 1975 to 1980 indicate that the population may be cyclic, with lower densities during alternate years.

Cyclic population trends, typical of cricetid mice population fluctuations, have been observed during the period 1975-1979 for other species captured in both the north floodplain woods and abandoned railroad right-of-way. Larger numbers of individuals and species were caught in 1976 and 1978, whereas lower values were noted in 1975, 1977, and 1979. Following this trend, relatively high densities would be expected in September 1980, however this did not occur. A comparison of mammal densities in both communities indicates lower populations in 1980 than 1979.

A flood that inundated the north floodplain woods during June 1979 is a probable cause for low densities in this community during 1980. Small mammal habitat was severely impacted during the flood and small mammal populations

Table 9-1 Mammals observed near Wolf Creek Generating Station, Burlington, Kansas, 1974-1980.

Common Name	Scientific Name	Locations[a] and Year						
		1974	1975	1976	1977	1978	1979	1980
Opossum	*Didelphis virginiana*	3	-	-	-	1,4	-	3
Short-tailed shrew	*Blarina brevicauda*	2,1a	-	1,2	-	1,2	1	-
Least shrew	*Cryptotis parva*	5	-	1	-	-	-	-
Eastern mole	*Scalopus aquaticus*	-	-	1	-	-	-	1
Eastern cottontail	*Sylvilagus floridanus*	1a,5,6,3	1,2,6,3	2,3	1,2,3	2,3,4	3	3
Fox squirrel	*Sciurus niger*	1a,6,3	1,6,3	1,3	1,3	1,2,3	1,3	1,4,3
Beaver	*Castor canadensis*	-	7	-	-	-	-	-
Western harvest mouse	*Reithrodontomys megalotis*	-	8	-	-	-	-	-
Deer mouse	*Peromyscus maniculatus*	2,5,6	-	2,8,9	2	2	2	-
White-footed mouse	*Peromyscus leucopus*	1a,6	1,6	1,2,8,9	1,2	1,2	1	1,2
Hispid cotton rat	*Sigmodon hispidus*	2,5	2	2,9	-	2	-	-
Eastern woodrat	*Neotoma floridana*	-	-	-	-	-	-	3
Prairie vole	*Microtus ochrogaster*	5	-	2,8,9	-	2	-	-
Woodland vole	*Microtus pinetorum*	1a	-	-	-	1	-	-
Muskrat	*Ondatra zibethicus*	-	-	-	-	-	-	4
House mouse	*Mus musculus*	-	-	8,9	-	-	-	-
Coyote	*Canis latrans*	1a,3	1,3	1,2,3	2,3,4	4	2	2,3
Fox	*Vulpes* or *Urocyon* sp.	-	-	-	-	-	-	1
Raccoon	*Procyon lotor*	5	1	1	-	1,2,4	1,2	1
Long-tailed weasel	*Mustela frenata*	-	-	-	-	-	-	3
Striped skunk	*Mephitis mephitis*	-	3	-	-	-	-	-
Bobcat	*Felis rufus*	-	-	-	1	1	-	-
White-tailed deer	*Odocoileus virginianus*	1a,6	1	1	1,2	1,4	1	1

[a]Locations:
1 - North floodplain woods (Community 1) (1975 to present)
1a- Floodplain woods (1974 only)
2 - Abandoned railroad right-of-way (Community 2)
3 - 20-mile wildlife survey route
4 - John Redmond Reservoir
5 - Open pasture (Community 3) (1974 and 1975 only)
6 - Mixed shrub-grass pasture (Community 4) (1974 and 1975 only)
7 - Mouth of Wolf Creek (1975 only)
8 - Wet mudflat (1976 only) (Community 9)
9 - Dry mudflat (1976 only) (Community 10)

Table 9-2 Small mammal capture data for two communities near Wolf Creek Generating Station, Burlington, Kansas, September 1980.

Location/Species	Total Captured	Total Marked	Total Recaptured	Number of Individuals	Percent Composition	Density Estimate (Number/ha)[a]
North Floodplain Woods						
Peromyscus leucopus	10	8	2	8	100.0	8.0
Abandoned Railroad Right-of-Way						
Peromyscus leucopus	1	1	0	1	100.0	0.9[b]

[a]Home range after Fitch (1958).
[b]Insufficient data; derived from the actual number of animals captured.

Table 9-3 Summary of small mammal densities (no./ha) in two communities near Wolf Creek Generating Station, Burlington, Kansas, 1974-1980.

Location/Species	1974		1975		1976		1977		1978		1979		1980	
	Jun	Sep	Jun	Sep	Jun	Sep	Jun	Sep	Jun	Sep	Jun	Sep	Jun	Sep
North Floodplain Woods														
Didelphis virginiana	NS[a]	NS	-[b]	-	-	-	-	-	0.03[c]	-	-	-	NS	-
Blarina brevicauda	NS	NS	-	-	1.5	14.6	-	-	1.5[c]	1.5[c]	0.8[c]	-	NS	-
Peromyscus leucopus	NS	NS	23.0	7.0	34.0	25.0	25.0	17.0	23.0	38.0	22.0	15.0	NS	8.0
Microtus pinetorum	NS	NS	-	-	-	-	-	-	-	1.6[c]	-	-	NS	-
Abandoned Railroad Right-of-Way														
Blarina brevicauda	0.7[c]	-	-	-	0.4[c]	1.3	-	-	1.3[c]	-	-	-	NS	-
Microtus ochrogaster	-	-	-	-	7.5	1.3[c]	-	-	-	2.5	-	-	NS	-
Peromyscus maniculatus	-	-	-	-	0.7	2.9	2.9	0.7[c]	11.4	6.4	1.4	-	NS	-
Peromyscus leucopus	-	-	-	-	-	0.9	0.9[c]	-	-	1.8	-	-	NS	0.9[c]
Sigmodon hispidus	13.0	2.0	-	0.5	16.0	23.0	-	-	20.0	11.0	-	-	NS	-

[a]Not sampled.
[b]None captured.
[c]Insufficient data; derived from the actual number of animals captured.

probably had not recovered by September 1980. Natural population variation is another explanation for low 1980 densities in the north floodplain woods and the probable cause for low densities in the abandoned railroad right-of-way.

Comparing the two communities shows that although small mammal species richness was equal in both communities, densities were greater in the north floodplain woods. In addition to small mammals captured during live-trapping, several eastern mole (Scalopus aquaticus) tunnels were observed during September in the north floodplain woods (Table 9-4).

Small-mammal trapping was not conducted during June as in previous years, therefore, seasonal changes in small mammal populations could not be examined during the 1980 monitoring program. Typically, seasonal variation does occur in small mammal populations. The highest densities are expected in the fall after the breeding season when young have been recruited into the population. Mortality during winter usually reduces population densities and the lowest population estimates are expected in the spring before the breeding season.

9.2.1.2 Eastern Cottontail Census

Habitat near WCGS supports low-to-moderate cottontail densities as indicated by data collected along the wildlife survey route during the 1980 monitoring program. The highest rabbit density index along the route was noted in June (0.15/mi). This density is 100 percent higher than the June 1979 density and about 25 percent higher than the five-year average for the period 1974-1979 (0.12/mi). During September and January, cottontail density was 0.04/mi; cottontails were not sighted along the route in May.

Data collected during Rural Mail Carrier Surveys (RMCS) by the Kansas Game and Fish Commission (1981, personal communication) did not show similar increases. Although not directly comparable by month, cottontail densities as calculated by RMCS for Coffey County during April, July, and October were 0.004, 0.02, and 0.01/mi respectively. The cottontail index for the southeast region that includes Coffey County was down in April (-22 percent) and July (-19 percent) and up in October (+10 percent) from last year's index. These data reflect seasonal and yearly fluctuations typical of eastern cottontail populations. No trend is indicated by these fluctuations.

9.2.1.3 Incidental Mammal Observations

Four large mammals were observed during terrestrial studies in the north floodplain woods: fox squirrel (Sciurus niger), fox, raccoon (Procyon lotor), and white-tailed deer (Odocoileus virginianus) (Table 9-4). Raccoon and white-tailed deer tracks were noted in May, June, and September. In addition, two deer were sighted in June. Squirrel activity and fox tracks were observed during September.

A coyote (Canis latrans) scat, noted during January was the only large-mammal observation in the abandoned railroad right-of-way during the 1980 monitoring program (Table 9-4).

Table 9-4 Incidental wildlife observations near Wolf Creek Generating Station, Burlington, Kansas, May 1980 - January 1981.

Location/Species	Scientific Name	Date	Type of Observation	Number
North Floodplain Woods				
Eastern mole	Scalopus aquaticus	3 September 1980	Tunnels	Several
Fox squirrel	Sciurus niger	3 September 1980	Sight	1
		5 September 1980	Sight	1
Fox sp.	Vulpes of Urocyon sp.	5 September 1980	Tracks	1 set
Raccoon	Procyon lotor	5 May 1980	Tracks	1 set
		17 June 1980	Tracks	1 set
		5 September 1980	Tracks	Many
White-tailed deer	Odocoileus virginianus	5 May 1980	Tracks	1 set
		16 June 1980	Sight	2
		17 June 1980	Tracks	1 set
		5 September 1980	Tracks	Many
Bullfrog	Rana catesbeiana	5 September 1980	Sight	Many
Abandoned Railroad Right-of-Way				
Coyote	Canis latrans	22 January 1981	Scat	1
Eastern yellowbelly racer	Coluber constrictor	6 May 1980	Sight	2
Western massasauga	Sistrurus catenatus	17 June 1980	Sight	1
		5 September 1980	Sight	1
Ornate box turtle	Terrapene ornata	18 June 1980	Sight	1
		5 September 1980	Sight	1
Box turtle	T. ornata or T. carolina	4 September 1980	Dead	1
hn Redmond Reservoir and Dam				
Fox squirrel	Sciurus niger	22 January 1981	Sight	2
Muskrat	Ondatra zibethicus	16 June 1980	Sight	1
Prairie kingsnake	Lampropeltis calligaster	3 September 1980	Dead	1
20-Mile Survey Route				
Opossum	Didelphis virginianus	2 September 1981	Sight	1
Eastern cottontail	Sylvilagus floridanus	16 June 1980	Sight	1
		17 June 1980	Sight	5
		18 June 1980	Sight	6
		2 September 1980	Dead	1
		4 September 1980	Sight	1
			Dead	1
		21 January 1981	Sight	3
Fox squirrel	Sciurus niger	6 May 1980	Sight	1
		22 January 1981	Sight	1
Eastern woodrat	Neotoma floridana	3 September 1980	Dead	1
Coyote	Canis latrans	5 May 1980	Chorus	1
		17 June 1980	Sight	1
Long-tailed weasel	Mustela frenata	18 June 1980	Dead	1
Blanchard's cricket frog	Acris crepitans	5 May 1980	Chorus	1
American toad	Bufo americanus	5 May 1980	Chorus	5
Snapping turtle	Chelydra serpentina	17 June 1980	Sight	1
Ornate box turtle	Terrapene ornata	17 June 1980	Sight	1
		18 June 1980	Sight	1
Box turtle	T. ornata or T. carolina	2 September 1980	Dead	1
		3 September 1980	Sight	1
		4 September 1980	Dead	1

Two mammalian species were observed at John Redmond Reservoir during the 1980 monitoring program (Table 9-4). Two fox squirrel were noted in January and one muskrat was sighted in June.

9.2.1.4 The 20-Mile Wildlife Survey Route

Six species were observed along the wildlife survey route (Table 9-4). Eastern cottontail was the most abundant species observed during wildlife surveys; 12 were noted in June, 3 during September and January, and no cottontail were sighted in May. In addition to cottontail observations during September surveys, single sightings of opossum (*Didelphis virginianus*) and eastern woodrat were also recorded. Fox squirrel was observed in May and January, coyote during May and June, and one long-tailed weasel in June.

9.2.1.5 Endangered and Threatened Species

No mammalian species listed as endangered or threatened (Kansas Fish and Game Commission 1978, USDI 1979) were observed near WCGS during the monitoring program.

9.2.2 Avifauna

Ninety-eight avian species were observed in the two sampling communities and along the wildlife survey route during the 1980 monitoring program. This total includes 39 summer, 33 permanent, 19 migrant, and 8 winter resident species (Table 9-5). A total of 65 species was recorded at John Redmond Reservoir (Table 9-6).

Johnston (1965) examined the distribution of birds in Kansas and reported that 383 species occur in the state; 184 of these species are known to breed in Kansas. The Flint Hills National Wildlife Refuge, which is several miles west of WCGS, has compiled a list of 183 species (USDI 1970). Waterfowl and waterbird populations at the refuge have been documented by the U.S. Fish and Wildlife Service for the period between October 1979 and September 1980 (Appendix H). A total of 156 avian species has been documented at the WCGS site since the monitoring program began in 1974 and 121 avian species have been observed at John Redmond Reservoir since 1976 (Tables 9-7 and 9-8). Wetland habitat, which attracts approximately 60 aquatic species at the Flint Hills refuge, was not present near WCGS, accounting for the lower number of observed species. Aquatic and wetland habitat will become available in 1981 when the WCGS cooling lake is complete, and utilization by species new to the site is expected.

9.2.2.1 Community Surveys

9.2.2.1.1 North Floodplain Woods Transect

A total of 27 species was observed in the north floodplain woods during May, June, September, and January surveys (Table 9-9). The largest number of species was observed during the spring migration in May; the fewest were sighted in winter during January (Table 9-10). Sixteen breeding species were

Table 9-5 Species list, residency status, and community and monthly occurrence of avifauna near Wolf Creek Generating Station, Burlington, Kansas, May 1980 through January 1981.

Common Name	Scientific Name	Residency Status[a]	Community 1	Community 2	20-mile Survey	Month May	Month Jun	Month Sep	Month Jan
Pied-billed Grebe	Podilymbus podiceps	M				X			
Double-crested Cormorant	Phalacrocorax auritus	M			X	X			
Great Blue Heron	Ardea herodias	S			X	X	X		
Green Heron	Butorides striatus	S			X	X	X		
Mallard	Anas platyrhynchos	P					X		
Gadwall	Anas strepera	M				X			
Blue-winged Teal	Anas discors	M			X	X			
Wood Duck	Aix sponsa	S					X		
Duck sp.	Anas sp.	-			X			X	
Turkey Vulture	Carthartes aura	S			X	X	X	X	
Black Vulture	Coragyps atratus	M			X			X	
Cooper's Hawk	Accipiter cooperi	M			X	X			
Red-tailed Hawk	Buteo jamaicensis	P			X	X	X	X	X
Rough-legged Hawk	Buteo lagopus	W			X			X	X
Bald Eagle	Haliaeetus leucocephalus	W			X				X
Marsh Hawk	Circus cyaneus	W			X	X		X	X
Osprey	Pandion haliaetus	M				X			
American Kestrel	Falco sparverius	P			X	X		X	X
White	Colinus virginianus	P		X	X	X	X	X	
ican Coot	Fulica americana	P			X	X			
Killdeer	Charadrius vociferus	S		X	X	X	X	X	
Upland Sandpiper	Bartramia longicauda	S			X		X	X	
Spotted Sandpiper	Actitis macularia	S				X			
Greater Yellowlegs	Tringa melanoleucus	S			X	X			
Least Sandpiper	Calidris minutilla	S				X			
Ring-billed Gull	Larus delawarensis	M				X			
Forster's Tern	Sterna forsteri	M				X			
Tern sp.	Sterna sp.	-			X			X	
Rock Dove	Columba livia	P			X	X	X	X	X
Mourning Dove	Zenaida macroura	P		X	X	X	X	X	X
Yellow-billed Cuckoo	Coccyzus americanus	S	X		X		X	X	
Black-billed Cuckoo	Coccyzus erythropthalmus	S		X	X			X	
Great Horned Owl	Bubo virginianus	P			X	X			X
Barred Owl	Strix varia	P	X			X			
Common Nighthawk	Chordeiles minor	S			X			X	
Chimney Swift	Chaetura pelagica	S			X	X	X	X	
Belted Kingfisher	Megaceryle alcyon	P			X		X		X
Common Flicker	Colaptes auratus	P	X	X	X	X	X	X	X
Red-bellied Woodpecker	Melanerpes carolinus	P	X		X	X	X	X	X
Red-headed Woodpecker	Melanerpes erythrocephalus	P	X	X	X	X	X	X	X
Hairy Woodpecker	Picoides villosus	P	X		X	X	X	X	
Downy Woodpecker	Picoides pubescens	P	X		X	X	X	X	X
Eastern Kingbird	Tyrannus tyrannus	S		X	X	X	X	X	
Western Kingbird	Tyrannus verticalis	S			X	X	X		
Scissor-tailed Flycatcher	Muscivora forficata	S			X	X	X	X	
Great Crested Flycatcher	Myiarchus crinitus	S	X		X	X	X	X	
Eastern Phoebe	Sayornis phoebe	S	X		X	X	X	X	
Least Flycatcher	Empidonax minimus	S	X		X	X			
Eastern Wood Pewee	Contopus virens	S	X		X	X	X	X	
Horned Lark	Eremophila alpestris	P			X	X	X		X
e Swallow	Iridoprocne bicolor	M					X		
h-winged Swallow	Stelgidopteryx ruficollis	S			X		X	X	
Swallow	Hirundo rustica	S		X	X	X	X	X	

Table 9-5 (continued)

Common Name	Scientific Name	Residency Status[a]	Community 1	Community 2	20-mile Survey	Month May	Month Jun	Month Sep	Month Jan
Cliff Swallow	Petrochelidon pyrrhonata	S			X		X	X	
Blue Jay	Cyanocitta cristata	P	X	X	X	X	X	X	X
Common Crow	Corvus brachyrhynchos	P	X		X	X	X	X	X
Black-capped Chickadee	Parus atricapillus	P	X	X	X	X	X	X	X
Tufted Titmouse	Parus bicolor	P	X		X	X	X	X	X
White-breasted Nuthatch	Sitta carolinensis	P	X		X	X	X	X	X
House Wren	Troglodytes aedon	S	X		X	X	X	X	
Mockingbird	Mimus polyglottos	P		X	X	X	X	X	X
Brown Thrasher	Toxostoma rufum	S		X	X	X	X	X	
American Robin	Turdus migratorius	S	X	X	X	X	X		X
Wood Thrush	Catharus mustelina	M	X			X			
Eastern Bluebird	Sialia sialis	P			X	X	X		X
Blue-gray Gnatcatcher	Polioptila caerulea	S	X			X			
Loggerhead Shrike	Lanius ludovicianus	P			X	X	X	X	X
Starling	Sturnus vulgaris	P			X	X	X	X	X
Bell's Vireo	Vireo bellii	S			X			X	
Red-eyed Vireo	Vireo olivaceus	S	X		X	X	X	X	
Warbling Vireo	Vireo gilvus	S			X	X	X		
Black-and-white Warbler	Mniotilta varia	M	X			X			
Tennessee Warbler	Vermivora ruficapilla	M			X	X			
Northern Waterthrush	Seiurus noveboracensis	M			X	X			
Common Yellowthroat	Geothlypis trichas	S			X	X	X		
Wilson's Warbler	Wilsonia pusilla	M			X			X	
House Sparrow	Passer domesticus	P			X	X	X	X	X
Eastern Meadowlark	Sturnella magna	P		X	X	X	X	X	X
Western Meadowlark	Sturnella neglecta	P		X			X		
Red-winged Blackbird	Agelaius phoeniceus	P		X	X	X	X	X	X
Orchard Oriole	Icterus spurius	S		X	X		X	X	
Northern Oriole	Icterus galbula	S			X	X	X	X	
Brewer's Blackbird	Euphagus cyanocephalus	W			X			X	
Common Grackle	Quiscalus quiscula	S	X	X	X	X	X	X	
Brown-headed Cowbird	Molothrus ater	P		X	X	X	X	X	
Summer Tanager	Piranga rubra	S	X			X			
Cardinal	Cardinalis cardinalis	P	X	X	X	X	X	X	X
Indigo Bunting	Passerina cyanea	S	X		X	X	X	X	
Dickcissel	Spiza americana	S		X	X	X	X	X	
American Goldfinch	Carduelis tristis	P	X		X	X	X	X	X
Grasshopper Sparrow	Ammodramus savannarum	S		X	X	X	X		
Vesper Sparrow	Pooecetes gramineus	M			X	X			
Lark Sparrow	Chondestes grammacus	S		X	X	X	X	X	
Dark-eyed Junco	Junco hyemalis	M		X	X				X
Tree Sparrow	Spizella arborea	W		X	X				X
Field Sparrow	Spizella pusilla	P		X	X	X	X		
Harris' Sparrow	Zonotrichia querula	W		X	X	X			X
White-crowned Sparrow	Zonotrichia leucophrys	W		X	X	X			X
Song Sparrow	Melospiza melodia	W			X	X			

[a] M = Migrant
P = Permanent resident
S = Summer resident
W = Winter resident

Table 9-6 Avian species observed near John Redmond Reservoir, Burlington, Kansas, May 1980 through January 1981.

Common Name	Scientific Name	Month			
		May	June	September	January
Pied-billed Grebe	Podilymbus podiceps	X		X	
White Pelican	Pelecanus erythrorhynchos			X	
Double-crested Cormorant	Phalacrocorax auritus			X	
Great Blue Heron	Ardea herodias	X	X	X	X
Green Heron	Butorides striatus		X		
Little Blue Heron	Florida caerulea			X	
Cattle Egret	Bubulcus ibis			X	
Great Egret	Casmerodius albus			X	
Snow Goose	Chen caerulescens				X
Mallard	Anas platyrhynchos		X	X	X
Gadwall	Anas strepera	X			
Pintail	Anas acuta				X
Blue-winged Teal	Anas discors	X		X	
Wood Duck	Aix sponsa		X	X	
Scaup sp.	Aythya sp.				X
Common Goldeneye	Bucephala clangula				X
Duck sp.	Anas sp.			X	X
Merganser sp.	Mergus sp.				X
Red-tailed Hawk	Buteo jamaicensis				X
Bald Eagle	Haliaeetus leucocephalus				X
Marsh Hawk	Circus cyaneus	X			X
Osprey	Pandion haliaetus			X	
American Kestrel	Falco sparverius				X
American Coot	Fulica americana	X		X	
Killdeer	Charadrius vociferus	X	X	X	
Upland Sandpiper	Bartramia longicauda		X	X	
Spotted Sandpiper	Actitis macularia	X			
Greater Yellowlegs	Tringa melanoleucus	X		X	
Pectoral Sandpiper	Calidris melanotos			X	
Least Sandpiper	Calidris minutilla	X			
Sanderling	Calidris alba			X	
Shorebird sp.	Charadriidae sp.			X	
Wilson's Phalarope	Steganopus tricolor			X	
Herring Gull	Larus argentatus			X	
Ring-billed Gull	Larus delawarensis	X		X	X
Gull sp.	Larus sp.			X	X
Forster's Tern	Sterna forsteri	X			
Least Tern	Sterna albifrons			X	
Tern sp.	Sterna sp.			X	
Mourning Dove	Zenaida macroura	X	X	X	
Chimney Swift	Chaetura pelagica		X		
Belted Kingfisher	Megaceryle alcyon		X		
Red-bellied Woodpecker	Melanerpes carolinus				X
Downy Woodpecker	Picoides pubescens				X
Eastern Kingbird	Tyrannus tyrannus	X	X		
Western Kingbird	Tyrannus verticalis	X	X		
Scissor-tailed Flycatcher	Muscivora forficata	X	X		
Tree Swallow	Iridoprocne bicolor		X		
Rough-winged Swallow	Stelgidopteryx ruficollis		X		
Barn Swallow	Hirundo rustica	X	X	X	
Cliff Swallow	Petrochelidon pyrrhonata		X		
Blue Jay	Cyanocitta cristata	X	X		X
Common Crow	Corvus brachyrhynchos			X	X
Mockingbird	Mimus polyglottos		X		X
Brown Thrasher	Toxostoma rufum	X			
American Robin	Turdus migratorius	X	X		X

Table 9-6 (continued)

Common Name	Scientific Name	Month			
		May	June	September	January
Loggerhead Shrike	Lanius ludovicianus	X	X		
Starling	Sturnus vulgaris	X	X		X
Warbling Vireo	Vireo gilvus		X		
House Sparrow	Passer domesticus		X	X	X
Eastern Meadowlark	Sturnella magna	X	X	X	X
Red-winged Blackbird	Agelaius phoeniceus	X	X	X	X
Northern Oriole	Icterus galbula	X			
Common Grackle	Quiscalus quiscula	X	X		
Brown-headed Cowbird	Molothrus ater	X	X		
Cardinal	Cardinalis cardinalis	X			X
Dickcissel	Spiza americana		X		
Dark-eyed Junco	Junco hyemalis				X
Tree Sparrow	Spizella arborea				X

Table 9-7 Avian species observed near Wolf Creek Generating Station, Burlington, Kansas, 1974 through 1980.

Common Name	Scientific Name	Year 1974	1975	1976	1977	1978	1979	1980
Pied-billed Grebe	Podilymbus podiceps							X
Double-crested Cormorant	Phalacrocorax auritus		X	X	X			X
Great Blue Heron	Ardea herodias	X	X	X	X	X	X	X
Green Heron	Butorides striatus	X	X	X	X		X	X
American Bittern	Botarus lentiginosus					X		
Canada Goose	Branta canadensis	X	X	X		X	X	
White-fronted Goose	Anser albifrons				X			
Snow Goose	Chen caerulescens	X	X	X	X			
Mallard	Anas platyrhynchos	X	X	X	X	X	X	X
Gadwall	Anas strepera							X
Pintail	Anas acuta				X			
Blue-winged Teal	Anas discors	X		X	X	X	X	X
Green-winged Teal	Anas crecca				X			
American Wigeon	Anas americana				X			
Wood Duck	Aix sponsa	X		X				X
Lesser Scaup	Aythya affinis						X	
Common Merganser	Mergus merganser				X			
Red-breasted Merganser	Mergus serrator					X	X	
Turkey Vulture	Carthartes aura	X	X	X	X	X	X	X
Black Vulture	Coragyps atratus							X
Sharp-shinned Hawk	Accipiter striatus				X	X	X	
Cooper's Hawk	Accipiter cooperii							X
Red-tailed Hawk	Buteo jamaicensis	X	X	X	X	X	X	X
Broad-winged Hawk	Buteo platypterus			X				
Swainson's Hawk	Buteo swainsoni		X	X		X		
Rough-legged Hawk	Buteo lagopus	X		X		X	X	X
Bald Eagle	Haliaeetus leucocephalus			X	X			X
Marsh Hawk	Circus cyaneus	X	X	X	X	X	X	X
Osprey	Pandion haliaetus							X
Prairie Falcon	Falco mexicanus					X		
Merlin	Falco columbarius					X		
American Kestrel	Falco sparverius	X	X	X	X	X	X	X
Greater Prairie Chicken	Tympanuchus cupido					X		
Bobwhite	Colinus virginianus	X	X	X	X	X	X	X
American Coot	Fulica americana							X
Killdeer	Charadrius vociferus	X	X	X	X	X	X	X
Common Snipe	Capella gallinago				X	X		
Upland Sandpiper	Bartramia longicauda	X			X		X	X
Spotted Sandpiper	Actitis macularia					X		X
Greater Yellowlegs	Tringa melanoleucus	X			X	X		X
Lesser Yellowlegs	Tringa flavipes		X					
Pectoral Sandpiper	Calidris melanotos							X
Least Sandpiper	Calidris minutilla							X
Dowitcher sp.	Limnodromus sp.				X			
Ring-billed Gull	Larus delawarensis			X		X	X	X
Franklin's Gull	Larus pipixcan				X			
Forster's Tern	Sterna forsteri							X
Rock Dove	Columba livia	X	X	X	X	X	X	X
Mourning Dove	Zenaida macroura	X	X	X	X	X	X	X
Yellow-billed Cuckoo	Coccyzus americanus	X	X	X	X	X	X	X
Black-billed Cuckoo	Coccyzus erythropthalmus			X				X
Great Horned Owl	Bubo virginianus		X		X		X	X
Barred Owl	Strix varia	X		X		X		X
Long-eared Owl	Asio otus	X						
Common Nighthawk	Chordeiles minor	X		X	X			X
Chimney Swift	Chaetura pelagica	X	X	X	X	X	X	X

Table 9-7 (continued)

Common Name	Scientific Name	Year 1974	1975	1976	1977	1978	1979	1980
Ruby-throated Hummingbird	Archilochus colubris	X	X					
Belted Kingfisher	Megaceryle alcyon				X		X	X
Common Flicker	Colaptes auratus	X	X	X	X	X	X	X
Pileated Woodpecker	Dryocopus pileatus	X						
Red-bellied Woodpecker	Melanerpes carolinus	X	X	X	X	X	X	X
Red-headed Woodpecker	Melanerpes erythrocephalus	X	X	X	X	X	X	X
Hairy Woodpecker	Picoides villosus	X	X	X		X	X	X
Downy Woodpecker	Picoides pubescens	X	X	X	X	X	X	X
Eastern Kingbird	Tyrannus tyrannus	X	X	X	X	X	X	X
Western Kingbird	Tyrannus verticalis	X	X				X	X
Scissor-tailed Flycatcher	Muscivora forficata	X	X	X	X	X	X	X
Great Crested Flycatcher	Myiarchus crinitus	X	X	X	X	X	X	X
Eastern Phoebe	Sayornis phoebe	X	X	X	X	X	X	X
Least Flycatcher	Empidonax minimus	X					X	X
Eastern Wood Pewee	Contopus virens	X	X	X	X	X	X	X
Horned Lark	Eremophila alpestris	X	X	X	X	X	X	X
Tree Swallow	Iridoprocne bicolor	X				X	X	X
Rough-winged Swallow	Stelgidopteryx ruficollis		X	X		X	X	X
Barn Swallow	Hirundo rustica	X	X	X	X	X	X	X
Cliff Swallow	Petrochelidon pyrrhonata	X	X	X	X			X
Purple Martin	Progne subis	X	X					
Blue Jay	Cyanocitta cristata	X	X	X	X	X	X	X
Common Crow	Corvus brachyrhynchos	X	X	X	X	X	X	X
Black-capped Chickadee	Parus atricapillus	X	X	X	X	X	X	X
Carolina Chickadee	Parus carolinensis			X				
Tufted Titmouse	Parus bicolor		X	X	X	X	X	X
White-breasted Nuthatch	Sitta carolinensis	X	X	X	X	X	X	X
Brown Creeper	Certhia familiaris	X	X	X	X	X	X	
House Wren	Troglodytes aedon	X	X	X	X	X	X	X
Winter Wren	Troglodytes troglodytes	X	X		X			
Carolina Wren	Thryothorus ludovicianus		X	X				
Mockingbird	Mimus polyglottos	X	X	X	X	X	X	X
Gray Catbird	Dumetella carolinensis	X	X	X		X	X	
Brown Thrasher	Toxostoma rufum	X	X	X	X	X	X	X
American Robin	Turdus migratorius	X	X	X	X	X	X	X
Wood Thrush	Catharus mustelina			X	X	X		X
Veery	Catharus fuscescens		X	X				
Eastern Bluebird	Sialia sialis	X	X	X	X	X	X	X
Blue-gray Gnatcatcher	Polioptila caerulea			X	X	X	X	X
Golden-crowned Kinglet	Regulus satrapa		X	X	X	X	X	
Ruby-crowned Kinglet	Regulus calendula			X	X		X	
Water Pipit	Anthus spinoletta						X	
Northern Shrike	Lanius excubitor	X						
Loggerhead Shrike	Lanius ludovicianus	X	X	X	X	X	X	X
Starling	Sturnus vulgaris	X	X	X	X	X	X	X
Bell's Vireo	Vireo bellii	X	X					X
Yellow-throated Vireo	Vireo flavifrons			X				
Solitary Vireo	Vireo solitarius			X				
Red-eyed Vireo	Vireo olivaceus	X	X	X	X	X	X	X
Warbling Vireo	Vireo gilvus			X	X	X	X	X
Black-and-white Warbler	Mniotilta varia			X				X
Nashville Warbler	Vermivora ruficapilla		X					X
Northern Parula	Parula americana			X				
Yellow Warbler	Dendroica petechia		X	X	X	X	X	
Yellow-rumped Warbler	Dendroica coronata		X	X	X			
Cerulean Warbler	Dendroica cerulea				X	X		

Table 9-7 (continued)

Common Name	Scientific Name	Year 1974	1975	1976	1977	1978	1979	1980
Blackburnian Warbler	Dendroica fusca		X					
Chestnut-sided Warbler	Dendroica pensylvanica						X	
Bay-breasted Warbler	Dendroica castanea				X			
Ovenbird	Seiurus aurocapillus		X				X	
Northern Waterthrush	Seiurus noveboracensis							X
Kentucky Warbler	Oporornis formosus			X		X	X	
Common Yellowthroat	Geothlypis trichas	X		X	X	X	X	X
Wilson's Warbler	Wilsonia pusilla		X	X		X		X
American Redstart	Setophaga ruticilla				X		X	
House Sparrow	Passer domesticus	X	X	X	X	X	X	X
Bobolink	Dolichonyx oryzivorous			X				
Eastern Meadowlark	Sturnella magna	X	X	X	X	X	X	X
Western Meadowlark	Sturnella neglecta		X	X		X	X	X
Yellow-headed Blackbird	Xanthocephalus xanthocephalus					X		
Red-winged Blackbird	Agelaius phoeniceus	X	X	X	X	X	X	X
Orchard Oriole	Icterus spurius	X	X	X	X	X	X	X
Northern Oriole	Icterus galbula	X	X	X	X	X	X	X
Brewer's Blackbird	Euphagus cyanocephalus				X			X
Common Grackle	Quiscalus quiscula	X	X	X	X	X	X	X
Brown-headed Cowbird	Molothrus ater	X	X	X	X	X	X	X
Summer Tanager	Piranga rubra		X	X	X		X	X
Cardinal	Cardinalis cardinalis	X	X	X	X	X	X	X
Rose-breasted Grosbeak	Pheucticus ludovicianus			X				
Indigo Bunting	Passerina cyanea	X	X	X	X	X	X	X
Dickcissel	Spiza americana	X	X	X	X	X	X	X
Purple Finch	Carpodacus purpureus				X			
Pine Siskin	Carduelis pinus		X		X			
American Goldfinch	Carduelis tristis	X	X	X	X	X	X	X
Rufous-sided Towhee	Pipilo erythrophthalmus	X			X			
Savannah Sparrow	Passerculus sandwichensis	X	X	X	X			
Grasshopper Sparrow	Ammodramus savannarum	X	X	X	X	X	X	X
Vesper Sparrow	Pooecetes gramineus	X	X					X
Lark Sparrow	Chondestes grammacus	X	X	X	X	X	X	X
Dark-eyed Junco	Junco hyemalis	X	X	X	X	X	X	X
Tree Sparrow	Spizella arborea	X	X	X	X	X	X	X
Chipping Sparrow	Spizella passerina	X		X	X	X		
Field Sparrow	Spizella pusilla	X	X	X	X	X	X	X
Harris' Sparrow	Zonotrichia querula	X	X	X	X	X	X	X
White-crowned Sparrow	Zonotrichia leucophrys	X	X	X	X	X	X	X
White-throated Sparrow	Zonotrichia albicollus		X	X	X			
Fox Sparrow	Passerella iliaca	X	X	X				
Lincoln's Sparrow	Melospiza lincolnii		X	X	X			
Song Sparrow	Melospiza melodia	X	X	X	X	X	X	X
Lapland Longspur	Calcarius lapponicus				X			
Total number of species		83	90	99	97	88	87	98
Total number of species (1974-1980)		156						

Table 9-8 Avian species observed near John Redmond Reservoir, Burlington, Kansas, 1976 through 1980.[a]

Common Name	Scientific Name	Year 1976	1977	1978	1979	1980
Pied-billed Grebe	Podilymbus podiceps	X				X
White Pelican	Pelecanus erythrorhynchos	X	X	X	X	X
Double-crested Cormorant	Phalacrocorax auritus	X	X	X		X
Great Blue Heron	Ardea herodias	X	X	X	X	X
Green Heron	Butorides striatus	X		X	X	X
Little Blue Heron	Florida caerulea		X			X
Cattle Egret	Bubulcus ibis		X			X
Great Egret	Casmerodius albus				X	X
Canada Goose	Branta canadensis	X	X			
Snow Goose	Chen caerulescens	X	X		X	X
Mallard	Anas platyrhynchos	X	X		X	X
Gadwall	Anas strepera	X	X			X
Pintail	Anas acuta	X				X
Blue-winged Teal	Anas discors	X	X	X	X	X
Green-winged Teal	Anas crecca	X	X			
American Wigeon	Anas americana	X				
Northern Shoveler	Anas clypeata	X	X			
Wood Duck	Aix sponsa		X	X		X
Redhead	Aythya americana	X				
Canvasback	Aythya valisineria	X				
Scaup sp.	Aythya sp.					X
Common Goldeneye	Bucephala clangula	X			X	X
Bufflehead	Bucephala albeola	X				
Red-breasted Merganser	Mergus serrator		X			
Merganser sp.	Mergus sp.					X
Turkey Vulture	Carthartes aura	X			X	
Red-tailed Hawk	Buteo jamaicensis	X	X	X	X	X
Swainson's Hawk	Buteo swainsoni	X	X			
Rough-legged Hawk	Buteo lagopus	X				
Bald Eagle	Haliaeetus leucocephalus	X	X		X	X
Marsh Hawk	Circus cyaneus	X	X	X	X	X
Osprey	Pandion haliaetus	X		X		X
American Kestrel	Falco sparverius	X	X	X		X
Bobwhite	Colinus virginianus			X		
American Coot	Fulica americana		X	X	X	X
Semipalmated Plover	Charadrius semipalmatus	X				
Killdeer	Charadrius vociferus	X	X	X	X	X
Black-bellied Plover	Pluvialis squatarola	X				
Common Snipe	Capella gallinago	X				
Upland Sandpiper	Bartramia longicauda	X	X	X		X
Spotted Sandpiper	Actitis macularia		X	X	X	X
Solitary Sandpiper	Tringa solitaria				X	
Greater Yellowlegs	Tringa melanoleucus	X	X	X	X	X
Lesser Yellowlegs	Tringa flavipes	X	X		X	
Pectoral Sandpiper	Calidris melanotos	X		X		X
Baird's Sandpiper	Calidris bairdii			X		
Least Sandpiper	Calidris minutilla		X		X	X
Dunlin	Calidris alpina	X	X			
Short-billed Dowitcher	Limnodromus griseus		X			
Long-billed Dowitcher	Limnodromus scolopaceus		X			
Semipalmated Sandpiper	Calidris pusillus		X	X	X	
Buff-breasted Sandpiper	Tryngites subruficollis	X				
Sanderling	Calidris alba	X				X
American Avocet	Recurvirostra americana		X			
Wilson's Phalarope	Steganopus tricolor	X	X		X	X
Herring Gull	Larus argentatus				X	X

Table 9-8 (continued)

Common Name	Scientific Name	Year 1976	1977	1978	1979	1980
Ring-billed Gull	Larus delawarensis	X	X	X	X	X
Franklin's Gull	Larus pipixcan	X	X			
Forster's Tern	Sterna forsteri	X	X			X
Least Tern	Sterna albifrons	X	X			X
Caspian Tern	Sterna caspia			X		
Black Tern	Chlidonias niger	X	X	X	X	
Mourning Dove	Zenaida macroura		X	X	X	X
Great Horned Owl	Bubo virginianus			X		
Common Nighthawk	Chordeiles minor			X		
Chimney Swift	Chaetura pelagica					X
Belted Kingfisher	Megaceryle alcyon	X			X	X
Common Flicker	Colaptes auratus		X		X	
Red-bellied Woodpecker	Melanerpes carolinus		X			X
Red-headed Woodpecker	Melanerpes erythrocephalus	X	X		X	
Hairy Woodpecker	Picoides villosus		X		X	
Downy Woodpecker	Picoides pubescens		X		X	X
Eastern Kingbird	Tyrannus tyrannus	X	X	X	X	X
Western Kingbird	Tyrannus verticalis		X	X	X	X
Scissor-tailed Flycatcher	Muscivora forficata	X	X	X	X	X
Horned Lark	Eremophila alpestris	X				
Tree Swallow	Iridoprocne bicolor	X	X	X		X
Rough-winged Swallow	Stelgidopteryx ruficollis					X
Barn Swallow	Hirundo rustica	X	X	X	X	X
Cliff Swallow	Petrochelidon pyrrhonata				X	X
Blue Jay	Cyanocitta cristata		X	X	X	X
Common Crow	Corvus brachyrhynchos	X			X	X
Black-capped Chickadee	Parus atricapillus				X	
House Wren	Troglodytes aedon		X			
Mockingbird	Mimus polyglottos	X	X	X	X	X
Gray Catbird	Dumetella carolinensis			X		
Brown Thrasher	Toxostoma rufum	X	X	X		X
American Robin	Turdus migratorius	X	X	X	X	X
Eastern Bluebird	Sialia sialis		X			
Ruby-crowned Kinglet	Regulus calendula	X				
Water Pipit	Anthus spinoletta	X				
Loggerhead Shrike	Lanius ludovicianus	X	X	X		X
Starling	Sturnus vulgaris	X	X	X	X	X
Bell's Vireo	Vireo bellii		X			
Warbling Vireo	Vireo gilvus					X
Yellow Warbler	Dendroica petechia				X	
House Sparrow	Passer domesticus		X	X	X	X
Eastern Meadowlark	Sturnella magna		X	X	X	X
Meadowlark sp.	Sturnella sp.	X				
Red-winged Blackbird	Agelaius phoeniceus	X	X	X	X	X
Northern Oriole	Icterus galbula		X	X	X	X
Common Grackle	Quiscalus quiscula	X	X	X	X	X
Brown-headed Cowbird	Molothrus ater		X	X	X	X
Cardinal	Cardinalis cardinalis	X	X	X		X
Dickcissel	Spiza americana	X	X	X	X	X
American Goldfinch	Carduelis tristis	X	X	X		
Savannah Sparrow	Passerculus sandwichensis		X			
Grasshopper Sparrow	Ammodramus savannarum	X	X			
Vesper Sparrow	Pooecetes gramineus	X				
Lark Sparrow	Chondestes grammacus		X			
Dark-eyed Junco	Junco hyemalis	X				X
Tree Sparrow	Spizella arborea	X	X			X

Table 9-8 (continued)

Common Name	Scientific Name	Year 1976	1977	1978	1979	1980
Chipping Sparrow	*Spizella passerina*		X			
Field Sparrow	*Spizella pusilla*		X			
Harris' Sparrow	*Zonotrichia querula*	X	X			
White-crowned Sparrow	*Zonotrichia leucophrys*		X			
Song Sparrow	*Melospiza melodia*	X				
Total number of species		70	74	46	49	65
Total number of species (1976-1980)		121				

[a] Avifauna was not censused at this location during the 1974 and 1975 monitoring programs.

Table 9-9 The number of birds observed per hour in the north floodplain woods, Community 1, near Wolf Creek Generating Station, Burlington, Kansas, May 1980 - January 1981.

Species	Number Observed/Hour			
	May	June	September	January
Yellow-billed Cuckoo	-	4.5	1.0	-
Barred Owl	0.5	-	-	-
Common Flicker	0.5	-	1.0	3.2
Red-bellied Woodpecker	2.1	1.8	5.7	1.6
Red-headed Woodpecker	1.0	1.8	1.9	4.0
Hairy Woodpecker	0.5	0.9	-	-
Downy Woodpecker	1.6	3.6	2.9	1.6
Great Crested Flycatcher	2.6	5.4	5.7	-
Eastern Phoebe	0.5	-	-	-
Least Flycatcher	0.5	-	-	-
Eastern Wood Pewee	0.5	5.4	5.7	-
Blue Jay	7.3	1.8	5.7	4.0
Common Crow	0.5	0.9	6.7	2.4
Black-capped Chickadee	4.7	-	10.5	9.6
Tufted Titmouse	3.7	1.8	4.8	4.0
White-breasted Nuthatch	0.5	2.7	7.6	4.0
House Wren	5.7	3.6	1.9	-
American Robin	-	-	-	0.8
Wood Thrush	1.0	-	-	-
Blue-gray Gnatcatcher	3.7	-	-	-
Red-eyed Vireo	4.2	4.5	1.0	-
Black-and-white Warbler	2.6	-	-	-
Common Grackle	-	0.9	-	-
Summer Tanager	1.0	-	-	-
Cardinal	2.6	1.8	-	1.6
Indigo Bunting	2.1	0.9	-	-
American Goldfinch	-	-	2.9	-
Total	49.9	42.3	65.0	36.8

Table 9-10 Number of species, birds per hour, and species diversity of avifauna recorded in two communities near Wolf Creek Generating Station, Burlington, Kansas, May 1974 - January 1980.

Variable	Month				
	May	Jun	Sep	Nov	Jan
North Floodplain Woods					
Number of Species					
1974	18	12	12	9	10
1975	23	9	11	11	20
1976	26	20	15	17	14
1977	16	18	16	12	12
1978	15	16	10	15	10
1979	19	13	19	17	11
1980	23	16	15	a	11
Birds per Hour					
1974	37.3	22.7	26.0	18.7	17.3
1975	72.6	8.0	15.7	39.2	97.9
1976	58.0	110.8	71.9	441.3	143.3
1977	48.0	90.0	68.0	60.0	51.9
1978	40.0	67.0	21.5	89.5	52.0
1979	81.7	62.6	74.8	99.3	46.9
1980	49.7	42.3	64.0	a	36.8
Species Diversity					
1974	2.63	2.35	2.30	1.89	1.96
1975	2.74	2.11	2.09	2.21	2.67
1976	2.91	2.56	2.32	0.98	2.25
1977	2.57	2.45	2.35	2.33	2.21
1978	2.39	2.35	2.16	2.36	1.93
1979	2.79	2.39	2.64	2.49	2.12
1980	2.80	2.60	2.51	a	2.20
Abandoned Railroad Right-of-Way					
Number of Species					
1974	21	17	13	15	12
1975	14	11	3	5	15
1976	14	19	17	10	2
1977	13	16	14	12	12
1978	19	13	17	12	9
1979	18	13	11	6	9
1980	12	13	12	a	8

Table 9-10 (continued)

Variable	Month				
	May	Jun	Sep	Nov	Jan
Abandoned Railroad Right-of-Way (continued)					
Birds per Hour					
1974	69.6	63.3	239.0	176.0	274.0
1975	68.7	29.6	11.4	82.4	157.8
1976	75.0	122.0	88.7	139.0	7.5
1977	82.8	76.3	84.8	56.5	141.0
1978	49.4	60.9	136.8	426.1	43.0
1979	72.8	22.7	38.1	35.7	98.4
1980	31.5	39.9	41.0	a	167.1
Species Diversity					
1974	2.66	2.62	1.53	1.98	1.47
1975	2.13	2.14	1.01	0.85	1.81
1976	2.20	2.45	2.16	1.50	0.45
1977	2.20	2.22	1.65	2.04	1.82
1978	2.49	2.20	2.03	1.54	1.60
1979	2.53	2.32	1.83	1.35	1.61
1980	2.39	2.23	2.07	a	1.56

[a] Not censused.

recorded in June and 15 species were noted in September. The largest bird concentrations coincided with spring and fall migration periods. Avian abundance was lowest during January.

Several species used this community continually throughout the monitoring period. Permanent residents included red-bellied woodpecker (Melanerpes carolinus), red-headed woodpecker (Melanerpes erythrocephalus), blue jay (Cyanocitta cristata), common crow (Corvus brachyrhynchos), and tufted titmouse (Parus bicolor) (Table 9-9).

Avian activity was lowest during winter as indicated by the number of species and birds recorded in January; 11 species were recorded, and an average of 36.8 birds/hour was observed (Table 9-9). Black-capped chickadee (Parus atricapillus) was the most abundant species in January. Avian community composition during winter was dominated by woodland residents, including four species of woodpeckers, tufted titmouse, and white-breasted nuthatch (Sitta carolinensis).

Sixteen species comprised the summer breeding avifauna in the north floodplain woods (Table 9-9). Species associated with open woodland and stream bank habitat primarily used this community at this time. An average of 42.3 birds/hour was observed in June, and the most abundant species were great crested flycatcher (Myiarchus crinitus) and eastern wood pewee (Contopus virens). Also abundant were yellow-billed cuckoo (Coccyzus americanus), red-eyed vireo (Vireo olivaceus), downy woodpecker (Picoides pubescens), and house wren (Troglodytes troglodytes).

The influx of spring and fall migrants was reflected in data collected in the north floodplain woods. During May, the highest species richness and the second largest avian abundance were reported (Table 9-9). Blue jay, house wren, and black-capped chickadee were the most abundant species in May. Although several species including barred owl (Strix varia), eastern phoebe (Sayornis phoebe), least flycatcher (Empidonax minimus), and summer tanager (Piranga rubra) were only observed during this month, transient species (i.e., species defined by Rapp et al. (1958) as passing through en route from a summer and winter residence that are outside the concerned area) were not observed in this community during May.

An average of 65.0 birds/hour, the highest average for this community during the study period, was observed during the fall migration in September (Table 9-9). Species with woodland habitat affiliations were the only birds observed during September; 15 species were noted. The black-capped chickadee was the most abundant species. The only species observed exclusively in September was American goldfinch (Carduelis tristis).

9.2.2.1.2 Abandoned Railroad Right-of-Way Transect

Twenty-eight species were observed in the abandoned railroad right-of-way (Table 9-11). Species richness remained relatively constant during the four sampling periods. The largest number of species was noted during the breeding season in June (13), twelve species were recorded during migration periods in May and September, and eight species were observed in January (Table 9-10).

Table 9-11 The number of birds observed per hour in the abandoned railroad right-of-way, Community 2, near Wolf Creek Generating Station, Burlington, Kansas, May 1980 - January 1981.

Species	Number Observed/Hour			
	May	June	September	January
Bobwhite	1.1	-	-	-
Killdeer	1.1	-	1.2	-
Mourning Dove	5.4	1.3	8.1	7.1
Black-billed Cuckoo	-	-	1.2	-
Common Flicker	2.1	-	1.2	2.4
Red-headed Woodpecker	-	-	1.2	-
Eastern Kingbird	-	1.3	-	-
Barn Swallow	-	-	6.9	-
Blue Jay	1.1	-	4.6	-
Black-capped Chickadee	-	4.0	-	-
Mockingbird	-	1.3	1.2	-
Brown Thrasher	-	1.3	2.3	-
American Robin	-	2.7	-	-
Eastern Meadowlark	1.1	-	1.2	12.9
Western Meadowlark	-	1.3	-	-
Red-winged Blackbird	2.1	12.0	-	-
Orchard Oriole	-	1.3	1.2	-
Common Grackle	-	6.7	-	-
Brown-headed Cowbird	3.2	2.7	11.5	-
Cardinal	-	-	-	8.2
Dickcissel	1.1	-	-	-
Grasshopper Sparrow	2.1	-	-	-
Lark Sparrow	-	1.3	-	-
Dark-eyed Junco	-	-	-	10.6
Tree Sparrow	-	-	-	105.9
Field Sparrow	3.2	2.7	-	-
Harris' Sparrow	5.4	-	-	27.1
White-crowned Sparrow	-	-	-	14.1
Sparrow sp.	2.1	-	-	-
Total	31.1	39.9	41.8	188.3

Avian abundance was highest in January (183.3 birds/hour), because of large flocks of wintering sparrows. A total of 41.8 birds/hour was recorded in September, 39.9 in June, and 31.1 in May.

Mourning dove was the only species recorded during all sampling months. Eleven additional species considered permanent residents of the area were also observed. These include bobwhite, two species of woodpecker, blue jay, black-capped chickadee, mockingbird (Mimus polyglottos), eastern and western meadowlarks (Sturnella neglecta, S. magna), red-winged blackbird (Agelaius phoeniceus), and two finch species (Table 9-11).

Winter visitors dominated the avifauna in January. Eight species were observed, and large flocks of wintering sparrows, including tree sparrow (Spizella arborea), Harris' sparrow (Zonotrichia querula), and white-crowned sparrow (Zonotrichia leucophrys) were responsible for the large number of birds recorded (188.3 birds/hour) (Table 9-11). Five additional species, mourning dove, common flicker (Colaptes auratus), eastern meadowlark, cardinal (Cardinalis cardinalis), and dark-eyed junco (Junco hyemalis) were also observed.

The abandoned railroad right-of-way did not provide good nesting habitat, and avian activity was low during the breeding season. Thirteen species and 39.9 birds/hour were recorded in June. The red-winged blackbird was the most abundant summer resident, and common grackle (Quiscalus quiscula) and black-capped chickadee were also common. Species composition was typical for this habitat type; mourning dove, blackbirds, and sparrows were noted.

Birds were not abundant during the spring sampling period in May. Twelve species were recorded and 31.1 birds/hour were observed (Table 9-11). Mourning dove and Harris' sparrow were the most abundant species, however, their densities were low. One upland gamebird, bobwhite, was noted in May.

The brown-headed cowbird (Molothrus ater) was the most abundant species during September (Table 9-11). A total of 12 species was observed in this month, with mourning dove, a permanent resident, and barn swallow (Hirundo rustica) noted in relatively high densities. Several species including black-billed cuckoo (Coccyzus erythropthalmus), red-headed woodpecker, and barn swallow were only sighted during September. Winter finches, the predominant species group noted during January, were not observed in September, and probably arrived after sampling. A total of 41.8 birds/hour was recorded in September.

9.2.2.1.3 Bird Species Diversity

Bird species diversity (BSD) reflects the total number of species in an area and the relative importance of species within an aggregation. Seasonal BSD values usually peak in the fall and spring because of the presence of migrants; lowest values usually occur in January when few species and individuals are in the area. Values are also usually higher in more structurally complex habitats.

BSD values were calculated for the north floodplain woods and abandoned railroad right-of-way sampling communities during May, June, September, and January (Table 9-10). Monthly values for the north floodplain woods reflected seasonal avian abundance and diversity patterns. The highest BSD value was recorded in May (2.80) reflecting the spring influx of species, and the lowest BSD was noted during January (2.20) when only permanent and winter residents were present. BSD was 2.60 in June and 2.51 in September. Similar BSD trends were observed in the abandoned railroad right-of-way community. The highest BSD was noted in May (2.39), the lowest in January (1.56). Values for June and September were 2.23 and 2.07, respectively.

BSD values were higher for all months in the north floodplain woods than in the abandoned railroad right-of-way community. This was expected because more structurally complex communities generally have higher species diversity (Karr 1968). In comparison to forest, grasslands are structurally simple and have low BSD (Shugart and James 1973).

9.2.2.1.4 Comparison With Previous Studies

Data collected prior to November 1974 in a floodplain woods community represented a different location and direct comparisons are not valid. Comparisons are possible for the north floodplain woods community studied after November 1974 and for all data collected in the abandoned railroad right-of-way community.

Data collected in the north floodplain woods in 1980 indicated that there were no consistent changes in avian community components from the previous years (Table 9-10). In the abandoned railroad right-of-way, the number of birds per hour in May was the lowest recorded during monitoring studies. However, other avian community characteristics showed no trends in changes from the previous year or from the average values obtained from the previous five years of monitoring. In general, the seven years' data from both communities show large fluctuations when annual species numbers and populations are compared (Table 9-10). No trends are indicated by these fluctuations.

9.2.2.2 <u>20-Mile Wildlife Survey Route</u>

9.2.2.2.1 Seasonal Analysis

The last four miles of the 20-mile wildlife survey route including miles 16 through 20 were rerouted during the 1980-81 monitoring program due to road inundation caused by filling of the cooling lake. The inundated portion of the route was replaced with a new section that was chosen because of similarity in habitat types to miles 16 through 20. The rerouting does not compromise the data, although data collected during this years' surveys are not numerically comparable to previous years data.

A total of 82 avian species was recorded along the wildlife survey route during 1980 monitoring surveys (Table 9-5). Avian species abundance and distribution reflected seasonal patterns and the variety of habitat types along the route. The influx of species into the area during migration periods was reflected by species richness, which was highest along the route during spring (61) and fall (53). The lowest number of species (33) was recorded

Table 9-12 Number of avian species and individuals observed along the 20-mile wildlife survey route near Wolf Creek Generating Station, Burlington, Kansas, May 1973 - January 1981.

Variable	Month				
	May	Jun	Sep	Nov	Jan
Number of Species					
1973	37	a	27	37	a
1974	42	45	43	35	31
1975	45	41	42	34	33
1976	55	55	46	40	26[b]
1977	50	53	34	52	35
1978	50	48	35	40	23[b]
1979	51	48	43	33	33
1980	61	49[c]	53	a	33
Number of Individuals					
1973	471	a	530	1806	a
1974	837	955	1288	2104	5218
1975	1452	1065	678	2568	2242
1976	1146	1198	768	1618	530[b]
1977	931	788	388	2905	1712
1978	1792	2247	550	2692	1063[b]
1979	1382	1588	870	1714	2279
1980	1450	1622[c]	1991	a	2154

[a]Not censused.
[b]Partial census, several miles not included.
[c]Census performed using a different technique.

during winter, and 49 species were recorded during the breeding season (Table 9-12).

Seasonal changes also occurred in the total number of individuals observed. Surprisingly, the largest number of individuals (2,154) was recorded during the wildlife survey in January. Large flocks of wintering house sparrows (Passer domesticus) in residential areas and red-winged blackbirds along wet and agricultural habitats caused the high winter count. During September, 1,991 individuals were observed, the highest value recorded during this month since monitoring began in 1974. A total of 1,622 individuals was recorded in June and the smallest number of birds was noted during May when 1,450 individuals were observed (Table 9-12).

The house sparrow and red-winged blackbird were the most abundant species observed during wildlife surveys in May, June, and January. Although they were common in September, several other species were more abundant. Large flocks of rough-winged swallow (Stelgidopteryx ruficollis), Brewer's blackbird (Euphagus cyanocephalus), common grackle, and brown-headed cowbird were observed during fall wildlife surveys, and these species were the most abundant during September (Appendix I).

9.2.2.2.2 Comparison With Previous Studies

Increases from 1979 in the number of species and individuals observed were recorded for all months except January when values were equal to or below 1979 values (Tables 9-12). In addition, the total number of species observed in May (61) and September (53) and the number of individuals recorded in September (1991) were the highest yet reported. Although most values increased over 1979 and several values were the highest since monitoring began in 1974, all data were within normal ranges of variation, and no trends are indicated by data collected along the wildlife survey route. Causes for fluctuations may be weather conditions during censusing and natural population variation.

9.2.2.3. Game Species

9.2.2.3.1 Bobwhite

Bobwhite were observed in the abandoned railroad right-of-way community in May and along the wildlife survey route during May and June (Tables 9-11 and 9-13). Bobwhite were not abundant in the abandoned railroad right-of-way (1.1/hour), however, more suitable quail habitat is located in areas censused by the wildlife survey route. An average of 1.35 calls/stop was heard along the route in June. This represents a 540 percent increase over calls reported in 1979 and equals quail call data reported along the route during June 1978. Population fluctuations are probably a response to many ecological factors including weather, habitat quality, parasites, and disease. Few bobwhite were heard calling in May and only 0.08 calls/stop were reported along the route.

Data collected by the Kansas Fish and Game Commission (1981, personal communication) indicate that statewide bobwhite populations are still recovering from the severe winter of 1978-1979. Although the October 1980 statewide index was 27 percent higher than that reported in 1979, it was still 26 and 39 percent below statewide 5- and 10-year averages, respectively. Data

Table 9-13 Quail call counts along the 20-mile wildlife survey route near Wolf Creek Generating Station, Burlington, Kansas, May and June 1980.

	Number of Bobwhite Calls/2 Minute Stop			
	May		June	
Mile	5	6	17	18
1	-	-	1	-
2	-	-	-	-
3	-	-	-	-
4	-	-	5	3
5	1	-	2	4
6	1	-	1	2
7	-	-	3	4
8	-	-	-	-
9	-	-	1	-
10	-	-	2	3
11	-	-	4	2
12	-	-	1	-
13	-	-	1	1
14	-	-	-	2
15	-	-	2	1
16	-	-	-	1
17	-	-	1	2
18	-	-	2	1
19	1	-	-	2
20	-	-	-	-
Total Calls	3	0	26	28
No. Calls/stop	0.15	0.0	1.30	1.40
Avg. No. Calls/stop	0.08		1.35	

collected for the Southeast region, which includes Coffey County, indicate that 1980 quail production was good. Two indicators of reproductive success, the number of young observed per 100 miles and number of young seen per adult, increased significantly compared to 1979 indicators.

9.2.2.3.2 Mourning Dove

Mourning dove were noted in the abandoned railroad right-of-way and along the 20-mile wildlife survey route in all four sampling months during the 1980 monitoring program (Tables 9-11 and 9-14). They were an important component of the abandoned railroad right-of-way avian community and were one of the most frequently recorded species in May (5.4/hour) and the second most frequently sighted bird in September (8.1/hour). A permanent resident of the area, mourning dove were noted during January (7.1/hour), and they are more common in the breeding season than the June estimate (1.3/hour) indicated. Mourning dove were not noted in the north floodplain woods during 1980.

The number observed in June along the wildlife survey route is probably more representative of the breeding population in the area; 135 doves were observed during two surveys in June for an average of 3.38 birds/mi. The June 1980 population index is about 17 percent higher than that recorded in 1979, and the third highest reported. The May population index was 1.70/mi. Mourning doves were also observed along the survey route during September and January (Appendix I). Fluctuations in dove densities represent natural cycles in dove population as influenced by various ecological factors, and reflect variation due to the nature of the surveys.

9.2.2.4 Endangered and Threatened Species

Bald eagle (*Haliaeetus leucocephalus*) listed as federally and state endangered in Kansas, was the only rare and endangered species observed during the 1980 monitoring program. During January, one bald eagle was observed along the wildlife survey route and 32 eagles were noted near John Redmond Reservoir during two observation periods. These eagles are part of the wintering concentration that occur annually at the nearby Flint Hills National Wildlife Refuge. Bald eagles are listed as abundant in this area from December through February (USDI 1970). Filling of the WCGS cooling lake will create additional habitat for wintering bald eagles, and eagle use of the site is expected to increase.

9.2.3 Reptiles and Amphibians

A total of eight herptile species was observed during habitat searches, along the 20-mile wildlife survey route, and at John Redmond Reservoir during the 1980 monitoring program (Tables 9-4 and 9-15). Prairie kingsnake (*Lampropeltis calligaster*) was the only species recorded in 1980 that has not been previously observed (Table 9-16). Since the monitoring program began in 1974, 11 frog and toad, 6 turtle, 2 lizard, and 6 snake species have been recorded.

9.2.3.1 Community Distribution

Habitat searches were conducted in the north floodplain woods and abandoned railroad right-of-way, and herptiles were noted during wildlife surveys to

Table 9-14 Mourning Dove observations along the 20-mile wildlife survey route near Wolf Creek Generating Station, Burlington, Kansas, May and June 1980.

	Number Observed/Mile			
	May		June	
Mile	5	6	17	18
1	1	4	1	4
2	10	3	-	6
3	-	1	2	12
4	-	1	6	19
5	-	-	10	11
6	1	-	1	4
7	1	4	-	4
8	4	1	-	-
9	3	-	-	-
10	8	6	-	2
11	-	-	3	-
12	3	3	1	1
13	-	-	-	-
14	1	-	2	-
15	3	1	-	3
16	-	-	7	4
17	4	2	4	6
18	-	-	14	4
19	-	-	1	2
20	2	1	1	-
Total No. Observed	41	27	53	82
No. Observed/20 mile	2.05	1.35	2.65	4.10
Avg. No. Observed/20 mile	1.70		3.38	

Table 9-15 Herpetofauna observed near Wolf Creek Generating Station, Burlington, Kansas, May 1980 - January 1981.

Common Name	Scientific Name	Months Observed			
		May	June	September	January
Blanchard's cricket frog	*Acris crepitans*	X	-	-	-
American toad	*Bufo americanus*	X	-	-	-
Bullfrog	*Rana catesbeiana*	-	-	X	-
Snapping turtle	*Chelydra serpentina*	-	X	-	-
Ornate box turtle	*Terrapene ornata*	-	X	X	-
Eastern yellowbelly racer	*Coluber constrictor*	X	-	-	-
Prairie kingsnake	*Lampropeltis calligaster*	-	-	X	-
Western massasauga	*Sistrurus catenatus*	-	X	-	-

Table 9-16 Herpetofauna observations near Wolf Creek Generating Station, Burlington, Kansas, 1974-1980.

Common Name	Scientific Name	Locations[a] and Year						
		1974	1975	1976	1977	1978	1979	1980
Blanchard's cricket frog	Acris crepitans	-	-	-	4	4,7	4	4
American toad	Bufo americanus	-	-	1	1,4,7	1,4	-	4
Great Plains toad	Bufo cognatus	1	-	-	-	-	-	-
Woodhouse's toad	Bufo woodhousei	-	-	4,7	4,7	4,7	-	-
Gray treefrog	Hyla versicolor	-	-	4	-	-	-	-
Western chorus frog	Pseudacris triseriata	-	5	4,7	4,7	4	-	-
Crawfish frog	Rana areolata	-	-	7	-	-	-	-
Rio Grande leopard frog	Rana berlandieri	1	-	-	-	-	-	-
Plains leopard frog	Rana blairi	-	-	-	-	-	2	-
Leopard frog	Rana sp.	-	5,6	1,7	-	-	-	-
Bullfrog	Rana catesbeiana	-	1	7	7	1,7	-	1
Snapping turtle	Chelydra serpentina	4	-	-	4	-	4	4
Western painted turtle	Chrysemys picta	-	-	4,7	7	-	-	-
Map turtle	Graptemys geographica	-	6	7	7	-	-	-
False map turtle	Graptemys pseudogeographica	-	6	-	-	-	-	-
Ornate box turtle	Terrapene ornata	2,3,4	2,3,4	2,4	2,4	2,7	2,4	2,4
Western spiny softshell	Trionyx spiniferus	-	6	-	-	-	-	-
Six-lined racerunner	Cnemidophorus sexlineatus	-	-	-	-	2	-	-
Eastern glass lizard	Ophisaurus ventralis	-	-	2	-	-	-	-
Eastern yellowbelly racer	Coluber constrictor	4	-	7	-	-	-	2
Black rat snake	Elaphe obsoleta	4	-	4	4	-	-	-
Prairie kingsnake	Lampropeltis calligaster	-	-	-	-	-	-	7
Bullsnake	Pituophis melanoleucus	-	-	-	7	-	-	-
Western massasauga	Sistrurus catenatus	-	-	2	-	-	-	2
Red-sided garter snake	Thamnophis sirtalis	-	-	-	1	-	-	-

[a]Locations:
1 - North floodplain woods
2 - Abandoned railroad right-of-way
3 - Mixed shrub-grass pasture (discontinued after 1975)
4 - 20-mile wildlife survey route
5 - Wolf Creek (1976 only)
6 - Neosha River (1976 only)
7 - John Redmond Reservoir (1976 - present)

qualitatively assess herpetofauna distribution, abundance, and community composition.

Five species noted during 1980, American toad (Bufo americanus), bullfrog (Rana catesbeiana), eastern yellowbelly racer (Coluber constrictor), prairie kingsnake, and western massasauga (Sistrurus catanatus) were not noted during the previous year. Only one species, plains leopard frog (Rana blairi), was observed during the 1979 study but not during the 1980 monitoring program.

The bullfrog was the only species observed in the north floodplain woods; many were noted during September. A higher species richness was observed in the abandoned railroad right-of-way where three species were sighted. The only species observed during May was eastern yellowbelly racer. Western massasauga and ornate box turtle (Terrapene ornata) were sighted in June and September.

A total of four herpetofaunal species was recorded along the wildlife survey route during May, June, and September; typically, herptile species were not noted in January (Table 9-4). Frog and toad activity was observed only during May along the wildlife survey route; choruses of Blanchard's cricket frog (Acris crepitans) and American toad were heard. Turtles were the only reptiles noted during wildlife surveys; one snapping (Chelydra serpentina) and two ornate box turtles were observed in June. Box turtle was also recorded during September. Prairie kingsnake, observed in September, was the only species noted at John Redmond Reservoir.

9.2.3.2 Endangered and Threatened Species

No herptile species listed as endangered or threatened (Kansas Fish and Game Commission 1978; USDI 1979) were observed near WCGS during the 1980 monitoring program.

9.2.4 Relationship Between Wildlife and the Environment

9.2.4.1 Mammals

Mammalian distribution is dependent upon a complex set of variables. Two of these, habitat and food availability, are an expression of vegetation structure determined by abiotic components. Mammals interact with their environment in a complex manner and subtle changes can affect their populations. Small mammal sampling in grassland habitats has indicated cyclic population trends from 1974 through 1979; the trend did not continue in 1980. The numbers of individuals and species captured have shown decreases and increases in alternate years (Table 9-3). Possible factors influencing these fluctuations include: (1) land-use changes affecting the sampling community, (2) drought conditions in the summer of 1974, (3) return of more favorable conditions in 1976 and 1978 compared to 1974, (4) weather conditions at the time of trapping, (5) higher mortality rate as a result of severe winter conditions in 1977 and 1978, and (6) naturally occurring population cycles.

Small mammal captures in woodland habitats also indicated cyclic patterns although these were not as sharply defined as those noted in grasslands. Similar variables probably affect both communities.

Larger mammals observed near WCGS did not exhibit cyclic population trends. Mammal populations (especially woodland species) probably have decreased because of the large acreage of forested area that has been cut, although the nature of our sampling cannot confirm this decrease. Generally, species were observed in their preferred habitat types near WCGS. Deer, squirrels, and woodrats were noted in wooded areas; muskrat in aquatic habitat; and the opossum and raccoon in woodlands near water. Coyote and fox species associated with open woodlands (i.e., tree islands surrounded by grassland, brushland, agriculture, or early successional habitats) also were observed. Eastern cottontail often were noted in brushy or edge areas, especially along the wildlife survey route.

9.2.4.2 Avifauna

Avian relationships with the environment parallel those described for mammals; vegetative cover and structure and food availability usually determine bird distribution and abundance. Avifauna can be divided into four groups reflecting their vegetative and habitat preference: woodland and forest, grassland, xeric shrub, and limnic species (Johnston 1964). Representatives of three groups can be found near WCGS, reflecting the variety of habitat types in the area. Species with woodland habitat affiliations found near WCGS include yellow-billed cuckoo, barred owl, common flicker, eastern kingbird, and wood thrush. Grassland species near WCGS include bobwhite, horned lark, eastern and western meadowlarks, dickcissel, and grasshopper sparrow. Species with limnic habitat association are those that require aquatic areas. Limnic species were noticed along Wolf Creek, John Redmond Reservoir, and Flint Hills National Wildlife Refuge and include great blue heron, Canada goose, mallard, blue-winged teal, spotted sandpiper, and red-winged blackbird. Species with xeric shrub habitat affiliations were not observed during the 1980 program.

Data on bird abundance collected in 1980 indicate the variability in species numbers and populations expected from seasonal influences. Annual variations observed from 1974 through 1980 were probably caused by many factors including weather, disease, land-use changes, and normal population fluctuations.

9.2.4.3 Herpetofauna

Reptiles and amphibians have more specific habitat requirements than mammals and birds, and they are often more narrowly distributed. Being exotherms, they can not internally regulate their body temperature and therefore are more sensitive to weather variables.

Reptiles and amphibians use many aspects of their habitat. Snakes use rock fissures, ant hills, and burrows for denning areas during winter. Snake denning sites have been known to be used annually. During winter, turtles usually hibernate in areas around springs and river inlets while frogs and salamanders use places of continued water flow, usually behind logs and rocks. Ponds provide essential aquatic areas for amphibians to breed, and

aquatic turtles need suitable shoreline nesting habitat. Vegetation also is important for herptiles because it shades the forest floor creating a favorable moisture regime that permits amphibians and reptiles to breed and forage (Pentecost and Vogt 1976).

Although herptile species are not as easily observed nor as studied as other taxa, sufficient life history information has been collected to determine their role in the biotic community and to assess environmental impacts upon their populations. Herpetofaunal tolerances to environmental stress and impacts are species specific and are a function of many factors including the species' degree of specialization, niche requirements, and morphology.

Several species occurring in habitat near WCGS and relatively tolerant to environmental disturbance (e.g., urbanization, pesticide use, forest clearings, and water pollution) are American toad, garter snake, snapping turtle, painted turtle, and chorus frog. Other species found near WCGS such as cricket frog are more sensitive and less tolerant of disturbance.

9.2.5 Construction Impacts

9.2.5.1 Sampling Communities

The sampling communities were not located within construction zones or areas of land disturbance; therefore, no impact was observed on smaller, short-ranging faunal species occurring in the north floodplain woods and abandoned railroad right-of-way communities. Larger and more mobile species may have altered their ranges or activities to avoid construction in the vicinity of WCGS. Data collected during community surveys and along the wildlife survey route indicated no meaningful changes in wildlife populations compared to previous monitoring studies.

9.2.5.2 Site

Wildlife populations in the vicinity of WCGS were undoubtedly affected by construction-related activities in 1980. Direct disturbance at the plant site and dam construction area have either destroyed or displaced species formerly inhabiting these areas. Because of their mobility, larger mammals and birds probably were displaced and smaller mammals and herpetofauna probably were destroyed. Temporarily disturbed habitats include gravel pits, quarries, borrow excavations, roadsides, and spoil areas. Most of these areas should eventually revegetate, or become aquatic habitat, and thus again provide natural habitats for wildlife species.

The loss of approximately 110 acres of riparian woodland along Wolf Creek during 1980 will probably have a greater relative effect on local wildlife populations than the destruction of cropland, pasture, or rangeland. Forested habitat is of limited extent on the site and generally supports a more diverse fauna. Forest dwelling species such as deer, squirrel, opossum, and white-footed mouse will be displaced or destroyed. Prior to inundation, wildlife species will forage on readily accessible new plant growth in the clear cut areas.

The greatest impact on terrestrial wildlife will occur when the cooling lake is completely filled. Inundated areas will be transformed to aquatic habitats and a significant change in species composition will occur. Waterfowl, waterbirds, aquatic mammals, and herptiles should become relatively more common and the species composition will probably be similar to that found near John Redmond Reservoir.

9.3 SUMMARY AND CONCLUSIONS

Habitat near WCGS supports low to moderate mammal densities. During live-trapping in the north floodplain woods and abandoned railroad right-of-way communities, only the white-footed mouse was captured. Density estimates for this species were 8.0/ha in the north floodplain woods and only 0.9/ha in the abandoned railroad right-of-way. Small mammal populations decreased from 1979 in the north floodplain woods and remained relatively unchanged in the abandoned railroad right-of-way. Cyclic population trends have been observed in both communities during the period 1975-1979. The cyclic trend did not continue in 1980, probably because of severe weather conditions. Eastern cottontails were not abundant near WCGS, however, cottontail densities along the wildlife survey route during June 1980 were 100 percent higher than in 1979 and approximately 25 percent higher than the 1974-1979 average. Nine large mammal species were observed during terrestrial wildlife studies. Fox squirrel, fox, raccoon, and white-tailed deer were observed in the north floodplain woods. Coyote was the only large mammal noted in the abandoned railroad right-of-way. Six species including eastern cottontail, opossum, eastern woodrat, fox squirrel, coyote, and long-tailed weasel were recorded along the 20-mile wildlife survey route. Four mammals, eastern woodrat, fox, long-tailed weasel, and muskrat were recorded for the first time dueing monitoring studies near WCGS.

Habitat near WCGS supports moderate avian densities and diversity. A total of 98 avian species was recorded during the 1980 monitoring study compared with 83 (1974) to 99 (1976) species reported in previous years. Sixty-five species were recorded at John Redmond Reservoir. Twenty-seven avian species were observed in the north floodplain woods and 28 in the abandoned railroad right-of-way. Total number of avian species, number observed per hour, and BSD were higher for all months in the north floodplain woods than in the abandoned railroad right-of-way except for birds per hour in January.

Eighty-two avian species were observed along the wildlife survey route during the 1980 monitoring study. The total number of avian species observed per month along the route was higher than 1979 except in January when the same number of species was recorded. Similarly, the total number of individuals observed per month along the wildlife survey route was higher in 1980 than 1979 for all months except January.

Two important gamebird species, bobwhite and mourning dove, were quantitatively censused during the 1980 monitoring program. Bobwhite populations increased from 1979, and 1.35 calls/stop were recorded during June. Data collected by the Kansas Game and Fish Commission also indicated that bobwhite populations

have increased in the area and indicators of reproductive success increased significantly from 1979 indicators. Mourning dove are abundant near WCGS and the 1980 population levels have increased from 1979.

Herpetofana were qualitatively censused at WCGS. Eight species were observed during the 1980 monitoring study; Blanchard's cricket frog, American toad, bullfrog, snapping turtle, ornate box turtle, eastern yellowbelly racer, prairie kingsnake, and western massasauga. One new species for the monitoring study, prairie kingsnake, was observed.

Bald Eagle, listed as federally endangered, was the only endangered or threatened species observed during the 1980 monitoring program. Eagle use near the site is expected to increase as wintering habitat is created by the WCGS cooling lake.

No construction-related effects on wildlife populations were discernible from data collected to date and no meaningful changes in wildlife species composition or abundance have been observed. Undoubtedly, many large wildlife species (especially woodland residents) were directly displaced from the area, and small species destroyed when large acreages of forested habitat were clear-cut for the cooling lake. Species that formerly inhabited the cut-over region have probably moved into suitable habitat nearby and their populations decreased as competition for limited resources intensified. Eventually stable and probably reduced populations will occur as a new equilibrium between wildlife and available habitat is reached.

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APPENDICES FOR CONSTRUCTION ENVIRONMENTAL MONITORING PROGRAM FOR WOLF CREEK GENERATING STATION, 1980-1981

APPENDIX A

WATER CHEMISTRY

Table A-1 Water chemistry and bacteriology methods.

Parameter	Method	Preservation Technique	Reference	Detection Limit
Alkalinity, total	Method 102	Refrigeration	A.P.H.A. et al. 1976	1 mg/l-$CaCO_3$
Ammonia	Gas diffusion electrode	H_2SO_4, refrigeration	Thomas and Booth 1973; Howe and Holley 1969	0.01 mg/l-N
	Method 132C	H_2SO_4, refrigeration	A.P.H.A. et al. 1976; Howe and Holley 1969	0.01 mg/l-N
	Autoanalyzer colorimetric phenate method	H_2SO_4, refrigeration	U.S.E.P.A., 1979 Howe and Holley 1969	0.01 mg/l-N
Bacteria, fecal coliform	Method 408B	$Na_2S_2O_3$, sterile bottle, refrigeration	A.P.H.A. et al. 1976	0 organisms/ 100 ml
Bacteria, fecal streptococci	Method 409B	$Na_2S_2O_3$, sterile bottle, refrigeration	A.P.H.A. et al. 1976	0 organisms/ 100 ml
	Delayed incubation method	$Na_2S_2O_3$, sterile bottle, refrigeration	Millipore Corp. 1973	0 organisms/ 100 ml
Biochemical oxygen demand (5-day)	Method 219	Refrigeration	A.P.H.A. et al. 1976	0.5 mg/l
Calcium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	2ug/l
Chloride	Method 112B	None required	A.P.H.A. et al. 1976	0.5 mg/l
	Autoanalyzer	None required	U.S.E.P.A. 1979	0.1 mg/l
Chemical oxygen demand	Low level method	Refrigeration	U.S.E.P.A. 1979	0.1 mg/l
Color, true	Method 118	None required	A.P.H.A. et al. 1976	1 unit
Conductance, specific	Method 154	None required	A.P.H.A. et al. 1976	1 μmho/cm
Copper	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.01 mg/l
	Atomic absorption chelation	HNO_3	Fishman and Midgett 1968	0.1 μg/l
	Atomic absorption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	0.2 μg/l
Hardness (EDTA)	Method 309B	HNO_3	A.P.H.A. et al. 1976	1 mg/l-$CaCO_3$
Hexane soluble	Soxhlet extraction	H_2SO_4 refrigeration	U.S.E.P.A. 1979	0.1 mg/l

Table A-1 (continued)

Parameter	Method	Preservation Technique	Reference	Detection Limit
Iron	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.03 mg/l
	Atomic absorption chelation	HNO_3	Fishman and Midgett 1968	1 μg/l
	Atomic absorption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	0.5 μg/l
Lead	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.1 μm/l
	Atomic absorption chelation	HNO_3	Fishman and Midgett 1968	1 μg/l
	Atomic absorption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	1 μg/l
Magnesium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1972a	1 μg/l
Manganese	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.01 mg/l
Mercury	Flameless atomic absorption	HNO_3	U.S.E.P.A. 1979	0.05 μg/l
Nitrate	Method 213C	H_2SO_4, refrigeration	A.P.H.A. et al. 1976; Howe and Holley 1969	0.01 mg/l-N
	Autoanalyzer cadmium reduction	H_2SO_4, refrigeration	U.S.E.P.A. 1979; Howe and Holley 1969	0.01 mg/l-N
Nitrite	Method II.6.	H_2SO_4 refrigeration	Strickland and Parsons 1972; Howe and Holley 1969	0.1 μg/l-N
Organic carbon, total	Method 138A	HCl, refrigeration	A.P.H.A. et al. 1976; Ocean, Int. Corp. (1974)a,b	1 mg/l
	Ocean. Int. Analyzer wet oxidation	HCl, refrigeration	Ocean. Inter. Corp. (1974)b	0.2 mg/l
Organic nitrogen, total	Methods 135 then 132C	H_2SO_4, refrigeration	A.P.H.A. et al. 1976; Howe and Holley 1969	0.01 mg/l
Orthophosphate, soluble	Method II.1.	Filtration, refrigeration	Strickland and Parsons 1972; Ryden et al. 1972	1 μg/l-P
Oxygen dissolved	Method 218B	Measured in the field	A.P.H.A. et al. 1976	0.1 mg/l
Oxygen, saturation	Calculated method 218B	-	A.P.H.A. et al. 1976	Expressed as percent

Table A-1 (continued)

Parameter	Method	Preservation Technique	Reference	Detection Limit
pH	Method 144A	Measured in the field	A.P.H.A. et al. 1976	0.1 pH
Phosphorus, total	Method 223C then method II.1.	None required	A.P.H.A. et al. 1976; Strickland and Parsons 1972	1 µg/l-P
Potassium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	5 µg/l
Residue, filtrable (total dissolved solids)	Method 148B	None required	A.P.H.A. et al. 1976	2 mg/l
Residue, nonfiltrable (total suspended solids)	Method 148C	None required	A.P.H.A. et al. 1976	1 mg/l
Selenium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	1 mg/l
	Atomic absorption H_2Se	HNO_3	Perkin-Elmer Corp. 1972b	1 µg/l
	Atomic absorption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	1 µg/l
Silica, soluble	Method 151C	Filtration	A.P.H.A. et al. 1976	0.01 mg/l-SiO_2
	Autoanalyzer method 105-71W	Filtration	Technicon Industrial Systems 1974	0.01 mg/l-SiO_2
Sodium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	2 µg/l
Sulfate	Method 156C	None required	A.P.H.A. et al. 1976	5 mg/l
	Autoanalyzer method 118-71 W	None required	Technicon Industrial System 1974	1 mg/l
Temperature	Whitney Thermometer, method 162	Measured *in situ*	A.P.H.A. et al. 1976	0.1 C
Turbidity	Hach Turbidimeter, method 163A	None required	A.P.H.A. et al. 1976	0.1 N.T.U.
Zinc	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.01 mg/l
	Atomic absorption chelation	HNO_3	Fishman and Midgett 1968	1 µg/l
	Atomic absorption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	0.1 µg/l

Table A-1 (continued) REFERENCES

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Table A-2 Meteorological data collected during field sampling near WCGS, February to December 1980.

Date	Time	Wind Speed (mph)	Wind Direction	Dry Bulb (°F)	Wet Bulb (°F)	Relative Humidity (%)	Cloud Cover (%)
15 Apr	8:40	-	-	41	31	24	0
17 Jun	7:45	6-8	E	65	60	75	50
28 Oct	8:20	10-15	NW	30	29	89	80
16 Dec	8:00	3-5	NW	45	39	57	0

Table A-3 Summary of surface water quality data collected near Wolf Creek Generating Station, April 1980 through December 1980.

Parameter	Sampling Date	Replicate	Location 1	10	4	7	3
Alkalinity, total (mg/l $CaCO_3$)	14 Apr	A	127	130	128	148	121
		B	128	130	128	148	121
	17 Jun	A	183	185	185	215	204
		B	183	186	183	216	207
	28 Oct	A	140	145	143	82	60
		B	145	145	145	85	58
	16 Dec	A	150	149	150	90	125
		B	150	147	148	92	122
Calcium, total (mg/l)	15 Apr	A	51	52	55	68	54
		B	51	51	54	69	54
	17 Jun	A	60	56	69	75	64
		B	54	55	59	73	61
	28 Oct	A	60	57	59	26	58
		B	61	57	59	25	58
	16 Dec	A	102	112	80	42	112
		B	109	112	104	53	125
Chloride (mg/l)	14 Apr	A	12.0	7.7	7.7	6.4	25.0
		B	9.3	7.5	7.7	6.6	5.0
	17 Jun	A	18.0	18.0	19.0	16.0	8.8
		B	19.0	19.0	19.0	10.0	7.7
	28 Oct	A	30.0	26.0	27.0	3.5	4.5
		B	30.0	27.0	28.0	3.0	4.0
	16 Dec	A	32	34	30	5	17
		B	32	30	30	5	17
Color, true (units)	15 Apr	A	44	40	38	27	44
		B	45	40	37	27	46
	17 Jun	A	13	11	11	21	17
		B	13	11	11	21	19
	28 Oct	A	13	11	10	61	13
		B	12	11	10	62	13
	16 Dec	A	-	-	-	-	-
		B	-	-	-	-	-
Specific conductance (µmhos/cm)	15 Apr	A	340	360	350	450	350
		B	340	350	350	450	350
	16 Jun	A	550	540	560	610	540
		B	550	540	540	600	540
	28 Oct	A	530	530	540	215	480
		B	530	530	540	215	480
	16 Dec	A	-	-	-	-	-
		B	-	-	-	-	-

Table A-3 (continued)

Parameter	Sampling Date	Replicate	Location 1	10	4	7	3
Iron, soluble (μg/l)	15 Apr	A	65	59	65	35	100
		B	68	61	62	30	110
	17 Jun	A	51	43	30	48	52
		B	35	36	32	39	50
	28 Oct	A	100	100	200	600	100
		B	<100	500	100	700	100
	16 Dec	A	<200	300	<200	1000	500
		B	<200	300	900	900	300
Iron, total (mg/l)	15 Apr	A	2.5	2.2	2.3	0.87	3.7
		B	2.5	2.3	2.4	0.86	4.1
	17 Jun	A	2.0	0.87	0.92	0.97	2.1
		B	2.1	0.90	0.86	1.1	2.4
	28 Oct	A	0.73	0.27	0.37	2.4	0.91
		B	0.93	0.26	0.31	2.3	0.93
	16 Dec	A	1.3	0.3	0.3	2.5	2.0
		B	3.0	0.3	0.3	2.5	2.0
Magnesium, total (mg/l)	15 Apr	A	9.5	9.9	9.9	11.0	8.4
		B	9.7	9.6	10.0	12.0	8.5
	17 Jun	A	20.0	20.0	20.0	17.0	15.0
		B	20.0	20.0	20.0	17.0	15.0
	28 Oct	A	18.0	17.0	17.0	6.3	18.0
		B	18.0	17.0	18.0	6.0	18.0
	16 Dec	A	42.9	38.7	37.2	12.3	39.3
		B	41.1	38.0	40.5	12.0	37.5
Dissolved oxygen (mg/l)	15 Apr	A	12.0	11.2	12.1	11.3	11.0
		B	11.9	11.3	11.9	11.5	10.9
	17 Jun	A	7.4	5.6	-	4.3	4.6
		B	7.6	5.8	5.3	4.2	4.9
	28 Oct	A	13.8	10.8	10.6	5.8	11.1
		B	13.7	10.6	10.5	5.6	11.2
	16 Dec	A	12.1	12.2	12.3	1.0	4.6
		B	12.2	12.4	12.3	1.0	4.7
Manganese, total (mg/l)	15 Apr	A	0.050	0.063	0.073	0.100	0.210
		B	0.058	0.070	0.066	0.100	0.230
	17 Jun	A	0.170	0.150	0.150	0.190	0.800
		B	0.190	0.160	0.150	0.210	0.820
	28 Oct	A	0.120	0.100	0.100	1.400	0.120
		B	0.130	0.100	0.100	1.500	0.130
	16 Dec	A	0.090	0.120	0.080	2.100	0.570
		B	0.090	0.050	0.080	2.100	0.540

Table A-3 (continued)

Parameter	Sampling Date	Replicate	Location 1	10	4	7	3
pH (units)	14 Apr	A	6.9	7.8	8.0	7.2	7.3
		B	6.8	7.8	7.8	7.4	7.2
	17 Jun	A	8.6	8.1	8.2	8.3	8.3
		B	8.5	8.2	8.1	8.2	8.1
	28 Oct	A	7.5	7.3	7.0	7.7	6.5
		B	7.5	7.2	7.1	7.6	6.6
	16 Dec	A	7.9	8.3	8.3	6.8	7.1
		B	7.8	8.2	8.3	6.9	7.1
Potassium, total (mg/l)	15 Apr	A	4.0	3.7	4.2	2.5	3.0
		B	4.1	3.6	3.2	3.1	3.1
	17 Jun	A	4.1	3.8	3.9	6.1	3.7
		B	4.1	3.8	3.8	6.1	3.7
	28 Oct	A	4.3	4.3	4.1	8.3	2.5
		B	4.3	4.2	4.2	8.4	2.5
	16 Dec	A	10.2	9.6	5.2	8.5	3.3
		B	7.5	5.2	5.2	7.9	3.9
Residue, filtrable (mg/l)	14 Apr	A	266	250	270	300	282
		B	258	250	260	312	280
	17 Jun	A	324	296	316	340	318
		B	312	309	311	344	316
	27 Oct	A	306	284	290	126	282
		B	316	300	298	152	298
	16 Dec	A	340	342	354	183	353
		B	355	381	359	205	387
Residue, nonfiltrable (mg/l)	15 Apr	A	228	57	58	21	90
		B	55	53	58	23	91
	17 Jun	A	61	19	10	5	53
		B	47	12	16	21	42
	28 Oct	A	20	6	<1	28	20
		B	30	16	14	42	24
	16 Dec	A	39	17	19	40	30
		B	37	14	17	41	29
Sodium, total (mg/l)	15 Apr	A	14	14	15	20	16
		B	14	15	15	19	16
	17 Jun	A	19	19	19	21	19
		B	19	19	19	21	19
	28 Oct	A	25.0	24.0	24.0	5.7	9.4
		B	26.0	23.0	24.0	5.7	9.4
	16 Dec	A	28.7	25.7	3.0	1.3	19.6
		B	24.8	30.3	7.0	3.9	19.4

Table A-3 (continued)

Parameter	Sampling Date	Replicate	Location 1	10	4	7	3
Sulfate (mg/l)	14 Apr	A	38	39	53	75	41
		B	42	28	39	78	45
	17 Jun	A	80	60	68	62	72
		B	80	62	68	61	73
	28 Oct	A	75	91	97	32	185
		B	87	99	98	32	177
	16 Dec	A	86	88	82	20	107
		B	71	83	75	21	104
Temperature (C)	14 Apr	A	9.4	9.4	9.4	9.4	9.4
		B					
	17 Jun	A	23.0	23.5	23.0	19.5	20.0
		B					
	28 Oct	A	8.0	8.0	8.0	8.0	8.0
		B					
	16 Dec	A	4.5	4.6	4.5	4.5	4.5
		B					
Turbidity (N.T.U.)	14 Apr	A	56	52	54	19	88
		B	54	54	52	19	92
	17 Jun	A	41	21	18	20	50
		B	40	16	23	27	52
	28 Oct	A	30	10	12	32	34
		B	30	10	13	31	34
	16 Dec	A	20	15	17	20	33
		B	21	16	16	20	35
Ammonia (mg/l-N)	14 Apr	A	<0.01	0.12	<0.01	<0.01	<0.01
		B	<0.01	<0.01	0.06	<0.01	<0.01
	17 Jun	A	0.10	0.03	0.02	0.15	0.08
		B	0.10	0.03	0.02	0.15	0.08
	28 Oct	A	0.16	0.13	0.15	0.02	0.02
		B	0.05	0.05	0.03	0.10	0.02
	16 Dec	A	0.22	0.07	0.20	0.09	0.10
		B	0.18	0.19	0.19	0.10	0.14
Nitrate (mg/l-N)	14 Apr	A	3.4	1.4	1.8	0.26	16.0
		B	2.3	1.7	1.5	0.39	4.0
	17 Jun	A	0.25	0.39	0.28	0.23	0.24
		B	0.31	0.36	0.34	0.20	0.16
	28 Oct	A	0.04	0.31	0.42	<0.01	0.35
		B	0.04	0.24	0.24	<0.01	0.36
	16 Dec	A	<0.005	0.06	0.08	0.01	0.64
		B	0.085	0.06	0.59	0.14	0.10

Table A-3 (continued)

Parameter	Sampling Date	Replicate	Location 1	10	4	7	3
Nitrite (mg/l-N)	14 Apr	A	0.032	0.027	0.028	0.007	0.030
		B	0.031	0.028	0.030	0.007	0.030
	17 Jun	A	0.088	0.021	0.019	0.030	0.012
		B	0.085	0.022	0.018	0.032	0.010
	28 Oct	A	0.007	0.017	0.007	<0.001	0.007
		B	<0.001	0.007	<0.001	<0.001	0.007
	16 Dec	A	0.014	0.003	0.003	0.006	0.018
		B	0.005	0.003	0.016	0.013	0.005
Organic Nitrogen, total (mg/l)	14 Apr	A	1.5	0.28	0.58	0.44	0.37
		B	0.60	0.30	0.34	0.30	0.40
	17 Jun	A	0.28	0.31	0.31	0.32	0.36
		B	0.41	0.27	0.34	0.40	0.36
	28 Oct	A	0.84	0.70	0.66	1.48	0.35
		B	1.05	0.63	0.88	1.40	0.65
	16 Dec	A	0.78	0.44	0.34	0.65	0.79
		B	0.59	0.53	0.74	0.86	0.62
Orthophosphate, soluble (μg/l-P)	15 Apr	A	78	92	81	<1	13
		B	71	78	77	12	28
	17 Jun	A	4	28	190	13	7
		B	48	35	7	35	6
	28 Oct	A	53	100	140	120	3
		B	72	110	130	96	2
	16 Dec	A	375	358	244	212	260
		B	42	180	228	228	244
Phosphorus, total (μg/l-P)	15 Apr	A	160	160	150	39	160
		B	160	87	74	44	130
	17 Jun	A	180	95	100	66	110
		B	150	97	100	73	120
	28 Oct	A	120	170	200	350	98
		B	120	150	190	350	100
	16 Dec	A	1576	243	437	245	481
		B	401	437	511	1769	437
Silica, soluble (mg/l-SiO_2)	14 Apr	A	3.8	3.6	3.6	3.5	-
		B	3.9	3.5	3.6	3.6	3.9
	17 Jun	A	0.62	1.3	1.7	5.9	9.9
		B	0.74	1.1	0.78	2.7	11
	28 Oct	A	0.52	0.41	0.39	2.2	1.2
		B	0.30	0.44	0.34	2.2	1.1
	16 Dec	A	0.58	0.23	0.25	3.7	3.9
		B	0.42	0.17	0.14	3.6	3.8

Table A-3 (continued)

Parameter	Sampling Date	Replicate	Location 1	10	4	7	3
Biochemical Oxygen Demand (5-day) (mg/l)	14 Apr	A	2.2	1.8	1.1	2.2	2.9
		B	2.5	1.6	2.3	2.6	2.2
	17 Jun	A	2.4	2.3	1.9	1.4	1.2
		B	2.2	2.3	2.0	1.5	1.2
	28 Oct	A	5.4	3.8	4.4	8.7	6.4
		B	4.6	4.2	4.1	8.9	6.9
	16 Dec	A	2.8	3.6	0.8	8.2	3.6
		B	2.8	3.6	0.8	8.6	3.2
Fecal Coliform (No./100 ml)	14 Apr	A	18	240	110	18	87
		B	21	120	107	18	123
	17 Jun	A	1	>1000	620	54	66
		B	0	>1000	420	45	0
	28 Oct	A	75	650	710	310	60
		B	78	640	660	>1000	137
	16 Dec	A	0	4	0	0	0
		B	0	5	1	0	0
Fecal Streptococci (No./100 ml)	14 Apr	A	67	45	58	48	29
		B	73	50	81	42	31
	17 Jun	A	78	160	20	250	4800
		B	59	100	16	260	3600
	28 Oct	A	38	174	190	700	193
		B	35	220	183	440	193
	16 Dec	A	11	56	47	35	32
		B	11	77	24	44	63
Chemical Oxygen Demand (mg/l)	14 Apr	A	21	19	20	17	23
		B	22	20	19	19	24
	17 Jun	A	20	23	14	23	22
		B	26	13	15	32	19
	28 Oct	A	21	109	10	62	44
		B	29	32	15	44	154
	16 Dec	A	22	54	46	120	53
		B	54	44	17	112	48
Hexane Soluble Materials (mg/l)	15 Apr	A	<3	8	5	BROKEN	5
		B	BROKEN	<3	<3	<3	<3
	17 Jun	A	<3	<3	<3	BROKEN	<3
		B	BROKEN	<3	BROKEN	BROKEN	<3
	28 Oct	A	208	<3	<3	<3	101
		B	209	<3	<3	<3	60
	16 Dec	A	14	407	4.9	462	4.5
		B	23	310	<3	381	<3

Table A-3 (continued)

Parameter	Sampling Date	Replicate	Location 1	10	4	7	3
Organic Carbon, total (mg/l)	14 Apr	A	8.5	8.6	7.6	5.5	9.0
		B	8.9	9.7	8.0	5.7	9.2
	17 Jun	A	8.4	9.8	7.3	8.0	9.6
		B	8.8	9.5	7.8	8.5	9.5
	28 Oct	A	8.4	6.9	10.0	21.0	6.6
		B	4.9	4.3	10.0	22.0	9.0
	16 Dec	A	8.5	6.5	8.4	17.5	5.1
		B	8.1	5.4	7.5	11.3	4.2
Copper, total (µg/l)	15 Apr	A	8.0	7.0	12.0	6.0	12.0
		B	12.0	11.0	13.0	1.0	7.0
	17 Jun	A	9.0	2.0	3.5	2.0	11.0
		B	11.0	7.0	9.0	2.0	4.0
	28 Oct	A	2.4	1.2	1.8	6.1	3.5
		B	3.5	1.1	2.7	3.1	5.0
	16 Dec	A	11.3	1.2	2.9	7.0	3.4
		B	3.4	2.7	2.3	7.4	5.6
Lead, total (µg/l)	15 Apr	A	<1	<1	<1	<1	<1
		B	<1	<1	<1	<1	<1
	17 Jun	A	<1	<1	<1	<1	<1
		B	<1	<1	<1	<1	<1
	28 Oct	A	-	-	-	-	-
		B	-	-	-	-	-
	16 Dec	A	6.7	2.9	3.6	4.6	2.3
		B	3.8	3.5	3.2	11.8	1.2
Mercury, total (µg/l)	15 Apr	A	0.24	0.49	<0.20	<0.20	1.5
		B	1.4	20	<0.20	1.0	0.60
	17 Jun	A	<0.20	0.27	0.82	0.69	4.0
		B	<0.20	1.6	0.86	2.8	0.42
	28 Oct	A	1.0	<0.1	<0.1	<0.1	<0.1
		B	0.8	<0.1	<0.1	<0.1	<0.1
	16 Dec	A	<0.1	2.7	1.3	<0.1	<0.1
		B	<0.1	1.3	<0.1	<0.1	<0.1
Selenium, total (µg/l)	15 Apr	A	<2	<2	<2	6	<2
		B	<2	<2	<2	16	<2
	17 Jun	A	<2	<2	<2	<2	<2
		B	<2	<2	<2	<2	<2
	28 Oct	A	-	-	-	-	-
		B	-	-	-	-	-
	16 Dec	A	<1	<1	<1	<1	<1
		B	<1	<1	<1	<1	<1

Table A-3 (continued)

Parameter	Sampling Date	Replicate	Location 1	10	4	7	3
Zinc, total (µg/l)	15 Apr	A	21	9	49	10	66
		B	50	25	18	15	18
	17 Jun	A	24	96	44	22	78
		B	13	52	19	51	55
	28 Oct	A	<50	<50	<50	<50	<50
		B	<50	<50	<50	<50	<50
	12 Dec	A	70	50	180	60	60
		B	50	50	80	50	40

APPENDIX B

PHYTOPLANKTON DATA

Table B-1 Analysis of phytoplankton samples collected near Wolf Creek Generating Station, Burlington, Kansas, 15 April 1980.

Location 1

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICRO-LITERS/LITER	OCCURRENCE
BACILLARIOPHYTA						
CENTRALES						
STEPHANODISCUS ASTRAEA	1556.	2694.	2125.	41.76%	2.240	81.24%
CYCLOTELLA ATOMUS	200.	319.	259.	5.10%	0.020	0.74%
CYCLOTELLA MENEGHINIANA	80.	160.	120.	2.35%	0.041	1.50%
MELOSIRA GRANULATA	0.	20.	10.	0.20%	0.012	0.42%
TOTAL CENTRALES	1836.	3193.	2514.	49.40%	2.314	83.91%
BACILLARIOPHYTA						
PENNALES						
ASTERIONELLA FORMOSA	0.	140.	70.	1.37%	0.026	0.95%
SURIRELLA OVALIS	20.	20.	20.	0.39%	0.028	1.03%
TOTAL PENNALES	20.	160.	90.	1.76%	0.055	1.99%
TOTAL BACILLARIOPHYTA	1856.	3352.	2604.	51.17%	2.368	85.90%
CHLOROPHYTA						
NON-FILAMENTOUS						
UNIDENTIFIED COCCOID GREEN	304.	224.	264.	5.20%	0.027	0.96%
ANKISTRODESMUS FALCATUS	299.	160.	229.	4.51%	0.006	0.22%
SELENASTRUM #ESTII	219.	160.	190.	3.72%	0.005	0.18%
DICTYOSPHAERIUM PULCHELLUM	50.	160.	105.	2.06%	0.017	0.62%
TETRASTRUM STAUROGENIAEFORME	90.	60.	75.	1.47%	0.006	0.24%
CHLAMYDOMONAS SPP.	80.	60.	70.	1.37%	0.026	0.94%
OOCYSTIS PUSILLA	25.	40.	32.	0.63%	0.013	0.48%
MICRACTINIUM PUSILLUM	20.	40.	30.	0.59%	0.015	0.55%
KIRCHNERIELLA SUBSOLITARIA	20.	15.	17.	0.34%	0.002	0.06%
SCENEDESMUS QUADRICAUDA	10.	0.	5.	0.09%	< 0.001	0.03%
OOCYSTIS BORGEI	5.	0.	2.	0.05%	0.003	0.13%
TOTAL NON-FILAMENTOUS	1122.	918.	1020.	20.05%	0.122	4.42%
TOTAL CHLOROPHYTA	1122.	918.	1020.	20.05%	0.122	4.42%
CYANOPHYTA						
NON-FILAMENTOUS						
APHANOCAPSA DELICATISSIMA	808.	301.	555.	10.90%	0.009	0.34%
CHROOCOCCUS DISPERSUS	619.	244.	432.	8.47%	0.006	0.20%
MERISMOPEDIA TENUISSIMA	40.	0.	20.	0.39%	< 0.001	0.00%
TOTAL NON-FILAMENTOUS	1467.	546.	1006.	19.77%	0.015	0.55%
TOTAL CYANOPHYTA	1467.	546.	1006.	19.77%	0.015	0.55%

Table B-1 (continued)

Location 1

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCUR-RENCE	BIOVOLUME MICRO-LITERS/ LITER	OCCUR-RENCE
EUGLENOPHYTA						
PHACUS PYRUM	20.	0.	10.	0.20%	0.040	1.46%
TOTAL EUGLENOPHYTA	20.	0.	10.	0.20%	0.040	1.46%
CRYPTOPHYTA						
RHODOMONAS MINUTA	140.	319.	229.	4.51%	0.020	0.74%
CRYPTOMONAS SPP.	100.	60.	80.	1.57%	0.134	4.85%
TOTAL CRYPTOPHYTA	239.	379.	309.	6.08%	0.154	5.59%
MICROFLAGELLATES						
UNIDENTIFIED MICROFLAGELLATES	80.	200.	140.	2.74%	0.057	2.08%
TOTAL MICROFLAGELLATES	80.	200.	140.	2.74%	0.057	2.08%
TOTAL PHYTOPLANKTON	4784.	5395.	5089.	100.00%	2.757	100.00%

Table B-1 (continued)

Location 10

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
BACILLARIOPHYTA						
CENTRALES						
STEPHANODISCUS ASTRAEA	2235.	1656.	1946.	39.63%	2.051	76.16%
CYCLOTELLA ATOMUS	519.	200.	359.	7.31%	0.028	1.05%
CYCLOTELLA MENEGHINIANA	160.	140.	150.	3.05%	0.052	1.92%
MELOSIRA DISTANS	80.	0.	40.	0.81%	0.005	0.19%
TOTAL CENTRALES	2993.	1995.	2494.	50.80%	2.136	79.32%
BACILLARIOPHYTA						
PENNALES						
ASTERIONELLA FORMOSA	80.	40.	60.	1.22%	0.023	0.83%
NITZSCHIA ACICULARIS	40.	0.	20.	0.41%	0.002	0.06%
NAVICULA CRYPTOCEPHALA	20.	0.	10.	0.20%	0.004	0.14%
TOTAL PENNALES	140.	40.	90.	1.83%	0.028	1.04%
TOTAL BACILLARIOPHYTA	3133.	2035.	2584.	52.63%	2.164	80.36%
CHLOROPHYTA						
NON-FILAMENTOUS						
ANKISTRODESMUS FALCATUS	299.	200.	249.	5.08%	0.006	0.25%
SELENASTRUM WESTII	399.	95.	247.	5.03%	0.006	0.24%
UNIDENTIFIED COCCOID GREEN	324.	155.	239.	4.88%	0.024	0.89%
CHLAMYDOMONAS SPP.	80.	140.	110.	2.24%	0.041	1.52%
TETRASTRUM STAUROGENIAEFORME	100.	60.	80.	1.63%	0.007	0.26%
OOCYSTIS PUSILLA	100.	60.	80.	1.63%	0.033	1.22%
MICRACTINIUM PUSILLUM	115.	30.	72.	1.47%	0.036	1.35%
DICTYOSPHAERIUM PULCHELLUM	40.	40.	40.	0.81%	0.006	0.24%
KIRCHNERIELLA SUBSOLITARIA	45.	20.	32.	0.66%	0.003	0.12%
CRUCIGENIA QUADRATA	0.	40.	20.	0.41%	< 0.001	0.00%
SCENEDESMUS LONGUS	40.	0.	20.	0.41%	0.001	0.05%
SCENEDESMUS ABUNDANS	0.	20.	10.	0.20%	0.002	0.08%
GOLENKINIA RADIATA	20.	0.	10.	0.20%	0.004	0.14%
LAGERHEIMIA QUADRISETA	0.	20.	10.	0.20%	< 0.001	0.01%
DICTYOSPHAERIUM EHRENBERGIANUM	20.	0.	10.	0.20%	0.005	0.18%
SCENEDESMUS QUADRICAUDA	10.	0.	5.	0.10%	< 0.001	0.03%
TOTAL NON-FILAMENTOUS	1591.	878.	1235.	25.15%	0.178	6.59%
TOTAL CHLOROPHYTA	1591.	878.	1235.	25.15%	0.178	6.59%
CHRYSOPHYTA						
CHRYSOCHROMULINA SPP.	20.	0.	10.	0.20%	< 0.001	0.02%
TOTAL CHRYSOPHYTA	20.	0.	10.	0.20%	< 0.001	0.02%

Table B-1 (continued)

Location 10

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICRO-LITERS/LITER	OCCURRENCE
CYANOPHYTA NON-FILAMENTOUS						
CHROOCOCCUS DISPERSUS	374.	294.	334.	6.80%	0.004	0.16%
APHANOCAPSA DELICATISSIMA	212.	90.	151.	3.07%	0.003	0.09%
APHANOCAPSA ELACHISTA	20.	40.	30.	0.61%	0.005	0.17%
TOTAL NON-FILAMENTOUS	606.	424.	515.	10.49%	0.011	0.43%
CYANOPHYTA FILAMENTOUS						
ANABAENA SPP.	0.	35.	17.	0.36%	0.017	0.62%
TOTAL FILAMENTOUS	0.	35.	17.	0.36%	0.017	0.62%
TOTAL CYANOPHYTA	606.	459.	532.	10.84%	0.028	1.05%
EUGLENOPHYTA						
TRACHELOMONAS VOLVOCINA	20.	20.	20.	0.41%	0.032	1.20%
EUGLENA POLYMORPHA	20.	0.	10.	0.20%	0.085	3.17%
PHACUS SPP.	20.	0.	10.	0.20%	0.040	1.49%
PHACUS LEMMERMANNII	20.	0.	10.	0.20%	0.010	0.39%
TOTAL EUGLENOPHYTA	80.	20.	50.	1.02%	0.168	6.25%
CRYPTOPHYTA						
RHODOMONAS MINUTA	379.	239.	309.	6.30%	0.028	1.02%
CRYPTOMONAS SPP.	60.	20.	40.	0.81%	0.066	2.48%
CHROOMONAS SPP.	40.	0.	20.	0.41%	0.006	0.23%
TOTAL CRYPTOPHYTA	479.	259.	369.	7.51%	0.101	3.74%
MICROFLAGELLATES						
UNIDENTIFIED MICROFLAGELLATES	180.	80.	130.	2.64%	0.053	1.98%
TOTAL MICROFLAGELLATES	180.	80.	130.	2.64%	0.053	1.98%
TOTAL PHYTOPLANKTON	6088.	3731.	4910.	100.00%	2.692	100.00%

Table B-1 (continued)

Location 4

TAXA	REPLICATES UNITS PER ML. A	REPLICATES UNITS PER ML. B	MEAN OF REPLICATES UNITS PER ML.	MEAN OF REPLICATES OCCURRENCE	BIOVOLUME MICROLITERS/LITER	BIOVOLUME OCCURRENCE
BACILLARIOPHYTA						
CENTRALES						
STEPHANODISCUS ASTRAEA	2614.	1497.	2055.	40.69%	2.166	75.89%
CYCLOTELLA ATOMUS	279.	279.	279.	5.53%	0.022	0.77%
MELOSIRA AMBIGUA	200.	60.	130.	2.57%	0.064	2.26%
CYCLOTELLA MENEGHINIANA	180.	60.	120.	2.37%	0.041	1.45%
TOTAL CENTRALES	3272.	1896.	2584.	51.16%	2.294	80.38%
BACILLARIOPHYTA						
PENNALES						
NITZSCHIA ACICULARIS	0.	20.	10.	0.20%	< 0.001	0.03%
NITZSCHIA SPP.	20.	0.	10.	0.20%	< 0.001	0.00%
GOMPHONEMA PARVULUM	20.	0.	10.	0.20%	0.004	0.13%
TOTAL PENNALES	40.	20.	30.	0.59%	0.005	0.16%
TOTAL BACILLARIOPHYTA	3312.	1916.	2614.	51.75%	2.299	80.54%
CHLOROPHYTA						
NON-FILAMENTOUS						
ANKISTRODESMUS FALCATUS	459.	259.	359.	7.11%	0.009	0.34%
SELENASTRUM WESTII	205.	324.	264.	5.23%	0.006	0.24%
UNIDENTIFIED COCCOID GREEN	224.	239.	232.	4.59%	0.023	0.82%
TETRASTRUM STAUROGENIAEFORME	80.	200.	140.	2.77%	0.012	0.44%
MICRACTINIUM PUSILLUM	120.	75.	97.	1.93%	0.049	1.71%
KIRCHNERIELLA SUBSOLITARIA	65.	110.	87.	1.73%	0.008	0.30%
OOCYSTIS PUSILLA	80.	80.	80.	1.58%	0.033	1.15%
CHLAMYDOMONAS SPP.	80.	40.	60.	1.19%	0.022	0.78%
CRUCIGENIA QUADRATA	60.	0.	30.	0.59%	< 0.001	0.00%
DICTYOSPHAERIUM PULCHELLUM	0.	60.	30.	0.59%	0.005	0.17%
SCENEDESMUS QUADRICAUDA	30.	15.	22.	0.44%	0.004	0.12%
ACTINASTRUM HANTZSCHII	20.	0.	10.	0.20%	0.005	0.18%
CARTERIA CORDIFORMIS	0.	20.	10.	0.20%	0.005	0.16%
SCENEDESMUS LONGUS	20.	0.	10.	0.20%	< 0.001	0.02%
SCENEDESMUS ACUMINATUS	20.	0.	10.	0.20%	< 0.001	0.02%
TOTAL NON-FILAMENTOUS	1462.	1422.	1442.	28.54%	0.185	6.46%
TOTAL CHLOROPHYTA	1462.	1422.	1442.	28.54%	0.185	6.46%
CHRYSOPHYTA						
OCHROMONAS SPP.	0.	60.	30.	0.59%	< 0.001	0.03%
MALLOMONAS TONSURATA	0.	20.	10.	0.20%	0.006	0.20%
SYNUROPSIS GLOBOSA	5.	0.	2.	0.05%	0.007	0.26%

Table B-1 (continued)

Location 4

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
TOTAL CHRYSOPHYTA	5.	80.	42.	0.84%	0.014	0.49%
CYANOPHYTA						
NON-FILAMENTOUS						
APHANOCAPSA DELICATISSIMA	219.	140.	180.	3.56%	0.003	0.11%
CHROOCOCCUS DISPERSUS	180.	160.	170.	3.36%	0.002	0.07%
MERISMOPEDIA TENUISSIMA	0.	40.	20.	0.40%	< 0.001	0.00%
APHANOCAPSA ELACHISTA	20.	10.	15.	0.30%	0.002	0.08%
TOTAL NON-FILAMENTOUS	419.	349.	384.	7.60%	0.007	0.27%
TOTAL CYANOPHYTA	419.	349.	384.	7.60%	0.007	0.27%
EUGLENOPHYTA						
TRACHELOMONAS CREBEA	20.	0.	10.	0.20%	0.048	1.69%
TRACHELOMONAS VOLVOCINA	20.	0.	10.	0.20%	0.016	0.57%
TOTAL EUGLENOPHYTA	40.	0.	20.	0.40%	0.064	2.26%
CRYPTOPHYTA						
RHODOMONAS MINUTA	219.	339.	279.	5.53%	0.025	0.87%
CRYPTOMONAS SPP.	180.	60.	120.	2.37%	0.201	7.03%
CHROOMONAS SPP.	0.	40.	20.	0.40%	0.006	0.22%
TOTAL CRYPTOPHYTA	399.	439.	419.	8.29%	0.232	8.11%
MICROFLAGELLATES						
UNIDENTIFIED MICROFLAGELLATES	100.	160.	130.	2.57%	0.053	1.87%
TOTAL MICROFLAGELLATES	100.	160.	130.	2.57%	0.053	1.87%
TOTAL PHYTOPLANKTON	5737.	4365.	5051.	100.00%	2.854	100.00%

Table B-2 Analysis of phytoplankton samples collected near Wolf Creek Generating Station, Burlington, Kansas, 17 June 1980.

Location 1

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
BACILLARIOPHYTA						
CENTRALES						
STEPHANODISCUS ASTRAEA	2275.	1646.	1961.	18.25%	1.935	56.16%
MELOSIRA GRANULATA	808.	1018.	913.	8.50%	0.186	5.40%
CYCLOTELLA MENEGHINIANA	210.	299.	254.	2.37%	0.073	2.14%
UNIDENTIFIED CENTRICS	239.	150.	195.	1.81%	0.004	0.13%
CYCLOTELLA ATOMUS	120.	239.	180.	1.67%	0.017	0.48%
MELOSIRA DISTANS	150.	60.	105.	0.97%	0.007	0.22%
SKELETONEMA POTAMOS	0.	60.	30.	0.28%	0.002	0.06%
TOTAL CENTRALES	3801.	3472.	3637.	33.86%	2.228	64.66%
BACILLARIOPHYTA						
PENNALES						
NITZSCHIA KUTZINGIANA	90.	0.	45.	0.42%	0.005	0.15%
NAVICULA CRYPTOCEPHALA	60.	0.	30.	0.28%	0.018	0.52%
TOTAL PENNALES	150.	0.	75.	0.69%	0.023	0.67%
TOTAL BACILLARIOPHYTA	3951.	3472.	3711.	34.56%	2.251	65.34%
CHLOROPHYTA						
NON-FILAMENTOUS						
CRUCIGENIA TETRAPEDIA	1122.	441.	782.	7.28%	0.030	0.86%
UNIDENTIFIED COCCOID GREEN	681.	591.	636.	5.92%	0.172	5.00%
PEDIASTRUM DUPLEX	404.	606.	505.	4.70%	0.020	0.59%
OOCYSTIS PUSILLA	352.	307.	329.	3.07%	0.042	1.23%
DICTYOSPHAERIUM PULCHELLUM	314.	239.	277.	2.58%	0.075	2.18%
CRUCIGENIA FENESTRATA	359.	0.	180.	1.67%	0.027	0.77%
COELASTRUM MICROPORUM	105.	239.	172.	1.60%	0.019	0.55%
CRUCIGENIA QUADRATA	172.	142.	157.	1.46%	0.009	0.28%
CHLAMYDOMONAS SPP.	120.	180.	150.	1.39%	0.068	1.99%
TETRASTRUM STAUROGENIAEFORME	195.	82.	138.	1.29%	0.008	0.25%
OOCYSTIS BORGEI	75.	75.	75.	0.69%	0.145	4.20%
SELENASTRUM MINUTUM	127.	7.	67.	0.62%	0.004	0.13%
ANKISTRODESMUS FALCATUS	60.	60.	60.	0.56%	0.001	0.03%
SPHAEROCYSTIS SCHROETERI	0.	120.	60.	0.56%	0.024	0.70%
SCENEDESMUS QUADRICAUDA	0.	90.	45.	0.42%	0.006	0.19%
DICTYOSPHAERIUM EHRENBERGIANUM	60.	0.	30.	0.28%	0.008	0.23%
SELENASTRUM WESTII	22.	30.	26.	0.24%	0.001	0.04%
KIRCHNERIELLA SUBSOLITARIA	15.	37.	26.	0.24%	0.002	0.05%
MICRACTINIUM PUSILLUM	0.	30.	15.	0.14%	0.002	0.05%
LAGERHEIMIA WRATISLAWIENSIS	0.	30.	15.	0.14%	0.002	0.06%
LAGERHEIMIA QUADRISETA	0.	30.	15.	0.14%	< 0.001	0.01%
SCENEDESMUS LONGUS	30.	0.	15.	0.14%	0.001	0.04%
SCENEDESMUS BICELLULARIS	0.	15.	7.	0.07%	< 0.001	0.01%
SCENEDESMUS SPP.	0.	7.	4.	0.03%	< 0.001	0.03%

Table B-2 (continued)

Location 1

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
TOTAL NON-FILAMENTOUS	4213.	3360.	3786.	35.25%	0.671	19.48%
TOTAL CHLOROPHYTA	4213.	3360.	3786.	35.25%	0.671	19.48%
CHRYSOPHYTA						
ARACHNOCHLORIS MINOR	0.	30.	15.	0.14%	0.002	0.04%
TOTAL CHRYSOPHYTA	0.	30.	15.	0.14%	0.002	0.04%
CYANOPHYTA						
NON-FILAMENTOUS						
CHROOCOCCUS DISPERSUS	1489.	494.	991.	9.23%	0.041	1.18%
APHANOCAPSA ELACHISTA	814.	934.	874.	8.13%	0.219	6.36%
MERISMOPEDIA TENUISSIMA	374.	853.	614.	5.71%	0.002	0.05%
APHANOCAPSA DELICATISSIMA	282.	48.	165.	1.54%	0.004	0.12%
MICROCYSTIS AERUGINOSA	135.	75.	105.	0.97%	0.005	0.14%
APHANOTHECE NIDULANS	135.	30.	82.	0.76%	0.007	0.21%
UNIDENTIFIED BLUE-GREEN COCCOID SP.	15.	0.	7.	0.07%	< 0.001	0.00%
TOTAL NON-FILAMENTOUS	3244.	2433.	2839.	26.43%	0.278	8.07%
TOTAL CYANOPHYTA	3244.	2433.	2839.	26.43%	0.278	8.07%
EUGLENOPHYTA						
PHACUS SPP.	0.	30.	15.	0.14%	0.179	5.20%
TRACHELOMONAS VOLVOCINA	0.	30.	15.	0.14%	0.029	0.84%
TOTAL EUGLENOPHYTA	0.	60.	30.	0.28%	0.208	6.05%
CRYPTOPHYTA						
RHODOMONAS MINUTA	359.	120.	239.	2.23%	0.026	0.75%
TOTAL CRYPTOPHYTA	359.	120.	239.	2.23%	0.026	0.75%
MICROFLAGELLATES						
UNIDENTIFIED MICROFLAGELLATES	120.	120.	120.	1.11%	0.009	0.26%
TOTAL MICROFLAGELLATES	120.	120.	120.	1.11%	0.009	0.26%
TOTAL PHYTOPLANKTON	11886.	9594.	10740.	100.00%	3.445	100.00%

Table B-2 (continued)

Location 10

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
BACILLARIOPHYTA						
CENTRALES						
CYCLOTELLA MENEGHINIANA	1167.	1287.	1227.	12.72%	0.356	7.71%
STEPHANODISCUS ASTRAEA	1497.	748.	1122.	11.64%	1.108	24.02%
CYCLOTELLA ATOMUS	629.	688.	658.	6.82%	0.061	1.33%
UNIDENTIFIED CENTRICS	509.	569.	539.	5.58%	0.012	0.27%
STEPHANODISCUS HANTZSCHII	120.	239.	180.	1.86%	0.055	1.19%
SKELETONEMA POTAMOS	90.	210.	150.	1.55%	0.010	0.22%
MELOSIRA GRANULATA	0.	269.	135.	1.40%	0.028	0.60%
MELOSIRA DISTANS	60.	60.	60.	0.62%	0.004	0.09%
TOTAL CENTRALES	4071.	4071.	4071.	42.20%	1.634	35.44%
BACILLARIOPHYTA						
PENNALES						
NITZSCHIA KUTZINGIANA	60.	120.	90.	0.93%	0.011	0.23%
COCCONEIS PLACENTULA	60.	30.	45.	0.47%	0.036	0.78%
NAVICULA CRYPTOCEPHALA	30.	30.	30.	0.31%	0.018	0.39%
TOTAL PENNALES	150.	180.	165.	1.71%	0.064	1.41%
TOTAL BACILLARIOPHYTA	4220.	4250.	4235.	43.90%	1.699	36.84%
CHLOROPHYTA						
NON-FILAMENTOUS						
CHLAMYDOMONAS SPP.	1107.	599.	853.	8.84%	0.390	8.45%
UNIDENTIFIED COCCOID GREEN	434.	531.	483.	5.00%	0.131	2.84%
CRUCIGENIA TETRAPEDIA	494.	150.	322.	3.34%	0.012	0.27%
PEDIASTRUM DUPLEX	322.	52.	187.	1.94%	0.007	0.16%
DICTYOSPHAERIUM PULCHELLUM	120.	180.	150.	1.55%	0.041	0.87%
CRUCIGENIA QUADRATA	112.	90.	101.	1.05%	0.006	0.14%
SCENEDESMUS QUADRICAUDA	60.	135.	97.	1.01%	0.014	0.31%
OOCYSTIS PUSILLA	90.	97.	94.	0.97%	0.012	0.26%
CARTERIA CORDIFORMIS	120.	60.	90.	0.93%	0.083	1.80%
COELASTRUM MICROPORUM	82.	60.	71.	0.73%	0.007	0.17%
PEDIASTRUM TETRAS	60.	60.	60.	0.62%	0.004	0.07%
OOCYSTIS BORGEI	45.	52.	49.	0.50%	0.094	2.04%
SCENEDESMUS LONGUS	0.	90.	45.	0.47%	0.004	0.08%
SCENEDESMUS ACUMINATUS	0.	90.	45.	0.47%	0.006	0.13%
KIRCHNERIELLA SUBSOLITARIA	15.	52.	34.	0.35%	0.002	0.05%
TETRASTRUM STAUROGENIAEFORME	0.	45.	22.	0.23%	0.001	0.03%
MICRACTINIUM PUSILLUM	0.	30.	15.	0.16%	0.002	0.04%
TETRAEDRON MUTICUM	0.	30.	15.	0.16%	< 0.001	0.00%
LAGERHEIMIA QUADRISETA	0.	30.	15.	0.16%	< 0.001	0.00%
SCENEDESMUS SPP.	7.	0.	4.	0.04%	< 0.001	0.02%
TOTAL NON-FILAMENTOUS	3068.	2412.	2750.	28.51%	0.819	17.75%

Table B-2 (continued)

Location 10

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
TOTAL CHLOROPHYTA	3068.	2432.	2750.	28.51%	0.819	17.75%
CHRYSOPHYTA						
ARACHNOCHLORIS MINOR	0.	6.	3.	0.03%	< 0.001	0.00%
TOTAL CHRYSOPHYTA	0.	6.	3.	0.03%	< 0.001	0.00%
CYANOPHYTA						
NON-FILAMENTOUS						
MERISMOPEDIA TENUISSIMA	950.	748.	849.	8.80%	0.003	0.06%
CHROOCOCCUS DISPERSUS	554.	546.	550.	5.70%	0.023	0.49%
APHANOCAPSA ELACHISTA	174.	162.	168.	1.74%	0.042	0.91%
APHANOCAPSA DELICATISSIMA	57.	54.	55.	0.57%	0.001	0.03%
UNIDENTIFIED BLUE-GREEN COCCOID SP.	52.	15.	34.	0.35%	0.001	0.03%
TOTAL NON-FILAMENTOUS	1787.	1525.	1656.	17.17%	0.069	1.52%
TOTAL CYANOPHYTA	1787.	1525.	1656.	17.17%	0.069	1.52%
EUGLENOPHYTA						
EUGLENA ACUS	30.	30.	30.	0.31%	1.298	28.14%
PHACUS CAUDATUS	30.	0.	15.	0.16%	0.056	1.22%
TRACHELOMONAS VOLVOCINA	30.	0.	15.	0.16%	0.029	0.62%
PHACUS HELIKOIDES	30.	0.	15.	0.16%	0.159	3.44%
TOTAL EUGLENOPHYTA	120.	30.	75.	0.77%	1.542	33.43%
PYRRHOPHYTA						
GYMNODINIUM SPP.	0.	30.	15.	0.16%	0.015	0.32%
TOTAL PYRRHOPHYTA	0.	30.	15.	0.16%	0.015	0.32%
CRYPTOPHYTA						
CRYPTOMONAS SPP.	479.	180.	329.	3.41%	0.407	8.81%
RHODOMONAS MINUTA	359.	269.	314.	3.26%	0.034	0.74%
CHROOMONAS SPP.	30.	30.	30.	0.31%	0.008	0.18%
TOTAL CRYPTOPHYTA	868.	479.	673.	6.98%	0.449	9.74%

Table B-2 (continued)

Location 10

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
MICROFLAGELLATES						
UNIDENTIFIED MICROFLAGELLATES	210.	269.	239.	2.48%	0.018	0.39%
TOTAL MICROFLAGELLATES	210.	269.	239.	2.48%	0.018	0.39%
TOTAL PHYTOPLANKTON	10272.	9021.	9647.	100.00%	4.612	100.00%

Table B-2 (continued)

Location 4

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
BACILLARIOPHYTA						
CENTRALES						
STEPHANODISCUS ASTRAEA	1975.	2245.	2110.	15.88%	2.083	47.74%
CYCLOTELLA MENEGHINIANA	1526.	1556.	1541.	11.60%	0.447	10.25%
UNIDENTIFIED CENTRICS	1078.	1586.	1332.	10.02%	0.031	0.70%
CYCLOTELLA ATOMUS	898.	1018.	958.	7.20%	0.089	2.04%
SKELETONEMA POTAMOS	299.	299.	299.	2.25%	0.020	0.47%
MELOSIRA GRANULATA	224.	90.	157.	1.18%	0.032	0.74%
MELOSIRA DISTANS	60.	0.	30.	0.23%	0.002	0.05%
TOTAL CENTRALES	6061.	6794.	6428.	48.36%	2.704	61.98%
BACILLARIOPHYTA						
PENNALES						
NITZSCHIA KUTZINGIANA	150.	90.	120.	0.90%	0.014	0.32%
NAVICULA CRYPTOCEPHALA	60.	30.	45.	0.34%	0.027	0.62%
UNIDENTIFIED PENNATES	60.	0.	30.	0.23%	< 0.001	0.00%
NITZSCHIA LONGISSMIA	0.	30.	15.	0.11%	0.007	0.17%
TOTAL PENNALES	269.	150.	210.	1.58%	0.049	1.12%
TOTAL BACILLARIOPHYTA	6330.	6944.	6637.	49.95%	2.753	63.10%
CHLOROPHYTA						
NON-FILAMENTOUS						
UNIDENTIFIED COCCOID GREEN	793.	703.	748.	5.63%	0.203	4.65%
CHLAMYDOMONAS SPP.	629.	688.	658.	4.96%	0.301	6.89%
CRUCIGENIA TETRAPEDIA	157.	703.	430.	3.24%	0.016	0.37%
DICTYOSPHAERIUM PULCHELLUM	254.	389.	322.	2.42%	0.087	2.00%
MICRACTINIUM PUSILLUM	531.	67.	299.	2.25%	0.037	0.84%
CRUCIGENIA QUADRATA	464.	120.	292.	2.20%	0.018	0.41%
COELASTRUM MICROPORUM	419.	82.	251.	1.89%	0.028	0.63%
PEDIASTRUM DUPLEX	217.	269.	243.	1.83%	0.009	0.22%
OOCYSTIS PUSILLA	142.	172.	157.	1.18%	0.020	0.46%
SELENASTRUM WESTII	180.	15.	97.	0.73%	0.005	0.11%
OOCYSTIS BORGEI	52.	135.	94.	0.70%	0.181	4.15%
SCENEDESMUS LONGUS	60.	90.	75.	0.56%	0.006	0.14%
TETRASTRUM STAUROGENIAEFORME	30.	90.	60.	0.45%	0.004	0.08%
SPHAEROCYSTIS SCHROETERI	60.	60.	60.	0.45%	0.024	0.56%
SCENEDESMUS BIJUGA	120.	0.	60.	0.45%	0.016	0.37%
ANKISTRODESMUS FALCATUS	90.	30.	60.	0.45%	0.001	0.03%
KIRCHNERIELLA SUBSOLITARIA	37.	22.	30.	0.23%	0.002	0.05%
LAGERHEIMIA QUADRISETA	30.	30.	30.	0.23%	< 0.001	0.00%
SCENEDESMUS QUADRICAUDA	30.	30.	30.	0.23%	0.004	0.10%
GOLENKINIA RADIATA	0.	30.	15.	0.11%	0.004	0.09%
SCENEDESMUS ABUNDANS	30.	0.	15.	0.11%	0.001	0.03%
CARTERIA CORDIFORMIS	0.	30.	15.	0.11%	0.014	0.32%
SCENEDESMUS BICELLULARIS	15.	0.	7.	0.06%	< 0.001	0.01%

Table B-2 (continued)

Location 4

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
TOTAL NON-FILAMENTOUS	4340.	3756.	4048.	30.47%	0.984	22.54%
TOTAL CHLOROPHYTA	4340.	3756.	4048.	30.47%	0.984	22.54%
CHRYSOPHYTA						
TRACHYCHLORON DEPAUPERATUM	0.	30.	15.	0.11%	< 0.001	0.02%
ARACHNOCHLORIS MINOR	0.	30.	15.	0.11%	0.002	0.03%
CHLORALLANTHUS OBLONGUS	30.	0.	15.	0.11%	0.002	0.05%
TOTAL CHRYSOPHYTA	30.	60.	45.	0.34%	0.004	0.09%
CYANOPHYTA NON-FILAMENTOUS						
MERISMOPEDIA TENUISSIMA	703.	958.	831.	6.25%	0.002	0.06%
CHROOCOCCUS DISPERSUS	793.	599.	696.	5.24%	0.029	0.65%
APHANOCAPSA ELACHISTA	251.	314.	283.	2.13%	0.071	1.63%
APHANOCAPSA DELICATISSIMA	102.	45.	73.	0.55%	0.002	0.04%
TOTAL NON-FILAMENTOUS	1850.	1916.	1883.	14.17%	0.104	2.38%
TOTAL CYANOPHYTA	1850.	1916.	1883.	14.17%	0.104	2.38%
EUGLENOPHYTA						
TRACHELOMONAS VOLVOCINA	60.	30.	45.	0.34%	0.087	2.00%
PHACUS CAUDATUS	0.	60.	30.	0.23%	0.113	2.58%
PHACUS SPP.	0.	30.	15.	0.11%	0.179	4.11%
TOTAL EUGLENOPHYTA	60.	120.	90.	0.67%	0.379	8.68%
PYRRHOPHYTA						
GLENODINIUM SPP.	0.	30.	15.	0.11%	0.022	0.51%
TOTAL PYRRHOPHYTA	0.	30.	15.	0.11%	0.022	0.51%
CRYPTOPHYTA						
RHODOMONAS MINUTA	180.	180.	180.	1.35%	0.020	0.45%
CHROOMONAS SPP.	60.	90.	75.	0.56%	0.021	0.49%
CRYPTOMONAS SPP.	60.	30.	45.	0.34%	0.055	1.27%
TOTAL CRYPTOPHYTA	299.	299.	299.	2.25%	0.096	2.21%

Table B-2 (continued)

Location 4

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICRO-LITERS/LITER	OCCURRENCE
MICROFLAGELLATES						
UNIDENTIFIED MICROFLAGELLATES	269.	269.	269.	2.03%	0.020	0.47%
TOTAL MICROFLAGELLATES	269.	269.	269.	2.03%	0.020	0.47%
TOTAL PHYTOPLANKTON	13179.	13394.	13287.	100.00%	4.363	100.00%

Table B-3 Analysis of phytoplankton samples collected near Wolf Creek Generating Station, Burlington, Kansas, 23 October 1980.

Location 1

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICRO-LITERS/LITER	OCCURRENCE
BACILLARIOPHYTA						
CENTRALES						
SKELETONEMA POTAMOS	8487.	2523.	5505.	4.77%	0.308	4.61%
UNIDENTIFIED CENTRICS	4817.	2294.	3555.	3.08%	0.224	3.35%
STEPHANODISCUS MINUTUS	2523.	1835.	2179.	1.89%	0.678	10.12%
MELOSIRA DISTANS	459.	1376.	918.	0.79%	0.179	2.67%
STEPHANODISCUS ASTRAEA	918.	918.	918.	0.79%	0.717	10.71%
CYCLOTELLA MENEGHINIANA	229.	0.	115.	0.09%	0.029	0.44%
TOTAL CENTRALES	17433.	8946.	13189.	11.43%	2.135	31.89%
BACILLARIOPHYTA						
PENNALES						
NITZSCHIA THYBLIONELLA	1376.	918.	1147.	0.99%	0.801	11.96%
NITZSCHIA KUTZINGIANA	918.	918.	918.	0.79%	0.134	2.00%
NITZSCHIA HOLSATICA	918.	0.	459.	0.40%	0.067	1.01%
NITZSCHIA ACICULARIS	0.	459.	229.	0.20%	0.006	0.09%
NAVICULA CRYPTOCEPHALA	229.	229.	229.	0.20%	0.273	4.07%
NITZSCHIA LINEARIS	0.	229.	115.	0.09%	0.123	1.84%
NITZSCHIA LONGISSMIA	0.	229.	115.	0.09%	0.017	0.26%
NITZSCHIA APICULATA	0.	229.	115.	0.09%	0.071	1.07%
TOTAL PENNALES	3441.	3211.	3326.	2.88%	1.493	22.30%
TOTAL BACILLARIOPHYTA	20874.	12157.	16515.	14.31%	3.628	54.20%
CHLOROPHYTA						
NON-FILAMENTOUS						
SELENASTRUM MINUTUM	7111.	6824.	6967.	6.04%	0.237	3.54%
ANKISTRODESMUS FALCATUS	5276.	2982.	4129.	3.58%	0.078	1.17%
DICTYOSPHAERIUM EHRENBERGIANUM	459.	4358.	2408.	2.09%	0.202	3.02%
UNIDENTIFIED COCCOID GREEN	1950.	2408.	2179.	1.89%	0.135	2.02%
CRUCIGENIA CRUCIFERA	1147.	0.	573.	0.50%	0.035	0.52%
TETRASTRUM STAUROGENIAEFORME	918.	229.	573.	0.50%	0.061	0.91%
OOCYSTIS PUSILLA	516.	631.	573.	0.50%	0.084	1.26%
CHLAMYDOMONAS SPP.	459.	229.	344.	0.30%	0.075	1.13%
LAGERHEIMIA QUADRISETA	229.	459.	344.	0.30%	0.010	0.15%
SCENEDESMUS QUADRICAUDA	0.	344.	172.	0.15%	0.020	0.31%
TETRAEDRON MUTICUM	229.	0.	115.	0.09%	0.016	0.23%
MICRACTINIUM PUSILLUM	115.	0.	57.	0.05%	0.005	0.07%
KIRCHNERIELLA SUBSOLITARIA	57.	57.	57.	0.05%	0.007	0.11%
PEDIASTRUM TETRAS	0.	57.	29.	0.02%	0.008	0.13%
TOTAL NON-FILAMENTOUS	18465.	18580.	18522.	16.05%	0.976	14.58%
TOTAL CHLOROPHYTA	18465.	18580.	18522.	16.05%	0.976	14.58%

Table B-3 (continued)

Location 1

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICRO-LITERS/LITER	OCCURRENCE
CHRYSOPHYTA						
CHRYSOCHROMULINA SPP.	459.	0.	229.	0.20%	0.009	0.15%
ARACHNOCHLORIS MINOR	0.	229.	115.	0.09%	0.013	0.20%
TOTAL CHRYSOPHYTA	459.	229.	344.	0.30%	0.023	0.35%
CYANOPHYTA						
NON-FILAMENTOUS						
MERISMOPEDIA TENUISSIMA	61875.	82233.	72054.	62.43%	0.259	3.88%
APHANOCAPSA DELICATISSIMA	2064.	1491.	1778.	1.54%	0.080	1.20%
UNIDENTIFIED BLUE-GREEN COCCOID SP.	0.	1491.	745.	0.64%	0.006	0.09%
CHROOCOCCUS DISPERSUS	1376.	0.	688.	0.60%	0.015	0.23%
APHANOCAPSA ELACHISTA	229.	344.	287.	0.25%	0.044	0.65%
TOTAL NON-FILAMENTOUS	65545.	85559.	75552.	65.47%	0.404	6.04%
TOTAL CYANOPHYTA	65545.	85559.	75552.	65.47%	0.404	6.04%
EUGLENOPHYTA						
TRACHELOMONAS VOLVOCINA	459.	229.	344.	0.30%	0.469	7.01%
EUGLENA GRACILIS	0.	229.	115.	0.09%	0.150	2.24%
PHACUS PYRUM	0.	229.	115.	0.09%	0.250	3.74%
TOTAL EUGLENOPHYTA	459.	688.	573.	0.50%	0.869	12.99%
CRYPTOPHYTA						
RHODOMONAS MINUTA	5505.	2064.	3785.	3.28%	0.621	9.27%
CRYPTOMONAS SPP.	229.	0.	115.	0.09%	0.172	2.57%
TOTAL CRYPTOPHYTA	5735.	2064.	3899.	3.38%	0.793	11.84%
TOTAL PHYTOPLANKTON	111536.	119278.	115407.	100.00%	6.694	100.00%

Table B-3 (continued)

Location 10

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
BACILLARIOPHYTA						
CENTRALES						
UNIDENTIFIED CENTRICS	2064.	3670.	2867.	9.16%	0.181	6.75%
SKELETONEMA POTAMOS	688.	3670.	2179.	6.96%	0.122	4.56%
STEPHANODISCUS MINUTUS	459.	1606.	1032.	3.30%	0.321	12.00%
STEPHANODISCUS ASTRAEA	229.	229.	229.	0.73%	0.179	6.69%
CYCLOTELLA ATOMUS	229.	0.	115.	0.37%	0.022	0.83%
TOTAL CENTRALES	3670.	9175.	6423.	20.53%	0.825	30.85%
BACILLARIOPHYTA						
PENNALES						
NITZSCHIA KUTZINGIANA	0.	1147.	573.	1.83%	0.083	3.13%
NITZSCHIA LONGISSMIA	0.	229.	115.	0.37%	0.017	0.64%
TOTAL PENNALES	0.	1376.	688.	2.20%	0.101	3.78%
TOTAL BACILLARIOPHYTA	3670.	10551.	7111.	22.73%	0.926	34.63%
CHLOROPHYTA						
NON-FILAMENTOUS						
SELENASTRUM MINUTUM	1892.	3039.	2466.	7.88%	0.083	3.13%
UNIDENTIFIED COCCOID GREEN	918.	2179.	1548.	4.95%	0.096	3.59%
LAGERHEIMIA QUADRISETA	1147.	1147.	1147.	3.67%	0.033	1.24%
ANKISTRODESMUS FALCATUS	459.	1835.	1147.	3.67%	0.022	0.81%
CHLAMYDOMONAS SPP.	459.	459.	459.	1.47%	0.100	3.76%
OOCYSTIS PUSILLA	287.	229.	258.	0.82%	0.038	1.42%
SCENEDESMUS QUADRICAUDA	115.	344.	229.	0.73%	0.027	1.02%
KIRCHNERIELLA SUBSOLITARIA	172.	57.	115.	0.37%	0.015	0.56%
SCENEDESMUS LONGUS	0.	229.	115.	0.37%	0.003	0.11%
DICTYOSPHAERIUM EHRENBERGIANUM	0.	172.	86.	0.27%	0.007	0.27%
TOTAL NON-FILAMENTOUS	5448.	9691.	7570.	24.20%	0.426	15.92%
TOTAL CHLOROPHYTA	5448.	9691.	7570.	24.20%	0.426	15.92%
CHRYSOPHYTA						
CHRYSOCHROMULINA SPP.	459.	918.	688.	2.20%	0.030	1.11%
TOTAL CHRYSOPHYTA	459.	918.	688.	2.20%	0.030	1.11%
CYANOPHYTA						
NON-FILAMENTOUS						
MERISMOPEDIA TENUISSIMA	6193.	14910.	10551.	33.73%	0.038	1.42%
CHROOCOCCUS DISPERSUS	918.	344.	631.	2.02%	0.014	0.52%

Table B-3 (continued)

Location 10

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCUR-RENCE	BIOVOLUME MICRO-LITERS/LITER	OCCUR-RENCE
UNIDENTIFIED BLUE-GREEN COCCOID SP.	57.	1032.	545.	1.74%	0.005	0.17%
APHANOCAPSA DELICATISSIMA	344.	459.	401.	1.28%	0.018	0.67%
TOTAL NON-FILAMENTOUS	7512.	16745.	12128.	38.77%	0.074	2.79%
TOTAL CYANOPHYTA	7512.	16745.	12128.	38.77%	0.074	2.79%
EUGLENOPHYTA						
TRACHELOMONAS VOLVOCINA	229.	0.	115.	0.37%	0.156	5.85%
TOTAL EUGLENOPHYTA	229.	0.	115.	0.37%	0.156	5.85%
CRYPTOPHYTA						
RHODOMONAS MINUTA	1376.	5276.	3326.	10.63%	0.545	20.39%
CRYPTOMONAS SPP.	0.	688.	344.	1.10%	0.516	19.31%
TOTAL CRYPTOPHYTA	1376.	5964.	3670.	11.73%	1.062	39.70%
TOTAL PHYTOPLANKTON	18694.	43869.	31282.	100.00%	2.675	100.00%

Table B-3 (continued)

Location 4

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCUR-RENCE	BIOVOLUME MICRO-LITERS/ LITER	OCCUR-RENCE
BACILLARIOPHYTA						
CENTRALES						
UNIDENTIFIED CENTRICS	1606.	2064.	1835.	3.88%	0.116	6.10%
SKELETONEMA POTAMOS	1835.	1147.	1491.	3.15%	0.083	4.40%
STEPHANODISCUS MINUTUS	229.	1376.	803.	1.70%	0.250	13.16%
MELOSIRA DISTANS	459.	0.	229.	0.48%	0.045	2.36%
STEPHANODISCUS ASTRAEA	0.	229.	115.	0.24%	0.089	4.72%
TOTAL CENTRALES	4129.	4817.	4473.	9.45%	0.583	30.74%
BACILLARIOPHYTA						
PENNALES						
NITZSCHIA KUTZINGIANA	459.	229.	344.	0.72%	0.050	2.65%
NITZSCHIA ACICULARIS	229.	229.	229.	0.48%	0.006	0.34%
NITZSCHIA LONGISSMIA	0.	229.	115.	0.24%	0.017	0.91%
TOTAL PENNALES	688.	688.	688.	1.45%	0.074	3.90%
TOTAL BACILLARIOPHYTA	4817.	5505.	5161.	10.91%	0.657	34.64%
CHLOROPHYTA						
NON-FILAMENTOUS						
SELENASTRUM MINUTUM	5964.	5677.	5821.	12.30%	0.198	10.43%
UNIDENTIFIED COCCOID GREEN	2064.	1720.	1892.	4.00%	0.117	6.19%
ANKISTRODESMUS FALCATUS	1376.	2294.	1835.	3.88%	0.035	1.84%
TETRASTRUM STAUROGENIAEFORME	0.	688.	344.	0.72%	0.037	1.94%
LAGERHEIMIA QUADRISETA	459.	229.	344.	0.72%	0.010	0.53%
OOCYSTIS PUSILLA	115.	459.	287.	0.61%	0.042	2.22%
CHLAMYDOMONAS SPP.	0.	459.	229.	0.48%	0.050	2.65%
CRUCIGENIA TETRAPEDIA	459.	0.	229.	0.48%	0.009	0.51%
SCENEDESMUS QUADRICAUDA	0.	229.	115.	0.24%	0.014	0.72%
DICTYOSPHAERIUM EHRENBERGIANUM	229.	0.	115.	0.24%	0.009	0.51%
ANKISTRODESMUS CONVOLUTUS	0.	229.	115.	0.24%	0.006	0.30%
SCENEDESMUS BICELLULARIS	0.	115.	57.	0.12%	0.002	0.13%
KIRCHNERIELLA SUBSOLITARIA	57.	57.	57.	0.12%	0.007	0.40%
TOTAL NON-FILAMENTOUS	10724.	12157.	11440.	24.18%	0.538	28.36%
TOTAL CHLOROPHYTA	10724.	12157.	11440.	24.18%	0.538	28.36%
CHRYSOPHYTA						
ARACHNOCHLORIS MINOR	459.	459.	459.	0.97%	0.053	2.81%
CHRYSOCHROMULINA SPP.	0.	459.	229.	0.48%	0.009	0.52%
TOTAL CHRYSOPHYTA	459.	918.	688.	1.45%	0.063	3.33%

Table B-3 (continued)

Location 4

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
CYANOPHYTA						
NON-FILAMENTOUS						
MERISMOPEDIA TENUISSIMA	36011.	16401.	26207.	55.39%	0.094	4.97%
APHANOCAPSA DELICATISSIMA	1376.	918.	1147.	2.42%	0.052	2.72%
CHROOCOCCUS DISPERSUS	745.	229.	487.	1.03%	0.011	0.57%
APHANOCAPSA FLACHISTA	0.	344.	172.	0.36%	0.026	1.38%
UNIDENTIFIED BLUE-GREEN COCCOID SP.	0.	344.	172.	0.36%	0.001	0.07%
TOTAL NON-FILAMENTOUS	38134.	18236.	28185.	59.58%	0.184	9.71%
TOTAL CYANOPHYTA	38134.	18236.	28185.	59.58%	0.184	9.71%
CRYPTOPHYTA						
RHODOMONAS MINUTA	459.	2982.	1720.	3.64%	0.282	14.88%
CRYPTOMONAS SPP.	0.	229.	115.	0.24%	0.172	9.07%
TOTAL CRYPTOPHYTA	459.	3211.	1835.	3.88%	0.454	23.95%
TOTAL PHYTOPLANKTON	54592.	40027.	47319.	100.00%	1.897	100.00%

Table B-4 Analysis of phytoplankton samples collected near Wolf Creek Generating Station, Burlington, Kansas 16 December 1980.

Location 1

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
BACILLARIOPHYTA						
CENTRALES						
UNIDENTIFIED CENTRICS	19135.	12035.	15585.	25.44%	4.161	29.93%
THALASSIOSIRA FLUVIATILIS	3043.	2434.	2738.	4.47%	2.139	15.38%
MELOSIRA DISTANS	1555.	1826.	1690.	2.76%	0.487	3.50%
SKELETONEMA POTAMOS	270.	744.	507.	0.82%	0.072	0.52%
STEPHANODISCUS MINUTUS	676.	203.	439.	0.71%	0.141	1.01%
CYCLOTELLA MENEGHINIANA	135.	0.	68.	0.11%	0.043	0.31%
STEPHANODISCUS ASTRAEA	0.	68.	34.	0.06%	0.032	0.23%
TOTAL CENTRALES	24814.	17309.	21062.	34.38%	7.074	50.88%
BACILLARIOPHYTA						
PENNALES						
NITZSCHIA ACICULARIS	3516.	2299.	2907.	4.75%	0.174	1.25%
SURIRELLA OVATA	0.	270.	135.	0.22%	0.184	1.32%
NITZSCHIA PALEA	68.	135.	101.	0.17%	0.022	0.15%
NITZSCHIA KUTZINGIANA	68.	68.	68.	0.11%	0.006	0.05%
NITZSCHIA LONGISSMIA	0.	68.	34.	0.06%	0.010	0.07%
NAVICULA CRYPTOCEPHALA	68.	0.	34.	0.06%	0.027	0.19%
TOTAL PENNALES	3719.	2840.	3279.	5.35%	0.424	3.05%
TOTAL BACILLARIOPHYTA	28533.	20149.	24341.	39.73%	7.498	53.93%
CHLOROPHYTA						
NON-FILAMENTOUS						
CRUCIGENIA CRUCIFERA	2130.	3600.	2865.	4.68%	0.751	5.40%
ANKISTRODESMUS FALCATUS	3043.	2637.	2840.	4.64%	0.111	0.79%
CHLAMYDOMONAS SPP.	2299.	3178.	2738.	4.47%	0.958	6.89%
UNIDENTIFIED COCCOID GREEN	2654.	2366.	2510.	4.10%	0.115	0.83%
DICTYOSPHAERIUM PULCHELLUM	1606.	2823.	2214.	3.61%	0.197	1.42%
SELENASTRUM MINUTUM	1724.	1234.	1479.	2.41%	0.031	0.22%
DICTYOSPHAERIUM EHRENBERGIANUM	693.	1487.	1090.	1.78%	0.100	0.72%
OOCYSTIS PUSILLA	625.	913.	769.	1.26%	0.105	0.75%
TETRASTRUM STAUROGENIAEFORME	220.	270.	245.	0.40%	0.012	0.08%
SCENEDESMUS QUADRICAUDA	203.	152.	177.	0.29%	0.017	0.12%
FRANCEIA OVALIS	338.	0.	169.	0.28%	0.001	0.00%
SCENEDESMUS ABUNDANS	68.	101.	85.	0.14%	0.025	0.18%
KIRCHNERIELLA SUBSOLITARIA	68.	101.	85.	0.14%	0.016	0.12%
MICRACTINIUM PUSILLUM	85.	51.	68.	0.11%	0.006	0.04%
GOLENKINIA RADIATA	0.	135.	68.	0.11%	0.029	0.21%
ELAKATOTHRIX VIRIDIS	101.	34.	68.	0.11%	0.021	0.15%
CARTERIA CORDIFORMIS	0.	135.	68.	0.11%	0.025	0.18%
OOCYSTIS BORGEI	17.	68.	42.	0.06%	0.042	0.30%
PTEROMONAS SPP.	0.	68.	34.	0.06%	0.006	0.05%
SCENEDESMUS LONGUS	68.	0.	34.	0.06%	0.003	0.02%
SCENEDESMUS BICELLULARIS	0.	34.	17.	0.03%	0.002	0.02%

Table B-4 (continued)

Location 1

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCURRENCE	BIOVOLUME MICROLITERS/LITER	OCCURRENCE
TOTAL NON-FILAMENTOUS	15940.	19388.	17664.	28.83%	2.574	18.51%
TOTAL CHLOROPHYTA	15940.	19388.	17664.	28.83%	2.574	18.51%
CHRYSOPHYTA						
CHRYSOCHROMULINA SPP.	6694.	9195.	7945.	12.97%	0.572	4.11%
ARACHNOCHLORIS MINOR	68.	135.	101.	0.17%	0.018	0.13%
TOTAL CHRYSOPHYTA	6761.	9331.	8046.	13.13%	0.590	4.24%
CYANOPHYTA NON-FILAMENTOUS						
MERISMOPEDIA TENUISSIMA	2451.	10260.	6356.	10.37%	0.023	0.16%
APHANOCAPSA DELICATISSIMA	676.	406.	541.	0.88%	0.024	0.18%
APHANOCAPSA ELACHISTA	304.	575.	439.	0.71%	0.158	1.13%
CHROOCOCCUS DISPERSUS	118.	203.	161.	0.26%	0.007	0.05%
TOTAL NON-FILAMENTOUS	3550.	11444.	7497.	12.24%	0.212	1.53%
TOTAL CYANOPHYTA	3550.	11444.	7497.	12.24%	0.212	1.53%
EUGLENOPHYTA						
EUGLENA GRACILIS	0.	203.	101.	0.17%	0.958	6.88%
TRACHELOMONAS VOLVOCINA	68.	68.	68.	0.11%	0.263	1.90%
TRACHELOMONAS HISPIDA	0.	68.	34.	0.06%	0.048	0.34%
TOTAL EUGLENOPHYTA	68.	338.	203.	0.33%	1.269	9.12%
PYRRHOPHYTA						
GYMNODINIUM SPP.	0.	203.	101.	0.17%	0.035	0.25%
GLENODINIUM SPP.	68.	0.	34.	0.06%	0.030	0.22%
TOTAL PYRRHOPHYTA	68.	203.	135.	0.22%	0.064	0.47%
CRYPTOPHYTA						
RHODOMONAS MINUTA	1758.	3178.	2468.	4.03%	0.234	1.69%
CRYPTOMONAS SPP.	609.	811.	710.	1.16%	1.435	10.32%
CHROOMONAS SPP.	68.	68.	68.	0.11%	0.016	0.11%
TOTAL CRYPTOPHYTA	2434.	4057.	3245.	5.30%	1.685	12.12%

Table B-4 (continued)

Location 1

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCUR-RENCE	BIOVOLUME MICRO-LITERS/ LITER	OCCUR-RENCE
MICROFLAGELLATES						
UNIDENTIFIED MICROFLAGELLATES	135.	135.	135.	0.22%	0.010	0.07%
TOTAL MICROFLAGELLATES	135.	135.	135.	0.22%	0.010	0.07%
T O T A L P H Y T O P L A N K T O N	57488.	65044.	61266.	100.00%	13.903	100.00%

Table B-4 (continued)

Location 10

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCUR-RENCE	BIOVOLUME MICRO-LITERS/ LITER	OCCUR-RENCE
BACILLARIOPHYTA						
CENTRALES						
UNIDENTIFIED CENTRICS	1623.	1487.	1555.	5.93%	0.415	9.14%
MELOSIRA DISTANS	0.	676.	338.	1.29%	0.097	2.15%
STEPHANODISCUS MINUTUS	270.	338.	304.	1.16%	0.097	2.15%
STEPHANODISCUS ASTRAEA	135.	270.	203.	0.77%	0.189	4.17%
CYCLOTELLA MENEGHINIANA	68.	203.	135.	0.52%	0.085	1.88%
SKELETONEMA POTAMOS	135.	68.	101.	0.39%	0.015	0.32%
TOTAL CENTRALES	2231.	3043.	2637.	10.06%	0.899	19.82%
BACILLARIOPHYTA						
PENNALES						
NITZSCHIA ACICULARIS	406.	135.	270.	1.03%	0.016	0.36%
NAVICULA CRYPTOCEPHALA	135.	68.	101.	0.39%	0.079	1.76%
NITZSCHIA LONGISSMIA	203.	0.	101.	0.39%	0.031	0.67%
NITZSCHIA PALEA	0.	68.	34.	0.13%	0.007	0.16%
TOTAL PENNALES	744.	270.	507.	1.93%	0.134	2.95%
TOTAL BACILLARIOPHYTA	2975.	3313.	3144.	12.00%	1.033	22.76%
CHLOROPHYTA						
NON-FILAMENTOUS						
ANKISTRODESMUS FALCATUS	2231.	3043.	2637.	10.06%	0.103	2.27%
CRUCIGENIA CRUCIFERA	3516.	947.	2231.	8.51%	0.585	12.88%
CHLAMYDOMONAS SPP.	1014.	2975.	1995.	7.61%	0.698	15.38%
UNIDENTIFIED COCCOID GREEN	1623.	2231.	1927.	7.35%	0.088	1.95%
DICTYOSPHAERIUM PULCHELLUM	1555.	1369.	1462.	5.58%	0.130	2.87%
SELENASTRUM MINUTUM	1099.	744.	921.	3.51%	0.019	0.43%
OOCYSTIS PUSILLA	845.	625.	735.	2.81%	0.100	2.20%
DICTYOSPHAERIUM EHRENBERGIANUM	693.	186.	439.	1.68%	0.040	0.89%
FRANCEIA OVALIS	744.	135.	439.	1.68%	0.003	0.07%
KIRCHNERIELLA SUBSOLITARIA	186.	101.	144.	0.55%	0.028	0.61%
GLOEOCYSTIS GIGAS	135.	0.	68.	0.26%	0.029	0.63%
LAGERHEIMIA QUADRISETA	0.	135.	68.	0.26%	0.003	0.06%
SCENEDESMUS QUADRICAUDA	34.	101.	68.	0.26%	0.006	0.14%
TETRASTRUM STAUROGENIAEFORME	0.	68.	34.	0.13%	0.002	0.04%
COSMARIUM SPP.	68.	0.	34.	0.13%	0.003	0.07%
SCENEDESMUS ABUNDANS	0.	68.	34.	0.13%	0.009	0.22%
SCENEDESMUS BICELLULARIS	34.	34.	34.	0.13%	0.004	0.09%
LAGERHEIMIA WRATISLAWIENSIS	68.	0.	34.	0.13%	0.010	0.23%
MICRACTINIUM PUSILLUM	0.	34.	17.	0.06%	0.002	0.03%
TOTAL NON-FILAMENTOUS	13844.	12796.	13320.	50.82%	1.864	41.07%
TOTAL CHLOROPHYTA	13844.	12796.	13320.	50.82%	1.864	41.07%

Table B-4 (continued)

Location 10

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCUR-RENCE	BIOVOLUME MICRO-LITERS/LITER	OCCUR-RENCE
CHRYSOPHYTA						
CHRYSOCHROMULINA SPP.	1555.	1420.	1487.	5.68%	0.107	2.36%
ARACHNOCHLORIS MINOR	68.	135.	101.	0.39%	0.018	0.39%
TOTAL CHRYSOPHYTA	1623.	1555.	1589.	6.06%	0.125	2.75%
CYANOPHYTA						
NON-FILAMENTOUS						
MERISMOPEDIA TENUISSIMA	4851.	3617.	4234.	16.16%	0.015	0.34%
CHROOCOCCUS DISPERSUS	778.	338.	558.	2.13%	0.026	0.57%
APHANOCAPSA DELICATISSIMA	642.	338.	490.	1.87%	0.022	0.49%
UNIDENTIFIED BLUE-GREEN COCCOID SP.	321.	118.	220.	0.83%	< 0.001	0.02%
APHANOCAPSA ELACHISTA	304.	68.	186.	0.70%	0.066	1.47%
TOTAL NON-FILAMENTOUS	6897.	4479.	5688.	21.70%	0.131	2.88%
TOTAL CYANOPHYTA	6897.	4479.	5688.	21.70%	0.131	2.88%
EUGLENOPHYTA						
EUGLENA GRACILIS	135.	0.	68.	0.26%	0.638	14.07%
TOTAL EUGLENOPHYTA	135.	0.	68.	0.26%	0.638	14.07%
CRYPTOPHYTA						
RHODOMONAS MINUTA	2502.	1623.	2062.	7.86%	0.196	4.32%
CRYPTOMONAS SPP.	135.	406.	270.	1.03%	0.547	12.04%
TOTAL CRYPTOPHYTA	2637.	2028.	2333.	8.90%	0.742	16.36%
MICROFLAGELLATES						
UNIDENTIFIED MICROFLAGELLATES	135.	0.	68.	0.26%	0.005	0.11%
TOTAL MICROFLAGELLATES	135.	0.	68.	0.26%	0.005	0.11%
TOTAL PHYTOPLANKTON	28246.	24172.	26209.	100.00%	4.538	100.00%

Table B-4 (continued)

Location 4

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCUR-RENCE	BIOVOLUME MICRO-LITERS/LITER	OCCUR-RENCE
BACILLARIOPHYTA						
CENTRALES						
UNIDENTIFIED CENTRICS	2028.	3178.	2603.	9.52%	0.695	14.28%
THALASSIOSIRA FLUVIATILIS	203.	473.	338.	1.24%	0.264	5.43%
STEPHANODISCUS MINUTUS	68.	338.	203.	0.74%	0.065	1.34%
MELOSIRA DISTANS	0.	270.	135.	0.49%	0.039	0.80%
CYCLOTELLA MENEGHINIANA	68.	135.	101.	0.37%	0.063	1.31%
SKELETONEMA POTAMOS	68.	135.	101.	0.37%	0.015	0.30%
STEPHANODISCUS ASTRAEA	68.	68.	68.	0.25%	0.063	1.30%
CYCLOTELLA ATOMUS	0.	68.	34.	0.12%	0.003	0.06%
TOTAL CENTRALES	2502.	4665.	3584.	13.11%	1.208	24.82%
BACILLARIOPHYTA						
PENNALES						
NITZSCHIA ACICULARIS	338.	68.	203.	0.74%	0.012	0.25%
NITZSCHIA LONGISSMIA	68.	68.	68.	0.25%	0.020	0.42%
NAVICULA CRYPTOCEPHALA	68.	0.	34.	0.12%	0.027	0.55%
SURIRELLA OVATA	68.	0.	34.	0.12%	0.046	0.94%
NITZSCHIA TRYBLIONELLA	68.	0.	34.	0.12%	0.035	0.72%
RHOICOSPHENIA CURVATA	68.	0.	34.	0.12%	0.028	0.57%
NITZSCHIA APICULATA	68.	0.	34.	0.12%	0.034	0.69%
TOTAL PENNALES	744.	135.	439.	1.61%	0.202	4.15%
TOTAL BACILLARIOPHYTA	3245.	4801.	4023.	14.72%	1.410	28.97%
CHLOROPHYTA						
NON-FILAMENTOUS						
ANKISTRODESMUS FALCATUS	1758.	4598.	3178.	11.63%	0.124	2.55%
DICTYOSPHAERIUM PULCHELLUM	1741.	4479.	3110.	11.38%	0.277	5.69%
CHLAMYDOMONAS SPP.	1352.	3245.	2299.	8.41%	0.805	16.53%
UNIDENTIFIED COCCOID GREEN	1555.	1893.	1724.	6.31%	0.079	1.63%
SELENASTRUM MINUTUM	811.	1623.	1217.	4.45%	0.026	0.53%
CRUCIGENIA CRUCIFERA	1014.	1133.	1073.	3.93%	0.281	5.78%
DICTYOSPHAERIUM EHRENBERGIANUM	541.	1521.	1031.	3.77%	0.094	1.95%
TETRASTRUM STAUROGENIAEFORME	355.	761.	558.	2.04%	0.027	0.56%
OOCYSTIS PUSILLA	524.	524.	524.	1.92%	0.071	1.46%
COELASTRUM MICROPORUM	0.	270.	135.	0.49%	0.012	0.25%
LAGERHEIMIA QUADRISETA	0.	203.	101.	0.37%	0.004	0.09%
SCENEDESMUS QUADRICAUDA	101.	51.	76.	0.28%	0.007	0.15%
CARTERIA CORDIFORMIS	0.	135.	68.	0.25%	0.025	0.52%
KIRCHNERIELLA SUBSOLITARIA	68.	34.	51.	0.19%	0.009	0.20%
MICRACTINIUM PUSILLUM	0.	85.	42.	0.15%	0.004	0.07%
SCENEDESMUS LONGUS	0.	68.	34.	0.12%	0.003	0.05%
SCENEDESMUS DIMORPHUS	68.	0.	34.	0.12%	0.025	0.50%
ELAKATOTHRIX VIRIDIS	34.	0.	17.	0.06%	0.005	0.11%
SCENEDESMUS BICELLULARIS	34.	0.	17.	0.06%	0.002	0.04%

Table B-4 (continued)

Location 4

TAXA	REPLICATES UNITS PER ML. A	B	MEAN OF REPLICATES UNITS PER ML.	OCCUR-RENCE	BIOVOLUME MICRO-LITERS/ LITER	OCCUR-RENCE
TOTAL NON-FILAMENTOUS	9956.	20622.	15289.	55.95%	1.882	38.67%
TOTAL CHLOROPHYTA	9956.	20622.	15289.	55.95%	1.882	38.67%
CHRYSOPHYTA						
CHRYSOCHROMULINA SPP.	1623.	2569.	2096.	7.67%	0.151	3.10%
ARACHNOCHLORIS MINOR	270.	0.	135.	0.49%	0.023	0.48%
TOTAL CHRYSOPHYTA	1893.	2569.	2231.	8.16%	0.174	3.58%
CYANOPHYTA NON-FILAMENTOUS						
MERISMOPEDIA TENUISSIMA	1014.	3854.	2434.	8.90%	0.008	0.18%
APHANOCAPSA DELICATISSIMA	270.	473.	372.	1.36%	0.017	0.34%
CHROOCOCCUS DISPERSUS	0.	203.	101.	0.37%	0.005	0.09%
TOTAL NON-FILAMENTOUS	1285.	4530.	2907.	10.64%	0.030	0.62%
TOTAL CYANOPHYTA	1285.	4530.	2907.	10.64%	0.030	0.62%
EUGLENOPHYTA						
EUGLENA GRACILIS	68.	0.	34.	0.12%	0.319	6.56%
TOTAL EUGLENOPHYTA	68.	0.	34.	0.12%	0.319	6.56%
CRYPTOPHYTA						
RHODOMONAS MINUTA	1758.	3110.	2434.	8.90%	0.231	4.75%
CRYPTOMONAS SPP.	338.	473.	406.	1.48%	0.820	16.85%
TOTAL CRYPTOPHYTA	2096.	3584.	2840.	10.39%	1.051	21.60%
TOTAL PHYTOPLANKTON	18543.	36106.	27324.	100.00%	4.866	100.00%

Table B-5 Mean total density (units/ml) of phytoplankton in samples collected near Wolf Creek Generating Station, Burlington, Kansas, 1973-1979.

Date	Neosho River				Wolf Creek				
	1[a]	10	4	$\bar{X}$	7	2	3	5	$\bar{X}$
27 March 1973	309	-[b]	364	337	-	272	230	-	251
12 June	3,893	-	3,279	3,586	-	753	998	-	876
11 September	1,761	-	3,611	2,686	-	5,397	1,083	-	3,240
12 December	1,434	-	1,133	1,284	-	51	46	-	49
$\bar{X}$	1,849	-	2,097	1,973	-	1,618	589	-	1,104
27 March 1974	4,401	4,694	3,674	4,256	-	615	928	736	760
11 June	1,183	431	362	659	-	526	1,193	722	814
10 September	1,555	2,498	1,937	1,997	-	5,229	1,883	1,438	2,850
10 December	9,879	7,490	8,521	8,630	-	1,074	3,661	498	1,744
$\bar{X}$	4,255	3,778	3,624	3,886	-	1,861	1,916	849	1,542
16 April 1975	16,627	14,126	17,791	16,181	2,193	2,113	4,537	3,819	3,166
10 June	1,946	1,270	1,506	1,574	1,203	2,164	2,196	3,056	2,155
9 September	12,604	9,486	10,571	10,887	2,871	3,908	12,405	11,465	7,662
3 December	7,827	4,638	4,994	5,820	3,669	509	3,345	510	2,008
$\bar{X}$	9,751	7,380	8,716	8,616	2,484	2,174	5,621	4,713	3,748
25 February 1976	31,437	42,501	43,799	39,246	173,954	6,484	962	2,021	45,855
6 April	5,655	7,636	7,641	6,977	5,136	3,905	5,182	1,686	3,977
3 May	8,137	-	-	8,137	-	-	-	-	-
15 June	8,721	7,440	7,572	7,911	1,364	2,968	5,012	8,299	4,411
12 July	6,537	-	-	6,537	-	-	-	-	-
10 August	3,549	10,138	22,695	12,127	2,778	10,234	7,289	4,594	6,224
5 October	8,360	3,398	5,420	5,726	2,941	9,994	-	-	6,468
14 December	3,076	1,588	701	1,788	-	-	-	-	-
$\bar{X}$	9,434	12,117	14,638	12,063	37,235	6,717	4,611	4,150	14,156
22 February 1977	8,534	9,426	9,536	9,165	2,613	-	1,219	-	1,916
5 April	8,325	11,240	8,927	9,497	698	-	5,380	-	3,039
2 May	14,474	-	-	14,474	-	-	-	-	-
9 June	2,455	873	1,105	1,478	307	-	6,280	4,389	3,659
11 July	962	-	-	962	-	-	-	-	-
9 August	14,189	11,053	7,118	10,787	2,367	-	1,737	13,352	5,819
4 October	2,514	2,395	1,692	2,200	1,570	-	1,508	439	1,172
13 December	1,885	1,595	1,532	1,671	349	-	1,403	921	891
$\bar{X}$	6,667	6,097	4,985	5,991	1,317	-	2,921	4,775	2,783
22 February 1978	6,793	10,051	8,961	8,602	2,202	-	1,001	522	1,242
25 April	1,319	1,240	1,312	1,290	1,841	-	2,808	1,631	2,093
22 May	10,214	-	-	10,214	-	-	-	-	-
27 June	9,954	7,148	7,501	8,201	2,168	-	4,338	5,780	4,095
19 July	12,089	-	-	12,089	-	-	-	-	-
29 August	9,733	9,885	9,372	9,663	43,636	-	-	-	43,636
10 October	13,150	6,104	5,162	8,139	10,102	-	8,539	-	9,320
12 December	5,720	1,974	2,844	3,513	5,571	-	2,486	2,799	3,619
$\bar{X}$	8,622	6,067	5,859	6,849	10,920	-	3,834	2,683	5,812
20 February 1979	2,174	591	462	1,076	-	-	-	-	-
10 April	5,952	6,073	6,825	6,283	-	-	-	-	-
21 May	5,132	-	-	5,132	-	-	-	-	-
12 June	2,086	2,520	2,646	2,417	-	-	-	-	-
9 July	1,168	-	-	1,168	-	-	-	-	-
7 August	3,743	3,621	3,609	3,658	-	-	-	-	-
9 October	5,813	4,969	5,178	5,320	-	-	-	-	-
11 December	58,445	55,039	55,347	56,277	-	-	-	-	-
$\bar{X}$	10,564	12,136	12,344	11,570	-	-	-	-	-

[a] Location 1 was in John Redmond Reservoir prior to 1976.
[b] Samples not collected.

Table B-6 Mean total biovolume (µl/liter) of phytoplankton in samples collected near Wolf Creek Generating Station, Burlington, Kansas, 1973-1979.

Date	Neosho River				Wolf Creek				
	1[a]	10	4	$\bar{X}$	7	2	3	5	$\bar{X}$
27 March 1973	0.26	-[b]	0.23	0.24	-	0.28	0.24	-	0.26
12 June	2.72	-	2.30	2.51	-	0.34	0.43	-	0.38
11 September	1.04	-	1.56	1.30	-	1.13	0.83	-	0.98
12 December	1.20	-	0.72	0.96	-	0.70	0.09	-	0.40
$\bar{X}$	1.30	-	1.20	1.25	-	0.61	0.40	-	0.50
27 March 1974	1.14	1.36	1.13	1.21	-	0.78	1.29	1.11	1.06
11 June	0.96	0.52	0.34	0.61	-	0.42	1.13	0.79	0.78
10 September	0.46	0.53	0.41	0.47	-	4.82	1.94	1.31	2.69
10 December	2.08	1.67	1.50	1.75	-	0.25	0.79	0.27	0.44
$\bar{X}$	1.16	1.02	0.84	1.01	-	1.57	1.29	0.87	1.24
16 April 1975	6.55	5.73	7.87	6.72	1.50	2.09	2.99	2.81	2.35
10 June	0.67	0.63	0.66	0.65	0.55	0.85	0.93	1.26	0.90
9 September	4.14	2.05	2.47	2.89	0.58	1.37	2.58	7.26	2.95
3 December	3.24	1.31	1.28	1.94	2.06	0.18	2.00	0.77	1.25
$\bar{X}$	3.65	2.43	3.07	3.05	1.17	1.12	2.12	3.02	1.86
25 February 1976	16.55	13.31	14.82	14.89	30.00	3.11	0.69	0.91	8.68
6 April	3.97	4.54	4.70	4.40	3.50	2.18	33.72	2.72	10.53
3 May	1.28	-	-	1.28	-	-	-	-	-
15 June	1.80	1.68	2.26	1.91	0.26	1.35	2.31	2.12	1.51
12 July	1.52	-	-	1.52	-	-	-	-	-
10 August	1.43	5.72	10.31	5.82	12.38	2.56	7.64	2.09	6.17
5 October	1.48	4.16	9.97	5.20	1.35	2.02	-	-	1.68
14 December	1.38	0.63	0.29	0.77	-	-	-	-	-
$\bar{X}$	3.68	5.01	7.06	5.09	9.50	2.24	11.09	1.96	6.16
22 February 1977	8.68	5.83	7.71	7.41	3.65	-	0.66	-	2.16
5 April	4.28	4.88	4.38	4.51	0.91	-	5.16	-	3.04
2 May	2.05	-	-	2.05	-	-	-	-	-
9 June	1.08	0.59	1.02	0.90	0.40	-	9.67	10.13	6.73
11 July	0.88	-	-	0.88	-	-	-	-	-
9 August	8.62	7.12	4.92	6.89	5.14	-	2.06	4.55	3.92
4 October	1.36	1.50	1.12	1.33	2.93	-	1.87	0.42	1.74
13 December	1.36	0.89	1.05	1.10	0.46	-	1.21	0.65	0.77
$\bar{X}$	3.54	3.47	3.37	3.47	2.25	-	3.44	3.94	3.12
22 February 1978	0.89	1.64	1.34	1.29	1.34	-	0.91	0.77	1.01
25 April	1.03	0.61	0.71	0.78	0.53	-	0.73	0.49	0.58
22 May	3.66	-	-	3.66	-	-	-	-	-
27 June	2.38	1.78	1.64	1.93	1.07	-	0.87	1.04	0.99
19 July	2.46	-	-	2.46	-	-	-	-	-
29 August	0.69	0.78	0.75	0.74	54.66	-	-	-	54.66
10 October	1.12	0.81	0.60	0.84	3.31	-	4.86	-	4.08
12 December	1.14	0.22	0.23	0.53	14.02	-	1.42	1.94	5.79
$\bar{X}$	1.67	0.97	0.88	1.22	12.49	-	1.76	1.06	5.86
20 February 1979	0.30	0.28	0.16	0.25	-	-	-	-	-
10 April	0.76	0.62	0.77	0.72	-	-	-	-	-
21 May	2.05	-	-	2.05	-	-	-	-	-
12 June	0.60	0.81	0.78	0.73	-	-	-	-	-
9 July	0.28	-	-	0.28	-	-	-	-	-
7 August	5.04	5.25	4.99	5.09	-	-	-	-	-
9 October	1.77	1.46	1.41	1.55	-	-	-	-	-
11 December	6.94	6.36	6.24	6.51	-	-	-	-	-
$\bar{X}$	2.22	2.46	2.39	2.34	-	-	-	-	-

[a] Location 1 was in John Redmond Reservoir prior to 1976.
[b] Samples not collected.

Table B-7 Mean diversity[a] of phytoplankton collected near Wolf Creek Generating Station, Burlington, Kansas, 1974-1979.

Date	Neosho River				Wolf Creek				
	1[b]	10	4	$\bar{X}$	7	2	3	5	$\bar{X}$
27 March 1974	2.01	0.91	1.94	1.62	-[c]	2.47	2.31	2.20	2.33
11 June	2.63	2.31	2.37	2.44	-	2.13	1.98	1.85	1.99
10 September	2.47	2.20	1.94	2.20	-	1.36	2.16	2.38	1.97
10 December	2.05	2.04	2.11	2.07	-	0.81	0.55	1.96	1.11
$\bar{X}$	2.29	1.87	2.09	2.08	-	1.69	1.75	2.10	1.85
16 April 1975	1.78	1.52	1.65	1.65	2.78	2.78	1.88	2.19	2.41
10 June	2.56	3.07	3.06	2.90	3.24	3.37	3.24	2.96	3.20
9 September	2.67	2.39	2.42	2.49	2.63	2.68	2.56	3.19	2.78
3 December	2.32	2.51	2.57	2.47	1.79	2.33	2.00	2.36	2.12
$\bar{X}$	2.33	2.37	2.43	2.38	2.61	2.79	2.42	2.68	2.63
25 February 1976	1.39	2.03	2.00	1.81	1.83	2.47	2.43	2.22	2.24
6 April	2.27	2.47	2.56	2.43	2.56	2.01	1.39	2.86	2.21
3 May	1.91	-	-	1.91	-	-	-	-	-
15 June	2.32	2.19	2.45	2.32	2.67	3.20	2.66	3.13	2.92
12 July	2.17	-	-	2.17	-	-	-	-	-
10 August	2.33	1.89	1.94	2.05	2.63	2.17	2.72	2.37	2.47
5 October	2.02	2.92	2.09	2.34	2.69	2.61	-	-	2.65
14 December	2.39	3.07	2.98	2.81	-	-	-	-	-
$\bar{X}$	2.10	2.43	2.34	2.27	2.48	2.49	2.30	2.65	2.48
22 February 1977	2.42	2.37	2.55	2.45	0.88	-	0.41	-	0.65
5 April	2.02	2.65	2.88	2.52	1.28	-	1.92	-	1.60
2 May	1.34	-	-	1.34	-	-	-	-	-
9 June	2.19	2.56	1.95	2.23	1.47	-	1.85	1.55	1.62
11 July	2.67	-	-	2.67	-	-	-	-	-
9 August	2.48	2.32	2.53	2.44	3.33	-	2.55	2.32	3.07
4 October	2.65	2.61	2.57	2.61	3.06	-	2.37	3.09	2.84
13 December	3.00	2.77	2.91	2.89	1.69	-	2.45	2.77	2.30
$\bar{X}$	2.35	2.55	2.57	2.48	1.95	-	1.93	2.43	2.06
22 February 1978	1.14	1.02	1.05	1.07	1.81	-	1.45	1.56	1.61
25 April	2.38	2.29	2.50	2.39	1.94	-	1.68	1.88	1.83
22 May	2.07	-	-	2.07	-	-	-	-	-
27 June	2.21	2.09	2.31	2.20	3.41	-	3.17	2.73	3.10
19 July	2.55	-	-	2.55	-	-	-	-	-
29 August	2.38	2.30	2.46	2.38	0.69	-	-	-	0.69
10 October	2.72	3.16	3.11	3.00	2.54	-	0.52	-	1.53
12 December	2.55	2.61	1.91	2.36	2.29	-	1.68	1.59	1.85
$\bar{X}$	2.25	2.24	2.22	2.24	2.11	-	1.70	1.94	1.92
20 February 1979	2.40	3.20	3.24	2.95	-	-	-	-	-
10 April	2.34	2.11	2.29	2.25	-	-	-	-	-
21 May	2.66	-	-	2.66	-	-	-	-	-
12 June	2.92	3.07	2.85	2.95	-	-	-	-	-
9 July	2.90	-	-	2.90	-	-	-	-	-
7 August	3.15	3.05	3.20	3.13	-	-	-	-	-
9 October	3.13	3.30	3.34	3.26	-	-	-	-	-
11 December	1.12	1.08	1.08	1.09	-	-	-	-	-
$\bar{X}$	2.58	2.64	2.67	2.62	-	-	-	-	-

[a] Based on Shannon (1948) using log base e.
[b] Location 1 was in John Redmond Reservoir prior to 1976.
[c] Samples not collected.

Table B-8 Mean chlorophyll a concentration (mg chl a/m^3) in phytoplankton samples collected near Wolf Creek Generating Station, Burlington, Kansas, 1973-1979.

Date	Neosho River				Wolf Creek				
	1[a]	10	4	$\bar{x}$	7	2	3	5	$\bar{x}$
12 April 1973	1.58	-[b]	1.93	1.78	-	4.63	2.49	-	3.56
12 June	8.13	-	2.23	5.18	-	1.01	1.44	-	1.23
11 September	13.41	-	19.75	16.58	-	5.75	4.67	-	5.21
12 December	3.57	-	3.13	3.35	-	0.28	0.39	-	0.34
$\bar{x}$	6.67	-	6.76	6.72	-	2.92	2.25	-	2.59
27 March 1974	8.77	6.57	7.54	7.63	-	5.40	9.00	9.04	7.81
11 June	0.70	0.77	0.80	0.76	-	0.74	2.14	1.74	1.54
10 September	4.14	1.83	0.80	2.26	-	10.63	3.54	3.30	5.82
10 December	10.50	9.17	9.00	9.56	-	2.07	3.17	2.68	2.64
$\bar{x}$	6.03	4.59	4.54	5.05	-	4.71	4.46	4.19	4.45
16 April 1975	34.97	33.33	34.00	34.10	2.59	6.30	14.20	12.43	8.88
10 June	3.67	1.84	2.27	2.59	2.00	2.07	2.43	2.54	2.26
9 September	10.97	10.34	6.70	9.34	3.57	6.17	10.07	30.00	12.45
3 December	21.67	6.57	7.87	12.04	9.27	1.75	10.50	3.29	6.20
$\bar{x}$	17.82	13.02	12.71	14.52	4.36	4.07	9.30	12.07	7.45
25 February 1976	38.67	11.67	17.33	22.56	51.67	4.63	1.46	1.63	14.85
6 April	18.33	15.37	16.63	16.78	7.57	3.30	5.80	3.93	5.15
3 May	6.67	-	-	6.67	-	-	-	-	-
15 June	16.00	14.23	12.77	14.33	2.37	7.93	10.90	27.00	12.05
12 July	11.43	-	-	11.43	-	-	-	-	-
10 August	7.27	16.00	16.00	13.09	13.57	12.10	14.67	6.67	11.75
5 October	7.17	9.73	19.73	12.21	7.90	5.37	-	-	6.64
14 December	6.33	2.99	2.53	3.95	-	-	-	-	-
$\bar{x}$	22.74	11.67	14.17	16.85	16.62	6.67	6.57	9.81	10.11
22 February 1977	12.27	12.43	11.60	12.10	16.37	-	5.30	-	10.84
5 April	21.33	14.53	14.33	16.73	13.67	-	17.00	-	15.34
2 May	13.37	-	-	13.37	-	-	-	-	-
9 June	1.53	1.47	1.53	1.51	0.68	-	12.83	17.93	10.48
11 July	1.77	-	-	1.77	-	-	-	-	-
9 August	35.90	28.54	43.25	35.90	28.11	-	12.30	35.03	19.45
4 October	8.54	6.32	5.26	6.71	12.65	-	7.73	3.82	8.07
13 December	8.20	7.61	7.96	7.92	4.79	-	6.49	3.13	4.80
$\bar{x}$	12.86	11.82	13.99	12.89	12.72	-	9.89	14.98	12.22
22 February 1978	35.04	29.85	28.98	31.29	5.94	-	2.70	4.36	4.33
25 April	12.00	10.33	9.54	10.62	4.40	-	8.66	6.49	6.52
22 May	38.62	-	-	38.62	-	-	-	-	-
27 June	30.11	21.29	23.42	24.94	11.20	-	24.94	31.63	22.59
19 July	41.97	-	-	41.97	-	-	-	-	-
29 August	24.63	20.68	27.98	24.43	34.98	-	-	-	34.98
10 October	37.41	14.86	14.56	22.28	47.14	-	42.88	-	45.01
12 December	20.07	2.95	2.15	8.39	35.28	-	8.56	9.05	17.63
$\bar{x}$	29.98	16.66	17.78	21.47	23.16	-	17.55	12.88	17.86
20 February 1979	3.38	2.50	1.42	2.43	-	-	-	-	-
10 April	6.40	5.61	5.41	5.81	-	-	-	-	-
21 May	11.22	-	-	11.22	-	-	-	-	-
12 June	2.66	5.61	4.64	4.30	-	-	-	-	-
9 July	1.53	-	-	1.53	-	-	-	-	-
7 August	21.53	17.07	16.62	18.41	-	-	-	-	-
9 October	11.52	10.21	11.11	10.95	-	-	-	-	-
11 December	48.06	50.96	50.64	49.89	-	-	-	-	-
$\bar{x}$	13.29	15.33	14.97	14.40	-	-	-	-	-

[a] Location 1 was in John Redmond Reservoir prior to 1976.
[b] Samples not collected.

Table B-9 Mean carbon fixation rate (mg C/m^3 per hr) in phytoplankton samples collected near Wolf Creek Generating Station, Burlington, Kansas, 1973-1979.

Date	Neosho River				Wolf Creek				
	1[a]	10	4	$\bar{X}$	7	2	3	5	$\bar{X}$
12 April 1973	3.51	-[b]	3.96	3.74	-	6.57	2.99	-	4.78
12 June	29.61	-	22.34	25.98	-	8.33	22.11	-	15.22
11 September	28.00	-	35.06	31.53	-	45.39	51.71	-	48.55
12 December	5.45	-	5.21	5.33	-	0.39	0.25	-	0.32
$\bar{X}$	16.64	-	16.64	16.64	-	15.17	19.27	-	17.22
27 March 1974	18.29	17.45	18.90	18.21	-	7.31	11.60	14.85	11.25
11 June	15.57	0.15	11.40	9.04	-	2.32	1.40	2.10	1.94
10 September	7.30	5.62	5.94	6.29	-	47.89	14.51	10.16	24.19
10 December	24.83	22.92	22.92	23.56	-	4.05	5.72	2.55	4.11
$\bar{X}$	16.50	11.54	14.79	14.28	-	15.39	8.31	7.42	10.37
16 April 1975	90.90	125.98	130.65	115.84	11.03	12.33	33.82	27.72	21.23
10 June	14.24	6.87	2.54	7.88	5.15	3.33	2.36	1.61	3.11
9 September	44.26	36.82	24.66	35.25	9.23	14.69	-	93.34	39.09
3 December	32.18	10.39	10.38	17.65	25.49	0.36	7.09	2.50	8.86
$\bar{X}$	45.40	45.02	42.06	44.16	12.73	7.68	14.42	31.29	16.67
25 February 1976	21.66	20.35	20.82	20.94	36.36	11.08	5.78	1.79	13.75
6 April	58.82	62.25	64.23	61.77	13.90	15.10	43.58	11.50	21.02
3 May	21.11	-	-	21.11	-	-	-	-	-
15 June	45.79	45.97	41.07	44.28	3.59	26.34	32.82	36.98	24.93
12 July	71.12	-	-	71.12	-	-	-	-	-
10 August	26.23	80.69	95.59	67.50	43.86	61.47	53.81	26.89	46.51
5 October	41.58	46.35	79.01	55.65	20.83	8.74	-	-	14.79
14 December	21.39	5.27	4.84	10.50	-	-	-	-	-
$\bar{X}$	38.46	43.48	50.93	43.71	23.71	24.55	34.00	19.29	25.25
22 February 1977	67.42	69.00	77.00	71.14	54.69	-	25.71	-	40.20
5 April	55.25	45.02	45.32	48.53	3.12	-	47.85	-	25.49
2 May	68.18	-	-	68.18	-	-	-	-	-
9 June	5.30	5.75	7.04	6.03	2.06	-	42.04	49.55	31.22
11 July	4.09	-	-	4.09	-	-	-	-	-
9 August	34.28	33.34	45.35	37.66	50.05	-	16.98	42.60	36.54
4 October	15.09	13.30	13.22	13.87	18.06	-	11.46	3.95	11.16
13 December	15.42	14.47	13.99	14.63	6.87	-	9.91	3.16	6.65
$\bar{X}$	33.13	30.15	33.55	32.39	22.48	-	25.66	24.82	24.26
22 February 1978	6.71	8.08	6.56	7.12	1.90	-	0.54	0.91	1.12
25 April	6.51	4.90	5.76	5.72	-	-	4.36	4.78	4.57
22 May	0.74	-	-	0.74	-	-	-	-	-
27 June	25.80	24.54	30.52	26.95	10.46	-	23.37	28.69	20.54
19 July	100.67	-	-	100.67	-	-	-	-	-
29 August	28.24	45.14	51.68	41.69	148.68	-	-	-	148.68
30 October	26.64	13.45	17.66	19.25	25.11	-	42.66	-	33.89
12 December	12.19	1.55	2.58	5.44	16.89	-	33.48	9.20	19.59
$\bar{X}$	25.94	16.28	19.13	20.45	40.60	-	20.88	10.89	24.12
20 February 1979	3.35	1.15	0.92	1.81	-	-	-	-	-
10 April	12.00	10.42	9.77	10.73	-	-	-	-	-
21 May	33.60	-	-	33.60	-	-	-	-	-
12 June	11.18	16.59	16.65	14.81	-	-	-	-	-
9 July	3.13	-	-	3.13	-	-	-	-	-
7 August	43.60	56.46	61.55	53.87	-	-	-	-	-
9 October	50.85	46.04	48.32	48.40	-	-	-	-	-
11 December	6.99	6.19	6.72	6.63	-	-	-	-	-
$\bar{X}$	20.59	22.81	23.99	22.27	-	-	-	-	-

[a] Location 1 was in John Redmond Reservoir prior to 1976.
[b] Samples not collected.

APPENDIX C

PERIPHYTON DATA

Table C-1 Identification, abundance and biovolume of periphytic algae collected from artificial substrates in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 17 June 1980.

Location 4

TAXON	MEAN UNITS #/SQ.CM.	%	MEAN BIOVOLUME MICRO L/SQ.DM.	%	STAN. DEV.
BACILLARIOPHYTA					
COCCONEIS PLACENTULA	462469.	15.1	16.4	8.8	54724.41
NITZSCHIA FRUSTULUM	250582.	8.2	0.5	0.3	83422.31
NAVICULA CRYPTOCEPHALA	226987.	7.4	3.4	1.8	667.51
GOMPHONEMA PARVULUM	170358.	5.6	3.2	1.7	35370.89
NITZSCHIA DISSIPATA	125527.	4.1	4.0	2.1	33368.37
ACHNANTHES LINEARIS	122223.	4.0	0.5	0.2	44713.90
ACHNANTHES MINUTISSIMA	104763.	3.4	0.4	0.2	54724.41
CYCLOTELLA ATOMUS	85415.	2.8	0.3	0.2	20688.53
NAVICULA VAUCHERIAE	68426.	2.2	0.3	0.1	43379.59
STEPHANODISCUS INVISITATUS	25011.	0.8	0.4	0.2	667.51
NITZSCHIA HANTZSCHIANA	23594.	0.8	0.2	0.1	17351.70
STEPHANODISCUS ASTRAEA	22179.	0.7	1.6	0.9	667.51
NITZSCHIA PALEA	21707.	0.7	0.3	0.2	4004.35
NAVICULA HEUFLERI	18404.	0.6	0.7	0.4	14014.86
GOMPHONEMA TERGESTINUM	12741.	0.4	0.3	0.1	8676.20
NITZSCHIA KUTZINGIANA	12269.	0.4	0.1	0.0	9343.71
COCCONEIS PEDICULUS	5662.	0.2	1.1	0.6	1334.31
RHOICOSPHENIA CURVATA	3775.	0.1	0.3	0.1	0.00
ACHNANTHES LANCEOLATA	3303.	0.1	0.0	0.0	2002.53
AMPHORA VENETA	2831.	0.0	0.0	0.0	1335.02
CYMBELLA SINUATA	2831.	0.0	0.0	0.0	1335.02
CYMBELLA LUNATA	2359.	0.0	0.1	0.1	3336.84
CYCLOTELLA PSEUDOSTELLIGERA	2359.	0.0	0.0	0.0	667.51
NAVICULA SCHONFELDII	1887.	0.1	0.1	0.0	2669.33
CYMBELLA MINUTA	1887.	0.1	0.1	0.0	2669.33
FRAGILARIA VAUCHERIAE	1887.	0.1	0.0	0.0	2669.33
NAVICULA NOTHA	1415.	0.0	0.0	0.0	2001.82
MELOSIRA DISTANS	1415.	0.0	0.0	0.0	2001.82
MELOSIRA GRANULATA	943.	0.0	0.0	0.0	1334.31
NAVICULA RADIOSA	943.	0.0	0.0	0.0	1334.31
MELOSIRA VARIANS	943.	0.0	0.1	0.1	1334.31
NITZSCHIA AMPHIBIA	943.	0.0	0.0	0.0	1334.31
CYCLOTELLA MENEGHINIANA	943.	0.0	0.0	0.0	0.00
NAVICULA SYMMETRICA	471.	0.0	0.0	0.0	666.80
TOTAL BACILLARIOPHYTA	1789463.	58.6	34.7	18.6	176186.90
CHLOROPHYTA					
CLADOPHORA GLOMERATA	91146.	3.0	139.4	74.9	128900.60
STIGEOCLONIUM TENUE	86512.	2.8	2.5	1.3	83021.37
CHLAMYDOMONAS SPP.	10813.	0.4	1.2	0.7	2184.25
PEDIASTRUM TETRAS	3089.	0.1	0.1	0.1	4369.21
COSMARIUM SPP.	1544.	0.1	2.1	1.1	2184.25
SCENEDESMUS ABUNDANS	1544.	0.1	0.0	0.0	2184.25
TOTAL CHLOROPHYTA	194650.	6.4	145.3	78.1	48064.17
CHRYSOPHYTA					
	7724.	0.3	0.2	0.1	10923.39
TOTAL CHRYSOPHYTA	7724.	0.3	0.2	0.1	10923.39
CYANOPHYTA					
LYNGBYA EPIPHYTICA	812597.	26.6	4.9	2.6	113608.00
LYNGBYA LIMNETICA	122043.	4.0	0.1	0.1	24032.44
PHORMIDIUM TENUE	67973.	2.2	0.5	0.3	8739.13
CHROOCOCCUS SPP.	35531.	1.2	0.2	0.0	2184.96
LYNGBYA NORDGAARDII	24717.	0.8	0.0	0.0	34955.82
TOTAL CYANOPHYTA	1062863.	34.8	5.7	3.1	96130.44
MISCELLANEOUS					
CRYPTOMONAS SPP.	1544.	0.1	0.2	0.1	2184.25
TOTAL MISCELLANEOUS	1544.	0.1	0.2	0.1	2184.25
TOTAL PERIPHYTON	3056249.	100.0	186.1	100.0	329120.70

Table C-1 (continued)

Location 10

TAXON	MEAN UNITS #/SQ.CM.	%	MEAN BIOVOLUME MICRO L/SQ.CM.	%	STAN. DEV.
BACILLARIOPHYTA					
COCCONEIS PLACENTULA	375605.	28.9	13.3	49.5	79429.31
NITZSCHIA FRUSTULUM	54994.	4.2	0.1	0.4	38060.02
NAVICULA CRYPTOCEPHALA	45048.	3.5	0.7	2.5	4137.28
ACHNANTHES MINUTISSIMA	33347.	2.6	0.1	0.5	10755.80
NAVICULA VAUCHERIAE	23987.	1.8	0.1	0.4	827.31
NITZSCHIA KUTZINGIANA	23986.	1.8	0.3	1.1	23994.25
GOMPHONEMA PARVULUM	21646.	1.7	0.4	1.5	9101.17
ACHNANTHES LINEARIS	14626.	1.1	0.0	0.0	4136.57
NITZSCHIA HANTZSCHIANA	8775.	0.7	0.0	0.3	2481.94
NITZSCHIA DISSIPATA	8775.	0.7	0.3	1.0	827.31
CYCLOTELLA ATOMUS	8190.	0.6	0.0	0.1	4964.60
FRAGILARIA VAUCHERIAE	8190.	0.6	0.2	0.6	11583.12
GOMPHONEMA OLIVACEUM	7605.	0.6	0.2	0.9	9101.17
STEPHANODISCUS INVISITATUS	7605.	0.6	0.1	0.5	827.31
STEPHANODISCUS ASTRAEA	5850.	0.4	0.4	1.6	3309.26
NITZSCHIA PALEA	5850.	0.4	0.0	0.3	4963.89
NAVICULA HEUFLERI	2340.	0.2	0.0	0.3	3309.26
CYMBELLA SINUATA	1755.	0.1	0.0	0.2	2481.94
NAVICULA TRIPUNCTATA	1170.	0.0	0.0	0.1	0.00
CYCLOTELLA PSEUDOSTELLIGERA	1170.	0.0	0.0	0.0	1654.63
NAVICULA GREGARIA	585.	0.0	0.0	0.0	827.31
ACHNANTHES LEWISIANA	585.	0.0	0.0	0.0	827.31
CYCLOTELLA MENEGHINIANA	585.	0.0	0.0	0.1	827.31
COCCONEIS PEDICULUS	585.	0.0	0.1	0.4	827.31
TOTAL BACILLARIOPHYTA	662858.	51.0	16.8	62.5	91839.00
CHLOROPHYTA					
STIGEOCLONIUM TENUE	178119.	13.7	5.1	18.8	251899.00
UNIDENTIFIED GREEN COCCOID	36390.	2.8	2.6	9.6	51463.23
SELENASTRUM WESTII	1915.	0.1	0.0	0.0	2708.22
TOTAL CHLOROPHYTA	216424.	16.6	7.7	28.4	306070.40
CYANOPHYTA					
LYNGBYA EPIPHYTICA	233662.	18.0	1.4	5.2	135430.10
LYNGBYA LIMNETICA	135983.	10.5	0.1	0.4	24377.51
PHORMIDIUM TENUE	28728.	2.2	0.2	0.8	8125.36
CHROOCOCCUS SPP.	17237.	1.3	0.0	0.3	2708.22
TOTAL CYANOPHYTA	415611.	32.0	1.8	6.6	121886.10
MISCELLANEOUS					
CRYPTOMONAS SPP.	3830.	0.3	0.5	1.8	5417.14
TRACHELOMONAS SPP.	1915.	0.1	0.2	0.7	2708.22
TOTAL MISCELLANEOUS	5745.	0.4	0.7	2.5	2708.93
TOTAL PERIPHYTON	1300641.	100.0	27.0	100.0	522504.50

Table C-2 Identification, abundance and biovolume of periphytic algae collected from artificial substrates in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 12 August 1980.

Location 4

TAXON	MEAN UNITS #/SQ.CM.	%	MEAN BIOVOLUME MICRO L/SQ.DM.	%	STAN. DEV.
BACILLARIOPHYTA					
NITZSCHIA FRUSTULUM	432739.	19.9	1.2	1.6	86091.69
COCCONEIS PLACENTULA	235953.	10.9	8.4	11.6	12013.03
STEPHANODISCUS INVISITATUS	126942.	5.8	1.6	2.2	16684.19
NITZSCHIA PALEA	82111.	3.8	0.6	0.9	6674.38
NITZSCHIA SUBACICULARIS	79752.	3.7	0.2	0.3	4671.15
NAVICULA HEUFLERI	62291.	2.9	1.5	2.1	17351.70
GOMPHONEMA PARVULUM	54740.	2.5	1.5	2.1	9343.00
ACHNANTHES LINEARIS	47190.	2.2	0.2	0.3	28029.72
NAVICULA SYMMETRICA	28314.	1.3	1.4	2.0	4003.64
CYCLOTELLA MENEGHINIANA	24538.	1.1	1.4	1.9	2669.33
CYCLOTELLA ATOMUS	21235.	1.0	0.0	0.1	4671.86
STEPHANODISCUS ASTRAEA	17932.	0.8	0.7	1.0	1335.02
NITZSCHIA AMPHIBIA	15572.	0.7	0.0	0.0	4671.86
NAVICULA VAUCHERIAE	13213.	0.6	0.0	0.1	1335.02
NITZSCHIA FILIFORMIS	11797.	0.5	0.8	1.1	3336.84
NAVICULA RHYNCHOCEPHALA	9437.	0.4	0.6	0.8	4004.35
NITZSCHIA LINEARIS	4719.	0.2	0.4	0.5	6673.67
ACHNANTHES MINUTISSIMA	3775.	0.2	0.0	0.0	5338.66
NAVICULA CRYPTOCEPHALA	3774.	0.2	0.0	0.1	2669.33
MELOSIRA GRANULATA	3303.	0.2	0.1	0.0	667.51
NITZSCHIA ANGUSTATA	2831.	0.1	0.0	0.1	1335.02
ACHNANTHES EXIGUA	2831.	0.1	0.0	0.0	4003.64
NITZSCHIA DISSIPATA	2831.	0.1	0.0	0.1	1335.02
NAVICULA ARVENSIS	1887.	0.0	0.0	0.0	0.00
ACHNANTHES LANCEOLATA	1415.	0.0	0.0	0.0	2001.82
NAVICULA MENISCULUS	1415.	0.0	0.0	0.0	2001.82
CYMBELLA TUMIDA	943.	0.0	0.5	0.7	1334.31
RHOICUSPHENIA CURVATA	943.	0.0	0.0	0.0	1334.31
AMPHORA OVALIS	943.	0.0	0.0	0.0	1334.31
NAVICULA PYGMAEA	471.	0.0	0.0	0.0	666.80
TOTAL BACILLARIOPHYTA	1295847.	59.6	21.6	29.9	150829.40
CHLOROPHYTA					
STIGEOCLONIUM TENUE	61794.	2.8	4.0	5.5	87389.94
CLADOPHORA GLOMERATA	37076.	1.7	38.0	52.7	52434.09
MOUGEOTIA SPP.	24717.	1.1	1.3	1.7	34955.82
UNIDENTIFIED FILAMENTOUS GREEN	16993.	0.8	1.3	1.9	24031.73
ANKISTRODESMUS FALCATUS	4634.	0.2	0.0	0.0	6554.17
UNIDENTIFIED GREEN COCCOID	4634.	0.2	0.9	1.2	2184.96
SELENASTRUM MINUTUM	1544.	0.0	0.0	0.0	2184.25
KIRCHNERIELLA SUBSOLITARIA	1544.	0.0	0.0	0.0	2184.25
SCENEDESMUS QUADRICAUDA	1544.	0.0	0.0	0.1	2184.25
TOTAL CHLOROPHYTA	154483.	7.1	45.4	63.1	39323.62
CHRYSOPHYTA					
TRIBONEMA BOMBYCINUM	21628.	1.0	1.7	2.4	30586.61
TOTAL CHRYSOPHYTA	21628.	1.0	1.7	2.4	30586.61
CYANOPHYTA					
LYNGBYA LIMNETICA	364587.	16.8	0.9	1.2	349562.40
LYNGBYA EPIPHYTICA	291978.	13.4	1.8	2.4	111423.10
LYNGBYA AERUGINEO-CAERULEA	23172.	1.1	0.5	0.6	32770.87
PHORMIDIUM TENUE	15448.	0.7	0.0	0.1	21847.48
CHROOCOCCUS SPP.	3089.	0.1	0.0	0.0	4369.21
CALOTHRIX EPIPHYTICA	1544.	0.0	0.0	0.0	2184.25
CHROOCOCCUS LIMNETICUS	1544.	0.0	0.1	0.2	2184.25
TOTAL CYANOPHYTA	701364.	32.3	3.4	4.7	458799.90
TOTAL PERIPHYTON	2173328.	100.0	72.1	100.0	618366.30

Table C-2 (continued)

Location 10

TAXON	MEAN UNITS #/SQ.CM.	%	MEAN BIOVOLUME MICRO L/SQ.DM.	%	STAN. DEV.
BACILLARIOPHYTA					
COCCONEIS PLACENTULA	976830.	35.8	34.7	48.5	54484.70
NITZSCHIA FRUSTULUM	254771.	9.3	0.7	1.0	133575.30
STEPHANODISCUS INVISITATUS	184553.	6.8	2.3	3.3	2636.80
NAVICULA HEUFLERI	182689.	6.7	4.4	6.2	50969.67
NITZSCHIA SUBACICULARIS	154726.	5.7	0.4	0.5	43060.68
NITZSCHIA PALEA	53439.	2.0	0.4	0.6	7030.76
ACHNANTHES LINEARIS	44740.	1.6	0.2	0.3	17575.84
NAVICULA VAUCHERIAE	35419.	1.3	0.2	0.3	878.23
NAVICULA SYMMETRICA	35418.	1.3	1.8	2.5	7908.99
NAVICULA RHYNCHOCEPHALA	31690.	1.2	1.9	2.7	11424.72
CYCLOTELLA MENEGHINIANA	26719.	1.0	1.5	2.1	7908.99
STEPHANODISCUS ASTRAEA	26098.	1.0	1.1	1.5	3515.73
CYCLOTELLA ATOMUS	13670.	0.5	0.1	0.0	5272.89
NITZSCHIA ANGUSTATA	5592.	0.2	0.1	0.1	4393.96
NITZSCHIA AMPHIBIA	5592.	0.2	0.0	0.0	6151.83
NAVICULA MENISCULUS	4970.	0.2	0.1	0.2	3515.03
GOMPHONEMA PARVULUM	4970.	0.2	0.1	0.2	5272.89
ACHNANTHES EXIGUA	3728.	0.1	0.0	0.0	5272.19
NAVICULA CRYPTOCEPHALA	3727.	0.1	0.0	0.1	3515.03
MELOSIRA GRANULATA	3106.	0.1	0.0	0.1	878.93
GYROSIGMA SPENCERII	3106.	0.1	0.9	1.2	878.93
NAVICULA CINCTA	3106.	0.1	0.1	0.1	4393.25
NAVICULA CAPITATA	2485.	0.0	0.0	0.1	0.00
ACHNANTHES MINUTISSIMA	1864.	0.0	0.0	0.0	2636.09
AMPHORA VENETA	1242.	0.0	0.0	0.0	1757.16
GOMPHONEMA TERGESTINUM	1242.	0.0	0.0	0.0	1757.16
NITZSCHIA KUTZINGIANA	1242.	0.0	0.0	0.0	1757.16
NITZSCHIA DISSIPATA	1242.	0.0	0.0	0.0	1757.16
NITZSCHIA ANGUSTATA	621.	0.0	0.0	0.0	878.23
FRAGILARIA CAPUCINA	621.	0.0	0.0	0.0	878.23
NAVICULA ACCOMODA	621.	0.0	0.0	0.0	878.23
NAVICULA ARVENSIS	621.	0.0	0.0	0.0	878.23
TOTAL BACILLARIOPHYTA	2070474.	75.8	51.3	71.8	291755.10
CHLOROPHYTA					
OEDOGONIUM SPP.	81369.	3.0	7.8	10.9	115073.10
STIGEOCLONIUM TENUE	40684.	1.5	2.6	3.6	57536.57
UNIDENTIFIED GREEN COCCOID	22376.	0.8	4.2	5.9	14383.96
SCENEDESMUS LONGUS	2034.	0.0	0.0	0.0	2876.51
SCENEDESMUS DIMORPHUS	2034.	0.0	0.1	0.1	2876.51
TOTAL CHLOROPHYTA	148497.	5.4	14.8	20.7	48905.63
CYANOPHYTA					
LYNGBYA EPIPHYTICA	187148.	6.9	1.1	1.6	11506.75
LYNGBYA LIMNETICA	176977.	6.5	0.4	0.6	31645.15
PHORMIDIUM TENUE	50855.	1.9	0.3	0.4	43152.61
LYNGBYA AERUGINEO-CAERULEA	34581.	1.3	0.7	1.0	2877.22
CHROOCOCCUS SPP.	34581.	1.3	0.4	0.5	14384.67
CHROOCOCCUS LIMNETICUS	28478.	1.0	2.5	3.5	5753.73
TOTAL CYANOPHYTA	512623.	18.8	5.4	7.6	63288.89
TOTAL PERIPHYTON	2731598.	100.0	71.5	100.0	277371.80

Table C-3 Identification, abundance and biovolume of periphytic algae collected from artificial substrates in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 27 October 1980.

Location 4

TAXON	MEAN UNITS #/SQ.CM.	%	MEAN BIOVOLUME MICRO L/SQ.DM.	%	STAN. DEV.
BACILLARIOPHYTA					
GOMPHONEMA PARVULUM	65070.	9.7	1.0	1.8	32268.82
NAVICULA GRACILOIDES	42736.	6.4	1.2	2.2	40633.89
NITZSCHIA FRUSTULUM	37545.	5.6	0.3	0.5	3927.27
NITZSCHIA PALEA	37062.	5.5	0.4	0.6	16561.15
NITZSCHIA FRUSTULUM V. PERMINUTA	24989.	3.7	0.0	0.0	20317.30
NITZSCHIA KUTZINGIANA	16297.	2.4	0.1	0.3	6658.82
COCCONEIS PLACENTULA	15694.	2.3	0.6	1.1	6829.24
NITZSCHIA SUBACICULARIS	14728.	2.2	0.0	0.0	14682.36
STEPHANODISCUS INVISITATUS	10140.	1.5	0.0	0.1	3414.62
NITZSCHIA DISSIPATA	9537.	1.4	0.2	0.4	1195.01
NAVICULA RHYNCHOCEPHALA	9416.	1.4	0.5	0.8	6467.70
ACHNANTHES MINUTISSIMA	7726.	1.2	0.0	0.0	3073.09
NAVICULA MINIMA	6519.	1.0	0.0	0.0	6146.17
NAVICULA RHYNCHOCEPHALA V. GERMAINII	5070.	0.8	0.2	0.3	1023.89
CYCLOTELLA ATOMUS	4949.	0.7	0.0	0.0	511.95
NAVICULA TRIPUNCTATA V. SCHIZONEMOIDES	4829.	0.7	0.2	0.3	0.00
NAVICULA SYMMETRICA	4346.	0.6	0.2	0.4	6146.17
CYCLOTELLA MENEGHINIANA	3863.	0.6	0.3	0.5	1366.13
NITZSCHIA FILIFORMIS	3500.	0.5	0.2	0.3	4268.80
ACHNANTHES LINEARIS	2897.	0.4	0.0	0.0	4096.96
NITZSCHIA ACICULARIS	2776.	0.4	0.0	0.0	3926.56
STEPHANODISCUS ASTRAEA V. MINUTULA	2414.	0.4	0.0	0.0	340.83
NITZSCHIA CAPITELLATA	2173.	0.3	0.1	0.2	3073.09
NAVICULA CAPITATA V. HUNGARICA	2051.	0.3	0.0	0.1	1536.54
DENTICULA ELEGANS	1810.	0.3	0.0	0.0	1195.01
NITZSCHIA SUBCAPITELLATA	1448.	0.2	0.1	0.0	0.00
GOMPHONEMA SUBCLAVATUM V. MEXICANUM	1327.	0.2	0.0	0.1	1195.72
MELOSIRA DISTANS V. LIRATA	1327.	0.2	0.0	0.0	853.48
SYNEDRA MINUSCULA	1327.	0.2	0.0	0.0	1877.37
NAVICULA SPP.	1086.	0.2	0.0	0.0	1195.01
NITZSCHIA LONGISSIMA	1086.	0.2	0.0	0.0	171.12
NAVICULA CRYPTOCEPHALA V. VENETA	1086.	0.2	0.0	0.0	854.19
NAVICULA MURALIS	844.	0.1	0.0	0.0	512.65
ACHNANTHES LANCEOLATA	724.	0.1	0.0	0.0	1023.89
NITZSCHIA SPP.	724.	0.1	0.0	0.0	1023.89
SURIRELLA SUECICA	723.	0.1	0.0	0.0	341.53
NITZSCHIA MICROCEPHALA	482.	0.0	0.0	0.0	0.00
NITZSCHIA CLAUSII	482.	0.0	0.0	0.0	0.00
CALONEIS BACILLUM	482.	0.0	0.0	0.0	0.00
ACHNANTHES EXIGUA	482.	0.0	0.0	0.0	0.00
NAVICULA CRYPTOCEPHALA	362.	0.1	0.0	0.0	511.95
PLEUROSIGMA DELICATULUM	362.	0.1	0.2	0.4	511.95
NAVICULA DECUSSIS	241.	0.0	0.0	0.0	340.83
GOMPHONEMA GRACILE	241.	0.0	0.0	0.1	340.83
CYMBELLA MEXICANA	241.	0.0	0.2	0.3	340.83
NAVICULA AURICULATA	241.	0.0	0.0	0.0	340.83
NITZSCHIA THYMLIONELLA V. VICTORIAE	241.	0.0	0.0	0.0	340.83
NITZSCHIA THYMLIONELLA V. DEBILIS	241.	0.0	0.0	0.0	340.83
NITZSCHIA HUNGARICA	241.	0.0	0.0	0.0	340.83
AMPHORA VENETA	241.	0.0	0.0	0.0	340.83
MELOSIRA VARIANS	120.	0.0	0.0	0.0	170.41
GYROSIGMA OBTUSATUM	120.	0.0	0.0	0.0	170.41
TOTAL BACILLARIOPHYTA	354667.	52.9	6.5	11.8	166293.90

Table C-3 (continued)

Location 4

TAXON	MEAN UNITS #/SQ.CM.	%	MEAN BIOVOLUME MICRO L/SQ.DM.	%	STAN. DEV.
CHLOROPHYTA					
OEDOGONIUM SPP.	189036.	28.2	43.1	78.1	195831.10
CHARACIUM AMBIGUUM	14364.	2.1	0.4	0.8	8937.83
CHLAMYDOMONAS SPP.	3447.	0.5	0.0	0.1	0.00
UNIDENTIFIED GREEN COCCOID	2872.	0.4	4.1	7.4	4062.33
STIGEOCLONIUM TENUE	2298.	0.3	0.3	0.6	3249.86
ANKISTRODESMUS FALCATUS	1723.	0.3	0.0	0.0	812.47
ANKISTRODESMUS SPIRALIS	574.	0.0	0.0	0.0	812.47
SCENEDESMUS QUADRICAUDA	574.	0.0	0.0	0.0	812.47
TETRASTRUM STAUROGENIAEFORME	574.	0.0	0.0	0.0	812.47
KIRCHNERIELLA SUBSOLITARIA	574.	0.0	0.0	0.0	812.47
TOTAL CHLOROPHYTA	216039.	32.2	48.1	87.1	183643.40
CYANOPHYTA					
LYNGBYA DIGUETII	34474.	5.1	0.2	0.4	13001.57
OSCILLATORIA LIMNETICA	24706.	3.7	0.0	0.0	20314.47
LYNGBYA NORDGAARDII	17237.	2.6	0.1	0.1	24376.80
ANABAENA SPP.	10342.	1.5	0.0	0.1	8126.07
OSCILLATORIA SPP.	5745.	0.9	0.0	0.0	3250.57
CHROOCOCCUS SPP.	5171.	0.8	0.1	0.1	5687.97
TOTAL CYANOPHYTA	97676.	14.6	0.5	0.8	22752.57
MISCELLANEOUS					
CRYPTOMONAS SPP.	1723.	0.3	0.1	0.2	812.47
TOTAL MISCELLANEOUS	1723.	0.3	0.1	0.2	812.47
TOTAL PERIPHYTON	670107.	100.0	55.2	100.0	40914.61

Table C-3 (continued)

Location 10

TAXON	MEAN UNITS #/SQ.CM.	%	MEAN BIOVOLUME MICRO L/SQ.CM.	%	STAN. DEV.
BACILLARIOPHYTA					
COCCONEIS PLACENTULA	72918.	13.5	2.9	23.4	11951.52
NITZSCHIA FRUSTULUM	50100.	9.2	0.3	2.8	9731.91
NITZSCHIA PALEA	40925.	7.6	0.4	3.1	13828.89
NITZSCHIA FRUSTULUM V. PERMINUTA	35734.	6.6	0.0	0.2	7853.84
NAVICULA GRACILOIDES	22092.	4.1	0.6	5.0	15195.02
GOMPHONEMA PARVULUM	20885.	3.9	0.3	2.6	9731.20
NAVICULA RHYNCHOCEPHALA	19315.	3.6	0.9	7.6	5463.81
STEPHANODISCUS INVISITATUS	17263.	3.2	0.1	1.0	3244.21
NAVICULA MINIMA	16780.	3.1	0.1	0.8	6999.65
NITZSCHIA SUBACICULARIS	12675.	2.3	0.0	0.2	5292.70
NAVICULA RHYNCHOCEPHALA V. GERMAINII	12072.	2.2	0.5	3.7	8536.19
ACHNANTHES MINUTISSIMA	10865.	2.0	0.0	0.3	1366.13
NAVICULA MENISCULUS V. UPSALIENSIS	9899.	1.8	0.1	0.8	4780.04
NITZSCHIA KUTZINGIANA	9054.	1.7	0.0	0.6	3244.21
CYCLOTELLA MENEGHINIANA	8450.	1.6	0.6	5.3	3414.62
MELOSIRA DISTANS V. LIRATA	7726.	1.4	0.0	0.3	1023.89
CYCLOTELLA ATOMUS	7243.	1.3	0.0	0.3	2732.26
STEPHANODISCUS ASTRAEA V. MINUTULA	6156.	1.1	0.0	0.8	853.48
NITZSCHIA ACICULARIS	6036.	1.1	0.0	0.4	3073.09
NITZSCHIA SUBCAPITELLATA	5432.	1.0	0.2	1.6	2561.14
ACHNANTHES LINEARIS	5311.	1.0	0.0	0.1	4097.68
NAVICULA CRYPTOCEPHALA	5190.	1.0	0.3	2.6	2902.67
NAVICULA SYMMETRICA	4949.	0.9	0.2	1.9	853.48
NITZSCHIA TRYBLIONELLA V. DEBILIS	4949.	0.9	0.1	0.8	1878.08
SURIRELLA SUECICA	4346.	0.8	0.1	1.1	0.00
AMPHORA PERPUSILLA	4345.	0.8	0.0	0.2	2731.55
NAVICULA CAPITATA V. HUNGARICA	3983.	0.7	0.1	1.2	1195.72
NAVICULA CRYPTOCEPHALA V. VENETA	3983.	0.7	0.1	0.4	2902.67
DENTICULA ELEGANS	3742.	0.7	0.0	0.1	1195.01
NITZSCHIA DISSIPATA	3742.	0.7	0.0	0.7	4610.34
NITZSCHIA AMPHIBIA	3621.	0.7	0.0	0.2	2390.02
NITZSCHIA SPP.	3500.	0.6	0.2	1.5	170.41
ACHNANTHES EXIGUA	3500.	0.6	0.0	0.3	853.48
NAVICULA MINUSCULA	3138.	0.6	0.0	0.1	4438.51
NAVICULA SPP.	3138.	0.6	0.0	0.2	0.00
ACHNANTHES LANCEOLATA	2897.	0.5	0.0	0.1	1366.13
NITZSCHIA HUNGARICA	2172.	0.4	0.0	0.6	2390.73
NITZSCHIA FONTICOLA	1327.	0.2	0.0	0.0	170.41
CYMBELLA SINUATA	1327.	0.2	0.0	0.3	512.65
NITZSCHIA LONGISSIMA	1086.	0.2	0.0	0.1	511.95
AMPHORA VENETA	1086.	0.2	0.0	0.1	854.19
PLEUROSIGMA DELICATULUM	1086.	0.2	0.7	5.5	854.19
COCCONEIS PEDICULUS	965.	0.2	0.1	0.8	683.07
NITZSCHIA MICROCEPHALA	844.	0.2	0.0	0.0	853.48
NAVICULA AURICULATA	844.	0.2	0.0	0.1	853.48
NITZSCHIA ACCOMODATA	724.	0.1	0.0	0.1	1023.89
NITZSCHIA FILIFORMIS	724.	0.1	0.0	0.3	1023.89
NAVICULA TRIPUNCTATA V. SCHIZONEMOIDES	724.	0.1	0.0	0.2	1023.89
GOMPHONEMA SUBCLAVATUM V. MEXICANUM	723.	0.1	0.0	0.3	341.53
NITZSCHIA APICULATA	482.	0.0	0.0	0.1	682.36
MELOSIRA GRANULATA	482.	0.0	0.0	0.0	341.53
NITZSCHIA CLAUSII	482.	0.0	0.0	0.1	682.36
NITZSCHIA CAPITELLATA	482.	0.0	0.0	0.2	682.36
NAVICULA PUPULA	361.	0.0	0.0	0.0	170.41

Table C-3 (continued)

Location 10

TAXON	MEAN UNITS #/SQ.CM.	%	MEAN BIOVOLUME MICRO L/SQ.DM.	%	STAN. DEV.
GYROSIGMA OBTUSATUM	241.	0.0	0.0	0.6	0.00
NAVICULA GOTTLANDICA	241.	0.0	0.0	0.1	340.83
NITZSCHIA PERTICA	241.	0.0	0.0	0.1	340.83
MELOSIRA VARIANS	241.	0.0	0.0	0.2	340.83
SYNEDRA MINUSCULA	241.	0.0	0.0	0.0	340.83
MELOSIRA GRANULATA V. ANGUSTISSIMA	120.	0.0	0.0	0.0	170.41
NAVICULA DECUSSIS	120.	0.0	0.0	0.0	170.41
NITZSCHIA ADAPTA	120.	0.0	0.0	0.0	170.41
TOTAL BACILLARIOPHYTA	473456.	87.4	10.1	82.1	108583.30
CHLOROPHYTA					
CHLAMYDOMONAS SPP.	11491.	2.1	0.3	2.0	1624.93
ANKISTRODESMUS FALCATUS	4596.	0.8	0.0	0.1	1624.93
UNIDENTIFIED GREEN COCCOID	574.	0.1	0.8	6.6	812.47
KIRCHNERIELLA SUBSOLITARIA	574.	0.1	0.0	0.0	812.47
TOTAL CHLOROPHYTA	17236.	3.2	1.1	8.9	4874.79
CYANOPHYTA					
LYNGBYA DIGUETII	25855.	4.8	0.2	1.3	2437.40
OSCILLATORIA LIMNETICA	8618.	1.6	0.0	0.1	5687.97
ANABAENA SPP.	8043.	1.5	0.1	0.5	3250.57
CHROOCOCCUS SPP.	1723.	0.3	0.0	0.1	2437.40
TOTAL CYANOPHYTA	44240.	8.2	0.2	2.0	8938.54
MISCELLANEOUS					
CRYPTOMONAS SPP.	5170.	1.0	0.4	3.3	812.47
EUGLENA PROXIMA	1149.	0.2	0.2	1.7	1624.93
PHACUS LEMMERMANNII	574.	0.1	0.3	2.1	812.47
TOTAL MISCELLANEOUS	6894.	1.3	0.9	7.1	3249.86
TOTAL PERIPHYTON	541826.	100.0	12.3	100.0	119146.80

Table C-4 Identification, abundance and biovolume of periphytic algae collected from artificial substrates in the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 16 December 1980.

Location 4

TAXON	MEAN UNITS #/SQ.CM.	%	MEAN BIOVOLUME MICRO L/SQ.DM.	%	STAN. DEV.
BACILLARIOPHYTA					
NITZSCHIA ACICULARIS	1015139.	50.1	6.6	25.0	213224.50
SURIRELLA SUECICA	130191.	6.4	5.7	21.7	20880.15
NITZSCHIA PALEA	124822.	6.2	1.3	5.1	632.86
NITZSCHIA ACICULARIS V. ADELOS	101111.	5.0	0.2	0.6	1265.72
NITZSCHIA KUTZINGIANA	70688.	3.5	0.3	1.1	10122.94
STEPHANODISCUS INVISITATUS	67556.	3.3	0.7	2.5	9490.79
CYCLOTELLA ATOMUS	51003.	2.5	0.3	1.2	0.00
STEPHANODISCUS ASTRAEA V. MINUTULA	46081.	2.3	0.8	2.9	1897.87
NAVICULA CRYPTOCEPHALA	31317.	1.5	1.8	6.8	7592.91
NITZSCHIA DISSIPATA	29080.	1.4	0.8	3.2	632.86
NAVICULA MINIMA	25501.	1.3	0.0	0.3	5695.04
NITZSCHIA ACICULAROIDES	21922.	1.1	0.3	1.1	1897.87
CYCLOTELLA MENEGHINIANA	21027.	1.0	0.8	2.9	6959.34
NITZSCHIA FRUSTULUM V. PERMINUTA	17448.	0.9	0.0	0.0	1897.87
NITZSCHIA LONGISSIMA	14763.	0.7	0.1	0.2	4428.61
NITZSCHIA HUNGARICA	11632.	0.6	1.1	4.0	1265.72
MELOSIRA DISTANS V. LIRATA	10737.	0.5	0.0	0.3	0.00
NITZSCHIA CAPITELLATA	7605.	0.4	0.2	0.9	8225.07
NITZSCHIA FRUSTULUM	7157.	0.4	0.0	0.2	2530.74
NITZSCHIA SPP.	6263.	0.3	0.2	0.9	1265.72
SURIRELLA OVATA V. AFRICANA	5816.	0.3	0.2	0.7	3163.60
NAVICULA CRYPTOCEPHALA V. VENETA	5815.	0.3	0.2	0.6	632.86
GOMPHONEMA PARVULUM	4920.	0.2	0.1	0.4	632.86
NAVICULA HEUFLERI V. LEPTOCEPHALA	4473.	0.2	0.1	0.4	1265.01
NITZSCHIA LINEARIS	4473.	0.2	0.2	0.6	6326.48
FRAGILARIA VAUCHERIAE	4026.	0.2	0.1	0.4	632.15
NITZSCHIA SUBCAPITELLATA	3578.	0.2	0.1	0.4	2530.74
NITZSCHIA AMPHIBIA	2684.	0.1	0.0	0.0	1265.72
COCCONEIS PLACENTULA V. EUGLYPTA	2684.	0.1	0.0	0.3	1265.72
NITZSCHIA SUBLINEARIS	1789.	0.0	0.0	0.3	2530.74
NAVICULA ACCOMODA	1342.	0.0	0.0	0.0	1897.87
GOMPHONEMA OLIVACEUM	1341.	0.0	0.1	0.2	632.86
SYNEDRA FASICICULATA V. TRUNCATA	894.	0.0	0.0	0.0	1265.01
NAVICULA MENISCULUS V. UPSALIENSIS	894.	0.0	0.0	0.0	1265.01
COCCONEIS PEDICULUS	894.	0.0	0.1	0.5	1265.01
NITZSCHIA APICULATA	894.	0.0	0.0	0.1	1265.01
THALASSIOSIRA FLUVIATILIS	447.	0.0	0.0	0.0	632.15
NAVICULA SYMMETRICA	447.	0.0	0.0	0.0	632.15
SURIRELLA OVATA	447.	0.0	0.0	0.1	632.15
TOTAL BACILLARIOPHYTA	1858913.	91.8	22.8	86.3	187917.20
CHLOROPHYTA					
ANKISTRODESMUS FALCATUS	20225.	1.0	0.1	0.4	0.00
OOCYSTIS PUSILLA	14249.	0.7	0.8	3.1	13000.87
CHLAMYDOMONAS SPP.	14019.	0.7	0.4	1.6	5525.33
UNIDENTIFIED GREEN COCCOID	11950.	0.6	0.9	3.2	2600.03
KIRCHNERIELLA SUBSOLITARIA	2757.	0.1	0.0	0.2	0.00
SCENEDESMUS QUADRICAUDA	1838.	0.0	0.1	0.2	650.54
STIGEOCLONIUM TENUE	1608.	0.0	0.0	0.0	975.10
QUADRIGULA LACUSTRIS	1148.	0.1	0.0	0.0	975.10
CRUCIGENIA CRUCIFERA	919.	0.0	0.0	0.0	1299.66
SCENEDESMUS BIJUGA	918.	0.0	0.0	0.0	649.83

Table C-4 (continued)

Location 4

TAXON	MEAN UNITS #/SQ.CM.	%	MEAN BIOVOLUME MICRO L/SQ.DM.	%	STAN. DEV.
GONIUM PECTORALE	689.	0.0	0.0	0.0	974.39
LAGERHEIMIA QUADRISETA	459.	0.0	0.0	0.0	649.83
OOCYSTIS LACUSTRIS	229.	0.0	0.1	0.2	324.56
MICRATINIUM PUSILLUM	229.	0.0	0.0	0.0	324.56
TOTAL CHLOROPHYTA	71240.	3.5	2.4	9.2	20799.54
CYANOPHYTA					
LYNGBYA EPIPHYTICA	32636.	1.6	0.0	0.1	9751.00
CHROOCOCCUS MINIMUS	16547.	0.8	0.0	0.1	5200.77
LYNGBYA NORDGAARDII	12640.	0.6	0.0	0.1	10726.10
CHROOCOCCUS SPP.	11261.	0.6	0.2	0.8	2925.30
OSCILLATORIA ANGUSTA	5055.	0.2	0.0	0.0	5200.77
LYNGBYA DIGUETII	919.	0.0	0.0	0.0	1299.66
CHROOCOCCUS MINUTUS	689.	0.0	0.0	0.0	325.27
SPIRULINA LAXA	689.	0.0	0.0	0.0	974.39
MERISMODEDIA TENUISSIMA	229.	0.0	0.0	0.0	324.56
TOTAL CYANOPHYTA	80667.	4.0	0.3	1.1	8775.90
MISCELLANEOUS					
CRYPTOMONAS SPP.	9882.	0.5	0.1	0.5	2925.30
EUGLENA GRACILIS	2757.	0.1	0.6	2.3	0.00
EUGLENA SPP.	459.	0.0	0.1	0.2	649.83
EUGLENA PROXIMA	229.	0.0	0.0	0.3	324.56
TRACHELOMONAS VOLVOCINA	229.	0.0	0.0	0.0	324.56
TOTAL MISCELLANEOUS	13558.	0.7	0.9	3.3	4224.25
TOTAL PERIPHYTON	2024379.	100.0	26.4	100.0	154117.40

Table C-4 (continued)

Location 10

TAXON	MEAN UNITS #/SQ.CM.	%	MEAN BIOVOLUME MICRO L/SQ.DM.	%	STAN. DEV.
BACILLARIOPHYTA					
NITZSCHIA ACICULARIS	122138.	14.3	0.8	3.4	63904.07
NITZSCHIA PALEA	119901.	14.0	1.3	5.4	27839.50
NAVICULA CRYPTOCEPHALA	108269.	12.6	6.2	26.1	12654.38
SURIRELLA SUECICA	81873.	9.6	3.6	15.2	1897.87
NITZSCHIA DISSIPATA	45634.	5.3	1.3	5.6	11388.66
STEPHANODISCUS INVISITATUS	30869.	3.6	0.3	1.3	5694.33
CYCLOTELLA ATOMUS	26396.	3.1	0.2	0.7	4429.32
NAVICULA MINIMA	21474.	2.5	0.1	0.2	7592.21
CYCLOTELLA MENEGHINIANA	20580.	2.4	0.8	3.2	5061.47
NITZSCHIA HUNGARICA	16553.	1.9	1.5	6.4	3163.60
NAVICULA CRYPTOCEPHALA V. VENETA	15211.	1.8	0.4	1.8	2531.44
STEPHANODISCUS ASTRAEA V. MINUTULA	14316.	1.7	0.2	1.0	6327.19
NITZSCHIA FRUSTULUM V. PERMINUTA	12079.	1.4	0.0	0.0	5694.33
NITZSCHIA CAPITELLATA	11184.	1.3	0.4	1.5	3163.60
ACHNANTHES MINUTISSIMA	8947.	1.0	0.0	0.2	1265.01
MELOSIRA DISTANS V. LIRATA	8947.	1.0	0.0	0.3	3796.46
NITZSCHIA ACICULAROIDES	8947.	1.0	0.1	0.5	5062.18
NITZSCHIA KUTZINGIANA	8947.	1.0	0.0	0.2	7592.21
NITZSCHIA ACICULARIS V. ADELOS	5816.	0.7	0.0	0.0	8225.07
NAVICULA MENISCULUS V. UPSALIENSIS	5815.	0.7	0.0	0.4	1898.58
NITZSCHIA SUBCAPITELLATA	5368.	0.6	0.1	0.6	0.00
GOMPHONEMA OLIVACEUM	4921.	0.6	0.2	0.8	6959.34
NAVICULA SPP.	4920.	0.6	0.0	0.0	632.86
GOMPHONEMA TENELLUM	4473.	0.5	0.1	0.5	3796.46
NITZSCHIA SPP.	4026.	0.5	0.1	0.6	3163.60
FRAGILARIA CONSTRUENS V. VENTER	2684.	0.3	0.0	0.0	3795.75
COCCONEIS PLACENTULA V. EUGLYPTA	2684.	0.3	0.0	0.3	1265.72
GOMPHONEMA PARVULUM	2684.	0.3	0.1	0.3	3795.75
NITZSCHIA FRUSTULUM	2684.	0.3	0.0	0.0	1265.72
NITZSCHIA APICULATA	2684.	0.3	0.0	0.3	3795.75
COCCONEIS PEDICULUS	2683.	0.3	0.4	1.8	2530.74
NITZSCHIA SUBLINEARIS	1789.	0.2	0.0	0.4	2530.74
NAVICULA CAPITATA V. HUNGARICA	1789.	0.2	0.0	0.1	2530.74
NAVICULA DEMISSA	1789.	0.2	0.0	0.0	2530.74
DIATOMA VULGARE	1789.	0.2	0.4	1.9	0.00
FRAGILARIA VAUCHERIAE	894.	0.1	0.0	0.1	1265.01
SYNEDRA ACUS	894.	0.1	0.1	0.4	1265.01
MELOSIRA GRANULATA	894.	0.1	0.0	0.1	1265.01
AMPHORA PERPUSILLA	894.	0.1	0.0	0.0	1265.01
NAVICULA GRACILOIDES	894.	0.1	0.0	0.1	1265.01
NITZSCHIA TRYBLIONELLA V. DEBILIS	894.	0.1	0.0	0.0	1265.01
NAVICULA HEUFLERI V. LEPTOCEPHALA	894.	0.1	0.0	0.1	1265.01
SURIRELLA OVATA V. AFRICANA	447.	0.1	0.0	0.1	632.15
TOTAL BACILLARIOPHYTA	747579.	87.3	19.4	82.0	105663.00
CHLOROPHYTA					
STIGEOCLONIUM TENUE	12870.	1.5	0.2	0.8	1299.66
ANKISTRODESMUS FALCATUS	11031.	1.3	0.1	0.2	4550.23
UNIDENTIFIED GREEN COCCOID	8273.	1.0	0.6	2.5	4550.23
OOCYSTIS PUSILLA	5285.	0.6	0.3	1.3	2925.30
CHLAMYDOMONAS SPP.	4826.	0.6	0.1	0.6	2275.47
QUADRIGULA LACUSTRIS	1838.	0.2	0.0	0.0	2600.03

Table C-4 (continued)

Location 10

TAXON	MEAN UNITS #/SQ.CM.	%	MEAN BIOVOLUME MICRO L/SQ.DM.	%	STAN. DEV.
KIRCHNERIELLA SUBSOLITARIA	1148.	0.1	0.0	0.1	975.10
SCENEDESMUS QUADRICAUDA	689.	0.0	0.0	0.0	325.27
SCENEDESMUS BIJUGA	459.	0.1	0.0	0.0	649.83
TETRASTRUM STAUROGENIAEFORME	459.	0.1	0.0	0.0	0.00
MICRATINIUM POSILLUM	229.	0.0	0.0	0.0	324.56
TOTAL CHLOROPHYTA	47110.	5.5	1.4	5.7	16576.70
CYANOPHYTA					
LYNGBYA NORDGAARDII	13329.	1.6	0.0	0.0	6500.43
LYNGBYA EPIPHYTICA	11261.	1.3	0.0	0.0	5525.33
CHROOCOCCUS SPP.	8503.	1.0	0.2	0.7	6175.87
CHROOCOCCUS MINIMUS	2987.	0.3	0.0	0.0	975.10
CHROOCOCCUS MINUTUS	1838.	0.2	0.0	0.1	1299.66
LYNGBYA DIGUETII	459.	0.1	0.0	0.0	649.83
LYNGBYA AEROGINEO-CAERULEA	459.	0.1	0.0	0.0	649.83
TOTAL CYANOPHYTA	38838.	4.5	0.2	0.9	6826.41
MISCELLANEOUS					
EUGLENA GRACILIS	10342.	1.2	2.3	9.6	3575.13
CRYPTOMONAS SPP.	10342.	1.2	0.1	0.6	325.27
EUGLENA MINUTA	1378.	0.2	0.0	0.3	1949.49
PHACUS PYRUM	459.	0.1	0.1	0.6	649.83
TRACHELOMONAS VOLVOCINA	459.	0.1	0.0	0.1	0.00
PHACUS ACUMINATUS	229.	0.0	0.0	0.1	324.56
TOTAL MISCELLANEOUS	23210.	2.7	2.7	11.4	1625.64
TOTAL PERIPHYTON	856738.	100.0	23.7	100.0	113787.60

Table C-5 Mean density (units/cm^2 x 10^4) of periphyton collected from natural substrates near Wolf Creek Generating Station, Burlington, Kansas, 1973-1979.

Date	Neosho River				Wolf Creek				
	1	10	4	$\bar{X}$	7	2	3	5	$\bar{X}$
12 April 1973	<1	-[a]	-	<1	-	1	54	<1	18
11 June	4,877	-	-	4,877	-	669	923	85	559
10 September	452	-	-	452	-	182	154	63	133
10 December	0	-	-	0	-	5	296	0	100
$\bar{X}$	1,332	-	-	1,332	-	214	357	37	203
27 March 1974	10	-	-	10	-	654	948	556	719
11 June	-	-	-	-	-	-	-	-	-
10 September	209	-	-	209	-	<1	349	-	175
10 December	0	-	-	0	-	18	25	91	45
$\bar{X}$	73	-	-	73	-	224	441	324	330
16 April 1975	-	-	-	-	231	119	273	237	215
10 June	132	-	-	132	122	25	57	0	51
9 September	304	-	-	304	55	23	45	3	32
2 December	0	-	-	0	-	0	0	0	0
$\bar{X}$	145	-	-	145	136	42	94	60	79
25 February 1976	622	253	209	361	5	45	7	4	15
6 April	377	395	694	489	-	15	6	11	11
15 June	3,033	4	114	1,050	36	107	54	6	51
10 August	812	84	22	306	30	15	18	6	17
5 October	388	212	68	223	15	27	-	-	21
14 December	865	121	352	446	-	-	-	-	-
$\bar{X}$	1,016	178	243	479	21	42	21	7	24
22 February 1977	831	874	61	589	-	-	-	-	-
5 April	510	377	162	349	-	-	-	-	-
9 June	177	-	-	177	7	-	17	1	8
9 August	256	638	9	301	2	-	12	-	7
3 October	1,055	-	-	1,055	156	-	16	4	58
13 December	20	-	-	20	76	-	565	308	316
$\bar{X}$	475	630	77	414	60	-	152	104	106
22 February 1978	-	-	-	-	-	-	-	-	-
25 April	22	-	-	22	-	-	80	-	80
27 June	340	167	16	174	-	-	149	-	149
29 August	668	29	107	268	-	-	19	-	19
10 October	1,042	154	223	473	-	-	20	-	20
12 December	552	941	1,551	1,014	-	-	-	-	-
$\bar{X}$	525	323	474	447	-	-	67	-	67
20 February 1979	3,334	7,021	8,425	6,260	-	-	-	-	-
9 April	-	-	-	-	-	-	-	-	-
13 June	-	-	-	-	-	-	-	-	-
7 August	401	-	-	401	-	-	-	-	-
8 October	703	653	229	529	-	-	-	-	-
11 December	-	-	-	-	-	-	-	-	-
$\bar{X}$	1,480	3,837	4,327	2,967	-	-	-	-	-

[a] Samples not collected.

Table C-6 Mean biovolume ($\mu l/dm^2$) of periphyton collected from natural substrates near Wolf Creek Generating Station, Burlington, Kansas, 1973-1979.

Date	Neosho River				Wolf Creek				
	1	10	4	$\bar{X}$	7	2	3	5	$\bar{X}$
12 April 1973	<0.1	-[a]	-	<0.1	-	<0.1	14.5	<0.1	4.8
11 June	382.3	-	-	382.3	-	80.3	178.4	10.4	89.7
10 September	60.3	-	-	60.3	-	6.4	11.1	2.9	6.8
10 December	0.0	-	-	0.0	-	0.5	11.0	0.0	3.8
$\bar{X}$	110.6	-	-	110.6	-	21.8	53.8	3.3	26.3
27 March 1974	0.4	-	-	0.4	-	57.1	72.0	41.1	56.7
11 June	-	-	-	-	-	-	-	-	-
10 September	0.9	-	-	0.9	-	<0.1	2.0	-	1.0
10 December	0.0	-	-	0.0	-	0.7	0.7	4.1	1.8
$\bar{X}$	0.4	-	-	0.4	-	19.3	24.9	22.6	22.2
16 April 1975	-	-	-	-	121.0	33.0	92.0	86.2	83.0
10 June	10085.9	-	-	10085.9	212.5	3.5	10.3	0.0	56.6
9 September	148.1	-	-	148.1	14.4	7.0	16.8	0.7	9.7
2 December	0.0	-	-	0.0	-	0.0	0.0	0.0	0.0
$\bar{X}$	3411.3	-	-	3411.3	116.0	10.9	29.8	21.7	39.8
25 February 1976	570.3	1273.0	247.2	696.8	1.4	11.6	1.1	1.4	3.9
6 April	487.5	5036.9	10903.2	5475.9	-	3.9	1.5	2.8	2.7
15 June	1175.1	0.7	13.4	396.4	5.7	25.0	582.6	2.7	154.0
10 August	932.9	10.4	31.4	324.9	5.4	1.7	8.9	0.7	4.2
5 October	521.4	94.8	96.8	237.7	1.5	3.3	-	-	2.4
14 December	2227.3	1729.6	1853.7	1936.9	-	-	-	-	-
$\bar{X}$	985.8	1357.6	2191.0	1511.4	3.5	9.1	148.5	1.9	38.9
22 February 1977	492.0	340.3	41.8	291.4	-	-	-	-	-
5 April	3159.2	523.0	864.9	1515.7	-	-	-	-	-
9 June	51.4	-	-	51.4	1.2	-	7.5	0.4	3.0
9 August	64.8	238.4	1.5	101.6	0.8	-	3.5	-	2.2
3 October	278.6	-	-	278.6	45.8	-	6.1	2.8	18.2
13 December	9.9	-	-	9.9	15.1	-	39.2	25.4	26.6
$\bar{X}$	676.0	367.2	302.7	505.5	15.7	-	14.1	9.5	13.4
22 February 1978	-	-	-	-	-	-	-	-	-
25 April	6.3	-	-	6.3	-	-	16.8	-	16.8
27 June	1635.5	75.3	4.7	571.8	-	-	82.6	-	82.6
29 August	593.4	4.7	731.8	443.3	-	-	3.5	-	3.5
10 October	476.8	35.6	114.1	208.8	-	-	4.8	-	4.8
12 December	3317.4	7436.2	609.6	3787.7	-	-	-	-	-
$\bar{X}$	1205.9	1888.0	365.0	1157.0	-	-	26.9	-	26.9
20 February 1979	726.5	1932.9	2432.5	1697.3	-	-	-	-	-
9 April	-	-	-	-	-	-	-	-	-
13 June	-	-	-	-	-	-	-	-	-
7 August	105.1	-	-	105.1	-	-	-	-	-
8 October	286.1	209.9	96.4	197.5	-	-	-	-	-
11 December	-	-	-	-	-	-	-	-	-
$\bar{X}$	372.6	1071.4	1264.4	827.1	-	-	-	-	-

[a] Samples not collected.

Table C-7 Mean chlorophyll a standing crop ($\mu g/dm^2$) of periphyton collected from natural substrates near Wolf Creek Generating Station, Burlington, Kansas, 1973-1979.

Date	Neosho River				Wolf Creek				
	1	10	4	$\bar{X}$	7	2	3	5	$\bar{X}$
12 April 1973	64.6	-[a]	-	64.6	-	74.8	567.7	8.9	217.2
11 June	289.1	-	-	289.1	-	114.0	415.2	33.9	187.7
10 September	562.5	-	-	562.5	-	172.9	81.5	66.8	107.1
10 December	7.1	-	-	7.1	-	265.0	592.8	7.7	288.5
$\bar{X}$	230.8	-	-	230.8	-	156.7	414.3	29.3	200.1
27 March 1974	36.4	-	-	36.4	-	1781.1	1939.3	2144.5	1955.0
11 June	-	-	-	-	-	-	-	-	-
10 September	214.7	-	-	214.7	-	-	448.2	-	448.2
10 December	2.2	-	-	2.2	-	134.1	262.8	396.0	264.3
$\bar{X}$	84.4	-	-	84.4	-	957.6	883.4	1270.3	1015.2
16 April 1975	-	-	-	-	525.7	425.0	1925.9	1701.4	1144.5
10 June	346.8	-	-	346.8	704.6	160.8	309.2	61.5	309.0
9 September	942.9	-	-	942.9	157.7	65.5	148.4	63.7	108.8
2 December	0.0	-	-	0.0	-	0.0	0.0	0.0	0.0
$\bar{X}$	429.9	-	-	429.9	462.6	162.8	595.9	456.6	416.6
25 February 1976	594.7	-	-	594.7	20.1	18.7	8.9	7.6	13.8
6 April	6172.0	1123.1	1082.1	2792.4	-	16.5	14.3	20.5	17.1
15 June	2451.9	148.8	71.3	890.7	201.5	174.9	142.1	-	172.8
10 August	1602.9	679.5	360.0	880.8	41.0	38.0	130.5	67.3	69.2
5 October	751.7	318.1	197.8	422.5	7.0	26.3	-	-	16.6
14 December	280.7	1108.0	1242.9	877.2	-	-	-	-	-
$\bar{X}$	1975.7	675.5	590.8	1136.6	67.4	54.9	74.0	31.8	58.4
22 February 1977	531.0	2305.5	316.8	1051.1	-	-	-	-	-
5 April	526.6	2159.8	2388.1	1691.5	-	-	-	-	-
9 June	627.5	-	-	627.5	108.7	-	287.6	65.0	153.8
9 August	1168.6	1359.0	139.4	889.0	6.4	-	63.5	-	35.0
3 October	1578.0	-	-	1578.0	115.4	-	323.4	74.8	171.2
13 December	117.6	-	-	117.6	552.4	-	3064.2	1172.6	1596.4
$\bar{X}$	758.2	1941.4	948.1	1101.5	195.7	-	934.7	437.5	530.4
22 February 1978	-	-	-	-	-	-	-	-	-
25 April	130.5	-	-	130.5	-	-	1025.1	-	1025.1
27 June	1867.1	680.7	281.6	943.1	-	-	159.9	-	159.9
29 August	485.2	116.3	362.6	321.4	-	-	453.5	-	453.5
10 October	518.1	338.6	335.5	397.4	-	-	70.4	-	70.4
12 December	1294.6	1689.3	1283.0	1422.3	-	-	-	-	-
$\bar{X}$	859.1	706.2	565.7	721.8	-	-	427.2	-	427.2
20 February 1979	1561.0	1504.9	2921.6	1995.8	-	-	-	-	-
9 April	-	-	-	-	-	-	-	-	-
13 June	-	-	-	-	-	-	-	-	-
7 August	932.9	-	-	932.9	-	-	-	-	-
8 October	707.0	726.2	625.0	686.1	-	-	-	-	-
11 December	-	-	-	-	-	-	-	-	-
$\bar{X}$	1067.0	1115.6	1773.3	1282.7	-	-	-	-	-

[a] Samples not collected.

Table C-8 Mean biomass standing crop (mg/dm^2) of periphyton collected from natural substrates near Wolf Creek Generating Station, Burlington, Kansas, 1973-1979.

Date	Neosho River				Wolf Creek				
	1	10	4	$\bar{X}$	7	2	3	5	$\bar{X}$
12 April 1973	210.6	-[a]	-	210.6	-	73.8	90.7	57.2	73.9
11 June	87.0	-	-	87.0	-	75.5	323.0	63.2	123.6
10 September	212.3	-	-	212.3	-	128.7	112.7	167.7	136.3
10 December	23.2	-	-	23.2	-	53.0	134.2	12.2	66.5
$\bar{X}$	133.3	-	-	133.3	-	82.8	142.5	75.1	100.1
27 March 1974	126.5	-	-	126.5	-	635.8	498.3	435.7	523.3
11 June	-	-	-	-	-	-	-	-	-
10 September	152.9	-	-	152.9	-	-	323.8	-	323.8
10 December	17.0	-	-	17.0	-	163.6	54.0	197.1	138.3
$\bar{X}$	98.8	-	-	98.8	-	399.7	292.0	316.4	329.8
16 April 1975	-	-	-	-	306.0	117.8	554.8	619.0	399.4
10 June	455.4	-	-	455.4	263.5	1001.9	773.5	680.7	679.9
9 September	317.5	-	-	317.5	121.3	217.6	82.1	182.3	150.8
2 December	170.4	-	-	170.4	-	28.8	72.0	89.0	63.3
$\bar{X}$	314.4	-	-	314.4	230.3	341.5	370.6	392.8	340.7
25 February 1976	606.5	528.2	-	567.4	313.6	147.0	8.0	57.4	131.5
6 April	3024.7	628.7	862.7	1505.4	-	50.9	25.7	317.9	131.5
15 June	782.0	181.7	48.0	337.2	84.2	593.8	60.7	-	246.2
10 August	381.7	643.7	459.3	494.9	37.4	43.5	116.0	249.1	111.5
5 October	305.6	981.7	464.2	583.8	88.0	115.0	-	-	101.5
14 December	163.2	576.5	311.8	350.5	-	-	-	-	-
$\bar{X}$	877.3	590.1	429.2	644.1	130.8	190.0	52.6	208.1	144.3
22 February 1977	957.4	431.3	285.5	558.1	-	-	-	-	-
5 April	1445.3	932.1	854.0	1077.1	-	-	-	-	-
9 June	139.8	-	-	139.8	84.6	-	139.8	138.5	121.0
9 August	127.2	345.7	319.5	264.1	33.5	-	47.8	-	40.6
3 October	349.4	-	-	349.4	243.2	-	197.3	112.4	184.3
13 December	77.8	-	-	77.8	379.7	-	344.5	186.5	303.6
$\bar{X}$	516.2	569.7	486.3	522.1	185.3	-	182.4	145.8	173.4
22 February 1978	-	-	-	-	-	-	-	-	-
25 April	98.5	-	-	98.5	-	-	364.5	-	364.5
27 June	972.4	314.0	134.9	473.8	-	-	314.9	-	314.9
29 August	571.7	199.2	218.2	329.7	-	-	124.0	-	124.0
10 October	1167.5	365.2	362.5	631.7	-	-	92.8	-	92.8
12 December	736.5	592.0	643.4	657.3	-	-	-	-	-
$\bar{X}$	709.3	367.6	339.8	490.5	-	-	224.0	-	224.0
20 February 1979	617.6	1087.8	1779.0	1161.5	-	-	-	-	-
9 April	-	-	-	-	-	-	-	-	-
13 June	-	-	-	-	-	-	-	-	-
7 August	60.2	-	-	60.2	-	-	-	-	-
8 October	374.5	752.5	396.5	507.8	-	-	-	-	-
11 December	-	-	-	-	-	-	-	-	-
$\bar{X}$	350.8	920.2	1087.8	724.0	-	-	-	-	-

[a] Samples not collected.

Table C-9 Mean diversity (Shannon 1948, using base 2 logarithms) of periphyton collected from natural substrates near Wolf Creek Generating Station, Burlington, Kansas, 1973-1979.

Date	Neosho River				Wolf Creek				
	1	10	4	$\bar{x}$	7	2	3	5	$\bar{x}$
12 April 1973	ID[a]	-[b]	-	ID	-	1.10	3.33	ID	2.22
11 June	1.76	-	-	1.76	-	3.05	3.44	2.55	3.01
10 September	3.13	-	-	3.13	-	2.08	2.99	4.17	3.08
10 December	ID	-	-	ID	-	1.31	2.97	ID	2.14
$\bar{x}$	2.44	-	-	2.44	-	1.88	3.18	3.36	2.70
27 March 1974	2.07	-	-	2.07	-	3.95	3.52	3.41	3.63
11 June	-	-	-	-	-	-	-	-	-
10 September	0.62	-	-	0.62	-	ID	0.94	-	0.94
10 December	ID	-	-	ID	-	2.82	2.13	2.94	2.63
$\bar{x}$	1.34	-	-	1.34	-	3.38	2.20	3.18	2.82
16 April 1975	-	-	-	-	1.65	2.20	3.07	2.99	2.48
10 June	0.28	-	-	0.28	3.36	3.34	2.54	ID	3.08
9 September	3.42	-	-	3.42	2.68	2.81	2.87	2.69	2.76
2 December	ID	-	-	ID	-	ID	ID	ID	ID
$\bar{x}$	1.85	-	-	1.85	2.56	2.78	2.83	2.84	2.75
25 February 1976	1.59	3.10	2.13	2.27	2.13	2.71	0.80	1.59	1.81
6 April	0.98	1.50	1.78	1.42	-	2.34	0.97	1.09	1.47
15 June	1.44	1.11	1.31	1.29	1.96	2.28	1.17	2.18	1.90
10 August	1.57	2.66	2.71	2.31	2.47	2.14	0.43	1.45	1.62
5 October	2.51	2.28	1.87	2.22	3.18	2.36	-	-	2.77
14 December	0.89	2.54	2.63	2.02	-	-	-	-	-
$\bar{x}$	1.50	2.20	2.07	1.92	2.44	2.37	0.84	1.58	1.84
22 February 1977	2.29	2.38	2.77	2.48	-	-	-	-	-
5 April	2.47	2.89	3.09	2.82	-	-	-	-	-
9 June	2.19	-	-	2.19	1.69	-	2.54	1.59	1.94
9 August	2.11	2.07	1.61	1.93	1.57	-	3.01	-	2.29
3 October	2.13	-	-	2.13	1.95	-	2.52	2.18	2.22
13 December	2.43	-	-	2.43	2.64	-	0.70	1.08	1.47
$\bar{x}$	2.27	2.45	2.49	2.37	1.96	-	2.19	1.62	1.95
22 February 1978	-	-	-	-	-	-	-	-	-
25 April	2.22	0	0	2.22	-	-	0.44	-	0.44
27 June	2.58	1.39	1.43	1.80	-	-	0.70	-	0.70
29 August	2.78	2.29	2.02	2.36	-	-	0.60	-	0.60
10 October	2.64	2.87	1.37	2.29	-	-	0.84	-	0.84
12 December	1.96	1.87	2.90	2.24	-	-	-	-	-
$\bar{x}$	2.44	2.10	1.93	2.18	-	-	0.64	-	0.64
20 February 1979	3.29	3.38	4.23	3.63	-	-	-	-	-
9 April	-	-	-	-	-	-	-	-	-
13 June	-	-	-	-	-	-	-	-	-
7 August	2.76	-	-	2.76	-	-	-	-	-
8 October	4.57	4.67	4.62	4.62	-	-	-	-	-
11 December	-	-	-	-	-	-	-	-	-
$\bar{x}$	3.54	4.02	4.42	3.93	-	-	-	-	-

[a] Insufficient data to calculate diversity.
[b] Samples not collected.

APPENDIX D

ZOOPLANKTON DATA

Table D-1 Mean density and percent occurrence of zooplankton collected from the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 14 April 1980.

Taxa	Location 1 No./m³	Location 1 %	Location 10 No./m³	Location 10 %	Location 4 No./m³	Location 4 %
COPEPODA						
Nauplii	13209	30.0	15226	33.1	16866	28.3
Calanoid copepodites	32	0.1	26	0.1	30	0.1
Cyclopoid copepodites	7428	16.9	7273	15.8	7212	12.1
Cyclops bicuspidatus thomasi	587	1.3	386	0.8	654	1.1
Cyclops vernalis	32	0.1	32	0.1	48	0.1
Diaptomus pallidus	0		2	<0.1	6	<0.1
Diaptomus siciloides	19	<0.1	26	0.1	34	0.1
Eucyclops agilis	0		10	<0.1	0	
Harpacticoida	45	0.1	72	0.2	82	0.1
TOTAL COPEPODA	21352	48.5	23053	50.1	24932	41.9
CLADOCERA						
Bosmina longirostris	440	1.0	866	1.9	908	1.5
Ceriodaphnia quadrangula	0		2	<0.1	0	
Chydorus sphaericus	14	<0.1	18	<0.1	58	0.1
Daphnia spp. (immature)	16	<0.1	14	<0.1	34	0.1
Daphnia galeata mendotae	6	<0.1	0		0	
Daphnia parvula	0		8	<0.1	10	<0.1
Daphnia pulex	16	<0.1	0		0	
TOTAL CLADOCERA	492	1.1	908	2.0	1010	1.7
ROTIFERA						
Asplanchna spp.	66	0.1	75	0.2	146	0.2
Bdelloid Rotifera	0		90	0.2	72	0.1
Brachionus spp.	2506	5.7	2651	5.8	2910	4.9
Conochiloides spp.	118	0.3	94	0.2	25	<0.1
Filinia spp.	2510	5.7	3073	6.7	2950	5.0
Kellicottia spp.	0		24	0.1	0	
Keratella spp.	13110	29.8	13420	29.2	24592	41.3
Notholca spp.	141	0.3	235	0.5	290	0.5
Polyarthra spp.	2487	5.6	1548	3.4	1672	2.8
Synchaeta spp.	671	1.5	826	1.8	935	1.6
Unidentified Rotifera	610	1.4	19	<0.1	0	
TOTAL ROTIFERA	22219	50.4	22055	47.9	33592	56.4
TOTAL ZOOPLANKTON	44063		46016		59534	

Table D-2 Mean density and percent occurrence of zooplankton collected from the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 17 June 1980.

Taxa	Location 1 No./m³	Location 1 %	Location 10 No./m³	Location 10 %	Location 4 No./m³	Location 4 %
COPEPODA						
Nauplii	48644	31.1	13364	11.4	-[a]	-
Calanoid copepodites	5556	3.6	394	0.3	-	-
Cyclopoid copepodites	3041	1.9	1154	1.0	-	-
Cyclops vernalis	3942	2.5	45	<0.1	-	-
Diaptomus clavipes	44	<0.1	0		-	-
Diaptomus pallidus	988	0.6	199	0.2	-	-
Diaptomus siciloides	9672	6.2	158	0.1	-	-
TOTAL COPEPODA	71887	46.0	15314	13.0	-	-
CLADOCERA						
Alona pulchella	0		4	<0.1	-	-
Bosmina longirostris	61	<0.1	12	<0.1	-	-
Daphnia spp. (immature)	1560	1.0	20	<0.1	-	-
Daphnia galeata mendotae	160	0.1	0		-	-
Daphnia parvula	284	0.2	8	<0.1	-	-
Daphnia pulex	12	<0.1	0		-	-
Daphnia retrocurva	420	0.3	8	<0.1	-	-
Diaphanosoma brachyurum	0		12	<0.1	-	-
Diaphanosoma leuchtenbergianum	56	<0.1	12	<0.1	-	-
Leptodora kindtii	247	0.2	4	<0.1	-	-
TOTAL CLADOCERA	2800	1.8	80	0.1	-	-
ROTIFERA						
Asplanchna spp.	0		75	0.1	-	-
Bdelloid Rotifera	2384	1.5	375	0.3	-	-
Brachionus spp.	61106	39.1	45496	38.8	-	-
Cephalodella spp.	238	0.2	4	<0.1	-	-
Conochiloides spp.	0		75	0.1	-	-
Filinia spp.	144	0.1	75	0.1	-	-
Hexarthra spp.	0		<0.1	<0.1	-	-
Keratella spp.	12131	7.8	8859	7.6	-	-
Monostyla spp.	0		75	0.1	-	-
Notholca spp.	0		75	0.1	-	-
Polyarthra spp.	5112	3.3	35586	30.4	-	-
Synchaeta spp.	0		10661	9.1	-	-
Trichocerca spp.	150	0.1	8	<0.1	-	-
Unidentified Rotifera	382	0.2	450	0.4	-	-
TOTAL ROTIFERA	81647	52.2	101814	86.9	-	-
TOTAL ZOOPLANKTON	156334		117208			

[a] Samples collected but not preserved.

Table D-3 Mean density and percent occurrence of zooplankton collected from the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 27 October 1980.

Taxa	Location 1 No./m³	1 %	10 No./m³	10 %	4 No./m³	4 %
COPEPODA						
Nauplii	23716	14.9	276	6.7	1386	23.1
Calanoid copepodites	8088	5.1	0		0	
Cyclopoid copepodites	3955	2.5	25	0.6	76	1.3
Cyclops bicuspidatus thomasi	98	0.1	2	0.1	0	
Cyclops varicans rubellus	0		0		7	0.1
Cyclops vernalis	1225	0.8	0		0	
Diaptomus pallidus	280	0.2	0		0	
Diaptomus siciloides	5557	3.5	9	0.2	0	
Ergasilus chautauquaensis	403	0.3	0		0	
Ergasilus megaceros	390	0.2	0		0	
Eucyclops agilis	0		0		13	0.2
Mesocyclops edax	111	0.1	0		0	
Harpacticoida	13	<0.1	0		0	
TOTAL COPEPODA	43836	27.5	312	7.5	1482	24.7
CLADOCERA						
Alona circumfimbriata	0		89	2.1	238	4.0
Alona spp.	0		6	0.1	28	0.5
Ceriodaphnia quadrangula	0		2	0.1	9	0.2
Chydorus sphaericus	0		27	0.7	126	2.1
Daphnia spp. (immature)	640	0.4	2	0.1	0	
Daphnia parvula	111	0.1	0		0	
Disparalona rostrata	0		27	0.7	3	0.1
Kurzia latissima	0		2	0.1	21	0.4
Macrothrix laticornis	0		3	0.1	2	<0.1
Pleuroxus hamulatus	0		47	1.1	321	5.4
Simocephalus vetulus	0		0		7	0.1
TOTAL CLADOCERA	751	0.5	205	4.9	755	12.6
ROTIFERA						
Bdelloid Rotifera	1425	0.9	810	19.5	357	6.0
Brachionus spp.	1908	1.2	861	20.7	1158	19.3
Cephalodella spp.	115	0.1	342	8.2	629	10.5
Colurella spp.	0		18	0.4	0	
Dicranophorus spp.	0		34	0.8	5	0.1
Euchlanis spp.	0		72	1.7	129	2.2
Filinia spp.	0		53	1.3	0	
Keratella spp.	1755	1.1	325	7.8	100	1.7
Lecane spp.	0		8	0.2	0	
Lepadella spp.	0		78	1.9	91	1.5
Monostyla spp.	0		67	1.6	105	1.8
Notommatid Rotifera	0		161	3.9	148	2.5
Platyias spp.	0		0		5	0.1
Polyarthra spp.	1513	1.0	47	1.1	10	0.2
Rotaria spp.	0		34	0.8	29	0.5
Scaridium spp.	0		23	0.6	43	0.7
Synchaeta spp.	108088	67.8	515	12.4	863	14.4
Testudinella spp.	0		24	0.6	5	0.1
Trichocerca spp.	0		124	3.0	81	1.4
Trichotria spp.	0		24	0.6	5	0.1
Unidentified Rotifera	0		15	0.4	0	
TOTAL ROTIFERA	114804	72.0	3635	87.6	3763	62.7
TOTAL ZOOPLANKTON	159391		4152		6000	

Table D-4 Mean density and percent occurrence of zooplankton collected from the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 16 December 1980.

Taxa	Location 1 No./m³	Location 1 %	Location 10 No./m³	Location 10 %	Location 4 No./m³	Location 4 %
COPEPODA						
Nauplii	18748	16.2	5084	11.1	11229	11.8
Calanoid copepodites	778	0.7	103	0.2	151	0.2
Cyclopoid copepodites	2545	2.2	422	0.9	872	0.9
Cyclops bicuspidatus thomasi	25	<0.1	3	<0.1	11	<0.1
Cyclops vernalis	402	0.4	20	<0.1	30	<0.1
Diaptomus pallidus	88	0.1	17	<0.1	21	<0.1
Diaptomus siciloides	2869	2.5	517	1.1	323	0.3
Ergasilus spp.	25	<0.1	6	<0.1	14	<0.1
Ergasilus chautauquaensis	38	<0.1	9	<0.1	7	<0.1
Ergasilus megaceros	50	<0.1	6	<0.1	4	<0.1
Eucyclops agilis	0		3	<0.1	0	
Eucyclops speratus	0		0		4	<0.1
Harpacticoida	0		3	<0.1	4	<0.1
TOTAL COPEPODA	25568	22.1	6193	13.5	12670	13.3
CLADOCERA						
Alona circumfimbriata	0		18	<0.1	48	0.1
Alona spp.	0		0		4	<0.1
Bosmina longirostris	13	<0.1	0		0	
Chydorus sphaericus	0		6	<0.1	115	0.1
Daphnia spp. (immature)	326	0.3	14	<0.1	28	<0.1
Daphnia parvula	364	0.3	12	<0.1	4	<0.1
Disparalona rostrata	0		0		4	<0.1
Macrothrix laticornis	0		3	<0.1	4	<0.1
Pleuroxus denticulatus	0		0		4	<0.1
Pleuroxus hamulatus	0		26	0.1	76	0.1
Simocephalus vetulus	0		3	<0.1	4	<0.1
TOTAL CLADOCERA	703	0.6	82	0.2	291	0.3
ROTIFERA						
Asplanchna spp.	80	0.1	13	<0.1	0	
Bdelloid Rotifera	556	0.5	262	0.6	444	0.5
Brachionus spp.	1271	1.1	1698	3.7	5773	6.0
Cephalodella spp.	159	0.1	241	0.5	323	0.3
Euchlanis spp.	0		246	0.5	479	0.5
Filinia spp.	0		13	<0.1	0	
Keratella spp.	37496	32.4	11279	24.5	24312	25.5
Lepadella spp.	0		112	0.2	283	0.3
Lophocharis spp.	0		0		15	<0.1
Monostyla spp.	0		0		15	<0.1
Notommata spp.	0		13	<0.1	0	
Notommatid Rotifera	159	0.1	0		0	
Notholca spp.	0		0		18	<0.1
Polyarthra spp.	36702	31.7	19619	42.6	36017	37.7
Synchaeta spp.	13028	11.3	6116	13.3	14725	15.4
Trichotria spp.	0		127	0.3	139	0.2
TOTAL ROTIFERA	89451	77.3	39739	86.4	82543	86.4
TOTAL ZOOPLANKTON	115722		46017		95504	

APPENDIX E

MACROINVERTEBRATE DATA

Table E-1. Summary of drifting macroinvertebrate composition, abundance (No./100 m^3), and percent occurrence at Location 1 in the tailwaters of John Redmond Reservoir near Wolf Creek Generating Station, 18 April 1980.

ORGANISM	REPLICATES (100 CU M) A	B	MEAN/ 100 CU M	%	SE	.95 CONF INT
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
NAIDIDAE						
DERO DIGITATA	0.	41.	20.7	0.3	20.7	262.6
ARTHROPODA						
INSECTA						
EPHEMEROPTERA						
HEPTAGENIIDAE						
STENONEMA TRIPUNCTATUM	223.	331.	276.6	4.5	54.0	686.7
TRICHOPTERA						
HYDROPSYCHIDAE						
UNIDENTIFIED HYDROPSYCHIDAE	0.	83.	41.3	0.7	41.3	525.1
DIPTERA						
CHAOBORIDAE						
CHAOBORUS PUNCTIPENNIS	4673.	4422.	4547.9	73.8	125.6	1595.4
CHAOBORU PUNCTIPENNIS PUPA	134.	455.	294.1	4.8	160.6	2040.0
CHIRONOMIDAE						
CHIRONOMINAE						
CHIRONOMUS SP.	223.	207.	214.6	3.5	7.9	101.0
CHIRONOMUS SP. PUPA	45.	41.	42.9	0.7	1.6	20.2
GLYPTOTENDIPES (PHYTOTENDIPES) SP.	134.	248.	190.8	3.1	57.2	727.1
POLYPEDILUM SP. PUPA	45.	0.	22.3	0.4	22.3	282.8
XENOCHIRONOMUS SP.	45.	0.	22.3	0.4	22.3	282.8
TANYPODINAE						
ABLABESMYIA SP. PUPA	89.	41.	65.2	1.1	23.8	303.0
PROCLADIUS (PSILOTANYPUS) SP.	89.	207.	147.8	2.4	58.8	747.3
PROCLADIS SP. PUPA	178.	289.	233.7	3.8	55.6	706.9
ORTHOCLADIINAE						
CRIOTOPUS SP.	45.	0.	22.3	0.4	22.3	282.8
THIENEMANNIELLA SP.	0.	41.	20.7	0.3	20.7	262.6
TUBIFICIDAE	-	-	-	-	-	-

Table E-1. (continued)

ORGANISM	REPLICATES (100 CU M) A	B	MEAN/ 100 CU M	%	SE	.95 CONF INT
CHIRONOMIDAE	890.	1075.	982.4	15.9	92.2	1171.5
INSECTA	5920.	6365.	6142.3	99.7	222.6	2827.8
TOTAL BENTHOS	5920.	6406.	6162.9	100.0	243.2	3090.5
NUMBER OF SPECIES FOUND IN EACH REPLICATE	12	12				

Table E-2. Summary of drifting macroinvertebrate composition, abundance (No./100 m^3), and percent occurrence at Location 1 in the tailwaters of John Redmond Reservoir near Wolf Creek Generating Station, 16 June 1980.

ORGANISM	REPLICATES (100 CU M) A	B	MEAN/ 100 CU M	%	SE	.95 CONF INT
PLATYHELMINTHES						
TURBELLARIA						
TRICLADIDA						
PLANARIIDAE						
DUGESIA SP.	0.	83.	41.7	0.4	41.7	530.2
ENTOPROCTA						
URNATELLIDAE						
URNATELLA GRACILIS	170.	0.	84.8	0.7	84.8	1077.2
ARTHROPODA						
CRUSTACEA						
DECAPODA						
ASTACIDAE						
UNIDENTIFIED ASTACIDAE	509.	0.	254.3	2.1	254.3	3231.6
INSECTA						
EPHEMEROPTERA						
EPHEMERIAE						
HEXAGENIA LIMBATA	85.	83.	84.1	0.7	0.7	8.4
CAENIDAE						
CAENIS SP.	85.	83.	84.1	0.7	0.7	8.4
HEPTAGENIIDAE						
UNIDENTIFIED HEPTAGENIIDAE	85.	0.	42.4	0.4	42.4	538.6
STENONEMA INTERPUNCTATUM	85.	167.	125.8	1.1	41.1	521.8
STENONEMA TRIPUNCTATUM	0.	83.	41.7	0.4	41.7	530.2
STENONEMA SP.	170.	83.	126.5	1.1	43.1	547.0
TRICHOPTERA						
HYDROPSYCHIDAE						
CHEUMATOPSYCHE SP.	1187.	1335.	1261.1	10.6	74.2	942.6
POTAMYIA FLAVA	0.	83.	41.7	0.4	41.7	530.2
DIPTERA						
CHAOBORIDAE						
CHAOBORUS PUNCTIPENNIS	3052.	4006.	3528.9	29.7	476.9	6059.5
CHAOBORU PUNCTIPENNIS PUPA	1865.	918.	1391.6	11.7	473.6	6017.1

Table E-2. (continued)

ORGANISM	REPLICATES (100 CU M) A	B	MEAN/ 100 CU M	%	SE	.95 CONF INT
SIMULIDAE						
UNIDENTIFIED SIMULIDAE	593.	334.	463.6	3.9	129.8	1649.4
CHIRONOMIDAE						
CHIRONOMINAE						
CHIRONOMUS SP.	0.	83.	41.7	0.4	41.7	530.2
CHIRONOMUS SP. PUPA	170.	0.	84.8	0.7	84.8	1077.2
DICROTENDIPES SP. PUPA	254.	417.	335.8	2.8	81.5	1035.1
GLYPTOTENDIPES (PHYTOTENDIPES) SP.	170.	0.	84.8	0.7	84.8	1077.2
POLYPEDILUM SP. PUPA	0.	83.	41.7	0.4	41.7	530.2
RHEOTANYTARSUS SP. PUPA	170.	0.	84.8	0.7	84.8	1077.2
XENOCHIRONOMUS SP.	254.	167.	210.6	1.8	43.7	555.4
TANYPODINAE						
COELOTANYPUS SP.	0.	83.	41.7	0.4	41.7	530.2
PROCLADIUS (PSILOTANYPUS) SP.	254.	0.	127.2	1.1	127.2	1615.8
PROCLADIS SP. PUPA	1611.	1085.	1347.9	11.4	262.9	3341.0
TANYPUS SP.	0.	167.	83.5	0.7	83.5	1060.4
TANYPUS SP. PUPA	339.	0.	169.6	1.4	169.6	2154.4
ORTHOCLADIINAE						
CRICOTOPUS (SS) FUSCUS GROUP	254.	0.	127.2	1.1	127.2	1615.8
CRICOTOPUS VIERRIENSIS	0.	83.	41.7	0.4	41.7	530.2
CRICOTOPUS (SS) SP. PUPA	1441.	501.	971.0	8.2	470.3	5975.1
NANOCLADIUS SP. PUPA	1017.	0.	508.7	4.3	508.7	6463.2
TUBIFICIDAE	-	-	-	-	-	-
CHIRONOMIDAE	5935.	2671.	4302.5	36.2	1632.0	20736.0
INSECTA	13141.	9848.	11494.2	96.8	1646.5	20920.8
TOTAL BENTHOS	13819.	9931.	11875.1	100.0	1943.9	24699.4
NUMBER OF SPECIES FOUND IN EACH REPLICATE	22	20				

Table E-3. Summary of drifting macroinvertebrate composition, abundance (No./100 m^3), and percent composition at Location 1 in the tailwaters of John Redmond Reservoir near Wolf Creek Generating Station, 27 October 1980.

ORGANISM	REPLICATES (100 CU M) A	B	MEAN/ 100 CU M	%	SE	.95 CONF INT
ARTHROPODA						
INSECTA						
EPHEMEROPTERA						
CAENIDAE						
CAENIS SP.	4.	0.	1.8	2.9	1.8	22.9
TRICHOPTERA						
PSYCHOMYIIDAE						
CYRNELLUS SP.	4.	0.	1.8	2.9	1.8	22.9
HYDROPSYCHIDAE						
UNIDENTIFIED HYDROPSYCHIDAE	4.	0.	1.8	2.9	1.8	22.9
CHEUMATOPSYCHE SP.	11.	11.	10.8	17.6	0.0	0.2
HYDROPSYCHE FRISONI	0.	7.	3.6	5.9	3.6	45.7
POTAMYIA FLAVA	0.	7.	3.6	5.9	3.6	45.7
DIPTERA						
CHAOBORIDAE						
CHAOBORUS PUNCTIPENNIS	7.	0.	3.6	5.9	3.6	45.9
CHAOBORU PUNCTIPENNIS PUPA	4.	0.	1.8	2.9	1.8	22.9
SIMULIDAE						
UNIDENTIFIED SIMULIDAE	36.	11.	23.4	38.3	12.6	160.7
CHIRONOMIDAE						
CHIRONOMINAE						
GLYPTOTENDIPES SP.	0.	4.	1.8	2.9	1.8	22.9
ORTHOCLADIINAE						
CRICOTOPUS TREMULUS	0.	4.	1.8	2.9	1.8	22.9
CRIOTOPUS SP.	0.	4.	1.8	2.9	1.8	22.9
CRICOTOPUS (SS) SP. PUPA	0.	4.	1.8	2.9	1.8	22.9
MOLLUSCA						
PELECYPODA						
HETERODONATA						
SPHAERIIDAE						
SPHAERIUM TRANSVERSUM	0.	4.	1.8	2.9	1.8	22.9
TUBIFICIDAE	-	-	-	-	-	-
CHIRONOMIDAE	0.	14.	7.2	11.7	7.2	91.5
INSECTA	69.	50.	59.5	97.1	9.1	115.6
TOTAL BENTHOS	69.	54.	61.3	100.0	7.3	92.7
NUMBER OF SPECIES FOUND IN EACH REPLICATE	7	9				

Table E-4. Summary of drifting macroinvertebrate composition, abundance (No./100 m^3), and percent occurrence at Location 1 in the tailwaters of John Redmond Reservoir near Wolf Creek Generating Station, 15 December 1980.

ORGANISM	REPLICATES (100 CU M) A	B	MEAN/ 100 CU M	%	SE	.95 CONF INT
ARTHROPODA						
INSECTA						
TRICHOPTERA						
HYDROPSYCHIDAE						
CHEUMATOPSYCHE SP.	2.	0.	0.7	100.0	0.8	9.5
TUBIFICIDAE	-	-	-	-	-	-
CHIRONOMIDAE	-	-	-	-	-	-
INSECTA	2.	0.	0.7	100.0	0.8	9.5
TOTAL BENTHOS	2.	0.	0.7	100.0	0.8	9.5
NUMBER OF SPECIES FOUND IN EACH REPLICATE	1	0				

Table E-5. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 4 in the Neosho River near Wolf Creek Generating Station, 17 June 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
ANNELIDA						
HIRUDINEA						
RHYNCHOBDELLIDA						
GLOSSIPHONIIDAE						
ACTINOBDELLA INEQUIANNA	0.	1.	9.4	0.7	9.4	120.1
ARTHROPODA						
INSECTA						
EPHEMEROPTERA						
EPHEMERIDAE						
EPHORON LEUKON	4.	9.	122.8	8.8	47.2	600.4
CAENIDAE						
CAENIS SP.	11.	13.	226.8	16.2	18.9	240.1
PLECOPTERA						
PERLODIDAE						
NEOPERLA CLYMENE	4.	1.	47.3	3.4	28.3	360.2
TRICHOPTERA						
HYDROPSYCHIDAE						
UNIDENTIFIED HYDROPSYCHIDAE	20.	13.	311.9	22.3	66.1	840.5
POTAMYIA FLAVA	12.	2.	132.3	9.5	94.5	1200.7
COLEOPTERA						
ELMIDAE						
STENELMIS SP.	0.	2.	18.9	1.4	18.9	240.1
DIPTERA						
CHAOBORIDAE						
CHAOBORUS PUNCTIPENNIS	0.	1.	9.4	0.7	9.4	120.1
CHIRONOMIDAE						
CHIRONOMINAE						
CHIRONOMUS SP.	0.	1.	9.4	0.7	9.4	120.1
CLADOTANYTARSUS SP.	0.	3.	28.4	2.0	28.4	360.2
CRYPTOCHIRONOMUS SP.	2.	4.	56.7	4.1	18.9	240.1
POLYPEDILUM (S.S.) CONVICTUM TYPE	1.	0.	9.4	0.7	9.4	120.1
POLYPEDILUM (S.S.) SIMULANS TYPE	0.	14.	132.3	9.5	132.3	1681.0
PSEUDOCHIRONOMUS SP.	0.	1.	9.4	0.7	9.4	120.1

Table E-5. (continued)

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
TANYTARSUS SP.	1.	1.	18.9	1.4	0.0	0.0
TANYPODINAE						
THIENEMANNIMYIA GROUP	16.	10.	245.7	17.6	56.7	720.4
ORTHOCLADIINAE						
NANOCLADIUS SP. PUPA	0.	1.	9.4	0.7	9.4	120.1
TUBIFICIDAE	-	-	-	-	-	-
CHIRONOMIDAE	20.	35.	519.8	37.2	141.8	1801.1
INSECTA	71.	76.	1389.2	99.3	47.3	600.4
TOTAL BENTHOS	71.	77.	1398.6	100.0	56.7	720.4
NUMBER OF SPECIES FOUND IN EACH REPLICATE	9	16				

Table E-6. *Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 10 in the Neosho River near Wolf Creek Generating Station, 17 June 1980.*

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
ARTHROPODA						
INSECTA						
EPHEMEROPTERA						
EPHEMERIDAE						
EPHORON LEUKON	14.	16.	283.5	6.4	18.9	240.1
CAENIDAE						
CAENIS SP.	5.	3.	75.6	1.7	18.9	240.1
TRICORYTHODES SP.	1.	1.	18.9	0.4	0.0	0.0
HEPTAGENIIDAE						
UNIDENTIFIED HEPTAGENIIDAE	1.	0.	9.4	0.2	9.4	120.1
HEPTAGENIA DIABASIA	0.	1.	9.4	0.2	9.4	120.1
PLECOPTERA						
PERLODIDAE						
NEOPERLA CLYMENE	24.	4.	264.6	6.0	189.0	2401.4
TRICHOPTERA						
HYDROPSYCHIDAE						
UNIDENTIFIED HYDROPSYCHIDAE	37.	14.	482.0	10.9	217.3	2761.6
CHEUMATOPSYCHE SP.	9.	34.	406.3	9.2	236.3	3001.8
HYDROPSYCHE ORRIS	0.	2.	18.9	0.4	18.9	240.1
POTAMYIA FLAVA	31.	35.	623.7	14.1	37.8	480.3
COLEOPTERA						
ELMIDAE						
STENELMIS SP.	28.	0.	264.6	6.0	264.6	3362.0
DIPTERA						
SIMULIDAE						
UNIDENTIFIED SIMULIDAE	1.	0.	9.4	0.2	9.4	120.1
CHIRONOMIDAE						
CHIRONOMINAE						
CHIRONOMUS SP.	0.	2.	18.9	0.4	18.9	240.1
CRYPTOCHIRONOMUS SP.	2.	2.	37.8	0.9	0.0	0.0
DICROTENDIPES SP.	1.	0.	9.4	0.2	9.4	120.1
PARALAUTERBORNIELLA SP.	1.	0.	9.4	0.2	9.4	120.1
POLYPEDILUM (S.S.) CONVICTUM TYPE	51.	0.	481.9	10.9	481.9	6123.7
POLYPEDILUM (S.S.) SIMULANS TYPE	11.	15.	245.7	5.6	37.8	480.3

Table E-6. (continued)

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
POLYPEDILUM SP. PUPA	3.	0.	28.4	0.6	28.4	360.2
PSEUDOCHIRONOMUS SP.	3.	0.	28.4	0.6	28.4	360.2
RHEOTANYTARSUS SP.	11.	1.	113.4	2.6	94.5	1200.7
RHEOTANYTARSUS SP. PUPA	1.	0.	9.4	0.2	9.4	120.1
TANYTARSUS SP.	6.	3.	85.1	1.9	28.4	360.2
TANYPODINAE						
THIENEMANNIMYIA GROUP	17.	3.	189.0	4.3	132.3	1681.0
ORTHOCLADIINAE						
CRICOTOPUS BICINCTUS	33.	2.	330.8	7.5	293.0	3722.2
CRIOTOPUS SP.	0.	2.	18.9	0.4	18.9	240.1
CRICOTOPUS SP. PUPA	1.	0.	9.4	0.2	9.4	120.1
HYDROBAENUS SP. PUPA	1.	0.	9.4	0.2	9.4	120.1
NANOCLADIUS SP. PUPA	2.	0.	18.9	0.4	18.9	240.1
THIENEMANNIELLA SP.	27.	1.	264.6	6.0	245.7	3121.9
EMPIDIDAE						
HEMERODROMIA SP.	0.	4.	37.8	0.9	37.8	480.3
TUBIFICIDAE	-	-	-	-	-	-
CHIRONOMIDAE	171.	31.	1908.9	43.3	1323.0	16810.0
INSECTA	322.	145.	4413.1	100.0	1672.7	21252.7
TOTAL BENTHOS	322.	145.	4413.1	100.0	1672.7	21252.7
NUMBER OF SPECIES FOUND IN EACH REPLICATE	26	19				

Table E-7. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 4 in the Neosho River near Wolf Creek Generating Station, 28 October 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	X	SE	.95 CONF INT
PLATYHELMINTHES						
TURBELLARIA						
TRICLADIDA						
PLANARIIDAE						
DUGESIA SP.	0.	3.	28.4	0.7	28.4	360.2
NEMATODA						
UNIDENTIFIED NEMATODA	1.	0.	9.4	0.2	9.4	120.1
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
ENCHYTRAEIDAE						
UNIDENTIFIED ENCHYTRAEIDAE	1.	0.	9.4	0.2	9.4	120.1
NAIDIDAE						
NAIS SP.	0.	1.	9.4	0.2	9.4	120.1
TUBIFICIDAE						
UNIDENTIFIED IMM. WITH CAPILLIFORMS	4.	2.	56.7	1.4	18.9	240.1
UNIDENTIFIED IMM. WITHOUT CAPILLIFORMS	4.	7.	104.0	2.5	28.3	360.2
BRANCHIURA SOWERBYI	7.	25.	302.4	7.4	170.1	2161.3
HIRUDINEA						
RHYNCHOBDELLIDA						
GLOSSIPHONIIDAE						
PLACOBDELLA SP.	0.	2.	18.9	0.5	18.9	240.1
ARTHROPODA						
INSECTA						
EPHEMEROPTERA						
EPHEMERIAE						
POTAMANTHUS SP.	20.	21.	387.5	9.4	9.4	120.1
CAENIDAE						
CAENIS SP.	6.	7.	122.9	3.0	9.4	120.1
TRICORYTHODES SP.	3.	5.	75.6	1.8	18.9	240.1
HEPTAGENIIDAE						
UNIDENTIFIED HEPTAGENIIDAE	14.	1.	141.8	3.4	122.9	1560.9
STENONEMA INTERPUNCTATUM	8.	0.	75.6	1.8	75.6	960.6
STENONEMA TRIPUNCTATUM	1.	2.	28.4	0.7	9.4	120.1
ODONATA						
GOMPHIDAE						
GOMPHUS SP.	0.	1.	9.4	0.2	9.4	120.1
COENAGRIONIDAE						
ARGIA SP.	2.	4.	56.7	1.4	18.9	240.1

Table E-7. (continued)

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
PLECOPTERA						
PERLODIDAE						
NEOPERLA CLYMENE	5.	2.	66.2	1.6	28.3	360.2
TRICHOPTERA						
LEPTOCERIDAE						
NECTOPSYCHE SP.	0.	2.	18.9	0.5	18.9	240.1
COLEOPTERA						
ELMIDAE						
STENELMIS SP.	26.	33.	557.5	13.6	66.2	840.5
DIPTERA						
CHIRONOMIDAE						
CHIRONOMINAE						
CHIRONOMUS SP.	2.	4.	56.7	1.4	18.9	240.1
CRYPTOCHIRONOMUS SP.	3.	0.	28.4	0.7	28.4	360.2
DICROTENDIPES SP.	41.	24.	614.3	14.9	160.6	2041.2
GLYPTOTENDIPES SP.	28.	15.	406.4	9.9	122.9	1560.9
PSEUDOCHIRONOMUS SP.	29.	22.	481.9	11.7	66.2	840.5
STICTOCHIRONOMUS SP.	0.	1.	9.4	0.2	9.4	120.1
TANYTARSUS SP.	3.	5.	75.6	1.8	18.9	240.1
TANYTARSUS SP. PUPA	1.	2.	28.4	0.7	9.4	120.1
TANYPODINAE						
ABLABESMYIA SP.	1.	2.	28.4	0.7	9.4	120.1
LARSIA SP.	1.	2.	28.4	0.7	9.4	120.1
THIENEMANNIMYIA GROUP	9.	6.	141.8	3.4	28.4	360.2
ORTHOCLADIINAE						
CRICOTOPUS BICINCTUS	0.	1.	9.4	0.2	9.4	120.1
NANOCLADIUS SP.	0.	1.	9.4	0.2	9.4	120.1
CERATOPGONODAE						
UNIDENTIFIED CERATOPOGONIDAE	1.	0.	9.4	0.2	9.4	120.1
MOLLUSCA						
GASTROPODA						
BASOMATOPHORA						
ANCYLIDAE						
FERRISSIA RIVULARIS	0.	4.	37.8	0.9	37.8	480.3
FERRISSIA SP.	0.	7.	66.2	1.6	66.2	840.5
TUBIFICIDAE	15.	34.	463.0	11.3	179.5	2281.4
CHIRONOMIDAE	118.	85.	1918.3	46.7	311.9	3962.4
INSECTA	204.	163.	3468.1	84.4	387.4	4922.9
TOTAL BENTHOS	221.	214.	4110.8	100.0	66.1	840.3
NUMBER OF SPECIES FOUND IN EACH REPLICATE	25	30				

Table E-8. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 10 in the Neosho River near Wolf Creek Generating Station, 28 October 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
PLATYHELMINTHES						
TURBELLARIA						
TRICLADIDA						
PLANARIIDAE						
DUGESIA SP.	1.	0.	9.4	0.1	9.4	120.1
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
TUBIFICIDAE						
UNIDENTIFIED IMM. WITH CAPILLIFORMS	0.	3.	28.4	0.2	28.4	360.2
UNIDENTIFIED IMM. WITHOUT CAPILLIFORMS	4.	0.	37.8	0.2	37.8	480.3
BRANCHIURA SOWERBYI	7.	20.	255.2	1.5	122.8	1560.9
LIMNODRILUS CERVIX	0.	1.	9.4	0.1	9.4	120.1
HIRUDINEA						
RHYNCHOBDELLIDA						
GLOSSIPHONIIDAE						
PLACOBDELLA SP.	1.	0.	9.4	0.1	9.4	120.1
ARTHROPODA						
INSECTA						
EPHEMEROPTERA						
EPHEMERIDAE						
POTAMANTHUS SP.	182.	66.	2343.6	13.5	1096.2	13928.3
CAENIDAE						
CAENIS SP.	18.	5.	217.3	1.3	122.8	1560.9
TRICORYTHODES SP.	133.	95.	2154.6	12.4	359.1	4562.7
HEPTAGENIIDAE						
UNIDENTIFIED HEPTAGENIIDAE	86.	16.	963.9	5.6	661.5	8405.0
STENONEMA INTERPUNCTATUM	4.	0.	37.8	0.2	37.8	480.3
STENONEMA TRIPUNCTATUM	26.	0.	245.7	1.4	245.7	3121.9
BAETIDAE						
UNIDENTIFIED BAETIDAE	0.	3.	28.4	0.2	28.4	360.2
BAETIS SP.	4.	3.	66.2	0.4	9.4	120.1

Table E-8. (continued)

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
ISONYCHIA SP.	6.	56.	585.9	3.4	472.5	6003.6
PARACLOEODES MINUTUM	0.	8.	75.6	0.4	75.6	960.6
PSEUDOCLOEON SP.	0.	48.	453.6	2.6	453.6	5763.4
ODONATA						
GOMPHIDAE						
GOMPHUS SP.	2.	1.	28.4	0.2	9.4	120.1
COENAGRIONIDAE						
ARGIA SP.	10.	0.	94.5	0.5	94.5	1200.7
PLECOPTERA						
PERLODIDAE						
NEOPERLA CLYMENE	90.	38.	1209.6	7.0	491.4	6243.7
TRICHOPTERA						
HYDROPSYCHIDAE						
UNIDENTIFIED HYDROPSYCHIDAE	45.	150.	1842.8	10.6	992.3	12607.5
CHEUMATOPSYCHE SP.	36.	161.	1861.6	10.7	1181.3	15009.0
HYDROPSYCHE FRISONI	0.	1.	9.4	0.1	9.4	120.1
POTAMYIA FLAVA	24.	112.	1285.2	7.4	831.6	10566.3
HYDROPTILIDAE						
HYDROPTILA SP.	5.	19.	226.8	1.3	132.3	1681.0
LEPTOCERIDAE						
OECETIS SP.	5.	5.	94.5	0.5	0.0	0.0
COLEOPTERA						
ELMIDAE						
STENELMIS SP.	41.	34.	708.8	4.1	66.1	840.5
DIPTERA						
SIMULIDAE						
UNIDENTIFIED SIMULIDAE	0.	3.	28.4	0.2	28.4	360.2
CHIRONOMIDAE						
CHIRONOMINAE						
CHIRONOMUS SP.	3.	1.	37.8	0.2	18.9	240.1
CRYPTOCHIRONOMUS SP.	3.	2.	47.3	0.3	9.4	120.1
DICROTENDIPES SP.	8.	0.	75.6	0.4	75.6	960.6
GLYPTOTENDIPES SP.	37.	4.	387.4	2.2	311.9	3962.4
POLYPEDILUM SP.	1.	1.	18.9	0.1	0.0	0.0
PSEUDOCHIRONOMUS SP.	4.	3.	66.2	0.4	9.4	120.1

Table E-8. (continued)

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
RHEOTANYTARSUS SP.	0.	2.	18.9	0.1	18.9	240.1
TANYTARSUS SP.	5.	1.	56.7	0.3	37.8	480.3
TANYTARSUS SP. PUPA	4.	1.	47.3	0.3	28.3	360.2
TANYPODINAE						
LARSIA SP.	3.	0.	28.4	0.2	28.4	360.2
THIENEMANNIMYIA GROUP	35.	14.	463.1	2.7	198.4	2521.5
ORTHOCLADIINAE						
CRICOTOPUS BICINCTUS	1.	0.	9.4	0.1	9.4	120.1
CRICOTOPUS TREMULUS	7.	8.	141.8	0.8	9.5	120.1
CRICOTOPUS VIERRIENSIS	0.	1.	9.4	0.1	9.4	120.1
CRIOTOPUS SP.	10.	9.	179.6	1.0	9.4	120.1
CRICOTOPUS (SS) SP. PUPA	1.	4.	47.3	0.3	28.3	360.2
EUKIEFFERIELLA SP. PUPA	0.	1.	9.4	0.1	9.4	120.1
NANOCLADIUS SP.	1.	2.	28.4	0.2	9.4	120.1
THIENEMANNIELLA SP.	1.	0.	9.4	0.1	9.4	120.1
LEPIDOPTERA						
PYRALIDAE						
PARAGYRAETIS SP.	31.	45.	718.2	4.1	132.3	1681.0
MOLLUSCA						
GASTROPODA						
BASOMATOPHORA						
ANCYLIDAE						
FERRISSIA RIVULARIS	0.	1.	9.4	0.1	9.4	120.1
PELECYPODA						
HETERODONATA						
SPHAERIIDAE						
SPHAERIUM SP.	4.	0.	37.8	0.2	37.8	480.3
TUBIFICIDAE	11.	24.	330.8	1.9	122.9	1560.9
CHIRONOMIDAE	124.	54.	1682.1	9.7	661.5	8405.0
INSECTA	872.	923.	16962.8	97.7	481.9	6123.4
TOTAL BENTHOS	889.	948.	17359.7	100.0	557.5	7083.7
NUMBER OF SPECIES FOUND IN EACH REPLICATE	39	39				

Table E-9. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 4 in the Neosho River near Wolf Creek Generating Station, 16 December 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	X	SE	.95 CONF INT
PLATYHELMINTHES						
TURBELLARIA						
TRICLADIDA						
PLANARIIDAE						
DUGESIA SP.	1.	0.	9.4	1.7	9.4	120.1
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
TUBIFICIDAE						
UNIDENTIFIED IMM. WITH CAPILLIFORMS	1.	0.	9.4	1.7	9.4	120.1
UNIDENTIFIED IMM. WITHOUT CAPILLIFORMS	4.	2.	56.7	10.0	18.9	240.1
BRANCHIURA SOWERBYI	24.	11.	330.8	58.3	122.9	1560.9
HIRUDINEA						
RHYNCHOBDELLIDA						
GLOSSIPHONIIDAE						
ACTINOBDELLA SP.	0.	1.	9.4	1.7	9.4	120.1
ARTHROPODA						
INSECTA						
EPHEMEROPTERA						
EPHEMERIAE						
POTAMANTHUS SP.	4.	0.	37.8	6.7	37.8	480.3
CAENIDAE						
CAENIS SP.	1.	0.	9.4	1.7	9.4	120.1
DIPTERA						
CHIRONOMIDAE						
CHIRONOMINAE						
CHIRONOMUS SP.	1.	0.	9.4	1.7	9.4	120.1
CLADOTANYTARSUS SP.	0.	1.	9.4	1.7	9.4	120.1
PSEUDOCHIRONOMUS SP.	2.	0.	18.9	3.3	18.9	240.1
STICTOCHIRONOMUS SP.	2.	0.	18.9	3.3	18.9	240.1
ORTHOCLADIINAE						
CRICOTOPUS VIERRIENSIS	1.	0.	9.4	1.7	9.4	120.1

Table E-9. (continued)

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
HYDROBAENUS SP.	2.	1.	28.4	5.0	9.4	120.1
MULLUSCA						
GASTROPODA						
BASOMATOPHORA						
PHYSIDAE						
PHYSA SP.	1.	0.	9.4	1.7	9.4	120.1
TUBIFICIDAE	29.	13.	396.9	70.0	151.2	1921.1
CHIRONOMIDAE	8.	2.	94.5	16.7	56.7	720.4
INSECTA	13.	2.	141.8	25.0	103.9	1320.8
TOTAL BENTHOS	44.	16.	567.0	100.0	264.6	3362.0
NUMBER OF SPECIES FOUND IN EACH REPLICATE	12	5				

Table E-10. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 10 in the Neosho River near Wolf Creek Generating Station, 16 December 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
TUBIFICIDAE						
UNIDENTIFIED IMM. WITH CAPILLIFORMS	3.	0.	28.4	6.5	28.4	360.2
UNIDENTIFIED IMM. WITHOUT CAPILLIFORMS	4.	0.	37.8	8.7	37.8	480.3
BRANCHIURA SOWERBYI	15.	1.	151.2	34.8	132.3	1681.0
LIMNODRILUS CERVIX	1.	0.	9.4	2.2	9.4	120.1
ARTHROPODA						
INSECTA						
EPHEMEROPTERA						
EPHEMERIDAE						
POTAMANTHUS SP.	1.	1.	18.9	4.3	0.0	0.0
CAENIDAE						
TRICORYTHODES SP.	0.	2.	18.9	4.3	18.9	240.1
PLECOPTERA						
PERLODIDAE						
NEOPERLA CLYMENE	4.	1.	47.3	10.9	28.3	360.2
TRICHOPTERA						
HYDROPSYCHIDAE						
CHEUMATOPSYCHE SP.	1.	0.	9.4	2.2	9.4	120.1
COLEOPTERA						
ELMIDAE						
STENELMIS SP.	2.	0.	18.9	4.3	18.9	240.1
DIPTERA						
SIMULIDAE						
UNIDENTIFIED SIMULIDAE	1.	0.	9.4	2.2	9.4	120.1
CHIRONOMIDAE						
TANYPODINAE						
THIENEMANNIMYIA GROUP	2.	0.	18.9	4.3	18.9	240.1
ORTHOCLADIINAE						
CRIOTOPUS SP.	1.	0.	9.4	2.2	9.4	120.1
TIPULIDAE						

Table E-10. (continued)

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
UNIDENTIFIED TIPULIDAE	4.	0.	37.8	8.7	37.8	480.3
MOLLUSCA						
GASTROPODA						
BASOMATOPHORA						
PHYSIDAE						
PHYSA SP.	1.	0.	9.4	2.2	9.4	120.1
PELECYPODA						
EULAMELLIBRANHIA						
UNIONIDAE						
UNIONIDAE IMMATURE	0.	1.	9.4	2.2	9.4	120.1
TUBIFICIDAE	23.	1.	226.8	52.2	207.9	2641.6
CHIRONOMIDAE	3.	0.	28.4	6.5	28.4	360.2
INSECTA	16.	4.	189.0	43.5	113.4	1440.9
TOTAL BENTHOS	40.	6.	434.7	100.0	321.3	4082.4
NUMBER OF SPECIES FOUND IN EACH REPLICATE	13	5				

Table E-11. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 3 in Wolf Creek near the Wolf Creek Generating Station, 15 April 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
NEMATODA						
UNIDENTIFIED NEMATODA	0.	2.	18.9	3.3	18.9	240.1
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
TUBIFICIDAE						
UNIDENTIFIED IMM. WITHOUT CAPILLIFORMS	8.	7.	141.8	24.6	9.5	120.1
BRANCHIURA SOWERBYI	2.	4.	56.7	9.8	18.9	240.1
ARTHROPODA						
INSECTA						
TRICHOPTERA						
HYDROPSYCHIDAE						
UNIDENTIFIED HYDROPSYCHIDAE	0.	1.	9.4	1.6	9.4	120.1
COLEOPTERA						
ELMIDAE						
UNIDENTIFIED ELMIDAE	3.	1.	37.8	6.6	18.9	240.1
DIPTERA						
CHIRONOMIDAE						
CHIRONOMINAE						
CRYPTOCHIRONOMUS SP.	6.	5.	104.0	18.0	9.4	120.1
DICROTENDIPES SP.	6.	0.	56.7	9.8	56.7	720.4
POLYPEDILUM (S.S.) SIMULANS TYPE	1.	1.	18.9	3.3	0.0	0.0
STICTOCHIRONOMUS SP.	0.	1.	9.4	1.6	9.4	120.1
ORTHOCLADIINAE						
CRICOTOPUS (SS) FUSCUS GROUP	0.	1.	9.4	1.6	9.4	120.1
CRIOTOPUS SP.	2.	0.	18.9	3.3	18.9	240.1
HYDROBAENUS SP.	5.	0.	47.3	8.2	47.3	600.4
CERATOPGONODAE						
UNIDENTIFIED CERATOPOGONIDAE	1.	2.	28.4	4.9	9.4	120.1
MOLLUSCA						
GASTROPODA						

Table E-11. (continued)

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
BASOMATOPHORA						
PHYSIDAE						
PHYSA SP.	0.	1.	9.4	1.6	9.4	120.1
PELECYPODA						
HETERODONATA						
SPHAERIIDAE						
SPHAERIUM SP.	0.	1.	9.4	1.6	9.4	120.1
TUBIFICIDAE	10.	11.	198.4	34.4	9.4	120.1
CHIRONOMIDAE	20.	8.	264.6	45.9	113.4	1440.9
INSECTA	24.	12.	340.2	59.0	113.4	1440.9
TOTAL BENTHOS	34.	27.	576.5	100.0	66.1	840.5
NUMBER OF SPECIES FOUND IN EACH REPLICATE	9	12				

Table E-12. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 7 in Wolf Creek near the Wolf Creek Generating Station, 15 April 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
TUBIFICIDAE						
UNIDENTIFIED IMM. WITH CAPILLIFORMS	1.	0.	9.4	0.7	9.4	120.1
UNIDENTIFIED IMM. WITHOUT CAPILLIFORMS	69.	47.	1096.2	81.7	207.9	2641.6
ILYODRILUS TEPLETONI	0.	1.	9.4	0.7	9.4	120.1
LIMNODRILUS CERVIX	4.	11.	141.8	10.6	66.1	840.5
LIMNODRILUS CLAPAREDEIANUS	1.	2.	28.4	2.1	9.4	120.1
ARTHROPODA						
INSECTA						
DIPTERA						
CHIRONOMIDAE						
CHIRONOMINAE						
CRYPTOCHIRONOMUS SP.	1.	0.	9.4	0.7	9.4	120.1
TANYPODINAE						
PROCLADIUS (PSILOTANYPUS) SP.	1.	1.	18.9	1.4	0.0	0.0
THIENEMANNIMYIA GROUP	2.	1.	28.4	2.1	9.4	120.1
TUBIFICIDAE	75.	61.	1285.2	95.8	132.3	1681.0
CHIRONOMIDAE	4.	2.	56.7	4.2	18.9	240.1
INSECTA	4.	2.	56.7	4.2	18.9	240.1
TOTAL BENTHOS	79.	63.	1341.9	100.0	151.2	1921.1
NUMBER OF SPECIES FOUND IN EACH REPLICATE	7	6				

Table E-13. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 3 in Wolf Creek near the Wolf Creek Generating Station, 17 June 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
NAIDIDAE						
NAIS BEHNINGI	0.	2.	18.9	1.6	18.9	240.1
NAIS BRETSCHERI	0.	5.	47.3	4.0	47.3	600.4
NAIS SP.	0.	39.	368.5	31.2	368.6	4682.8
TUBIFICIDAE						
UNIDENTIFIED IMM. WITHOUT CAPILLIFORMS	7.	8.	141.8	12.0	9.5	120.1
LIMNODRILUS CERVIX	1.	0.	9.4	0.8	9.4	120.1
ARTHROPODA						
INSECTA						
EPHEMEROPTERA						
EPHEMERIAE						
EPHORON LEUKON	0.	1.	9.4	0.8	9.4	120.1
COLEOPTERA						
UNIDENTIFIED COLEOPTERA	0.	2.	18.9	1.6	18.9	240.1
ELMIDAE						
STENELMIS SP.	1.	0.	9.4	0.8	9.4	120.1
DIPTERA						
CHAOBORIDAE						
CHAOBORU PUNCTIPENNIS PUPA	1.	0.	9.4	0.8	9.4	120.1
CHIRONOMIDAE						
CHIRONOMINAE						
CHIRONOMUS SP.	0.	12.	113.4	9.6	113.4	1440.9
CHIRONOMUS SP. PUPA	0.	1.	9.4	0.8	9.4	120.1
CRYPTOCHIRONOMUS SP.	2.	0.	18.9	1.6	18.9	240.1
POLYPEDILUM (S.S.) SIMULANS TYPE	7.	8.	141.8	12.0	9.5	120.1
STICTOCHIRONOMUS SP.	3.	5.	75.6	6.4	18.9	240.1
TANYPODINAE						
PROCLADIUS (PSILOTANYPUS) SP.	0.	4.	37.8	3.2	37.8	480.3
THIENEMANNIMYIA GROUP	8.	7.	141.8	12.0	9.5	120.1
CERATOPGONODAE						

Table E-13. (continued)

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
CERATOPGONODAE	0.	1.	9.4	0.8	9.4	120.1
TUBIFICIDAE	8.	8.	151.2	12.8	0.0	0.0
CHIRONOMIDAE	20.	37.	538.7	45.6	160.6	2041.2
INSECTA	22.	41.	595.3	50.4	179.5	2281.4
TOTAL BENTHOS	30.	95.	1181.3	100.0	614.2	7804.7
NUMBER OF SPECIES FOUND IN EACH REPLICATE	8	13				

Table E-14. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 7 in Wolf Creek near the Wolf Creek Generating Station, 17 June 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
NAIDIDAE						
NAIS SP.	1.	0.	9.4	0.8	9.4	120.1
TUBIFICIDAE						
UNIDENTIFIED IMM. WITHOUT CAPILLIFORMS	36.	14.	472.5	41.3	207.9	2641.6
LIMNODRILUS CERVIX	30.	11.	387.5	33.9	179.5	2281.4
LIMNODRILUS HOFFMEISTERI	1.	0.	9.4	0.8	9.4	120.1
ARTHROPODA						
CRUSTACEA						
AMPHIPODA						
TALITRIDAE						
HYALELLA AZTECA	1.	0.	9.4	0.8	9.4	120.1
DECAPODA						
ASTACIDAE						
UNIDENTIFIED ASTACIDAE	1.	0.	9.4	0.8	9.4	120.1
INSECTA						
TRICHOPTERA						
HYDROPSYCHIDAE						
UNIDENTIFIED HYDROPSYCHIDAE	0.	1.	9.4	0.8	9.4	120.1
COLEOPTERA						
ELMIDAE						
STENELMIS SP.	0.	1.	9.4	0.8	9.4	120.1
DIPTERA						
CHIRONOMIDAE						
CHIRONOMINAE						
CHIRONOMUS SP.	0.	5.	47.3	4.1	47.3	600.4
DICROTENDIPES SP.	1.	0.	9.4	0.8	9.4	120.1
GLYPTOTENDIPES (PHYTOTENDIPES) SP.	0.	1.	9.4	0.8	9.4	120.1
POLYPEDILUM SP. PUPA	0.	1.	9.4	0.8	9.4	120.1
STICTOCHIRONOMUS SP.	0.	3.	28.4	2.5	28.4	360.2
TANYPODINAE						
PROCLADIUS (PSILOTANYPUS) SP.	6.	7.	122.9	10.7	9.4	120.1
TUBIFICIDAE	67.	25.	869.4	76.0	396.9	5043.0
CHIRONOMIDAE	7.	17.	226.8	19.8	94.5	1200.7
INSECTA	7.	19.	245.7	21.5	113.4	1440.9
TOTAL BENTHOS	77.	44.	1143.4	100.0	311.9	3962.4
NUMBER OF SPECIES FOUND IN EACH REPLICATE	8	9				

Table E-15. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 3 in Wolf Creek near the Wolf Creek Generating Station, 28 October 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
NEMATODA						
UNIDENTIFIED NEMATODA	1.	0.	9.4	0.7	9.4	120.1
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
ENCHYTRAEIDAE						
UNIDENTIFIED ENCHYTRAEIDAE	3.	2.	47.3	3.6	9.4	120.1
NAIDIDAE						
NAIS SP.	6.	1.	66.2	5.0	47.3	600.4
TUBIFICIDAE						
UNIDENTIFIED IMM. WITH CAPILLIFORMS	1.	4.	47.3	3.6	28.3	360.2
UNIDENTIFIED IMM. WITHOUT CAPILLIFORMS	59.	42.	954.5	72.7	160.7	2041.2
LIMNODRILUS CERVIX	2.	4.	56.7	4.3	18.9	240.1
LIMNODRILUS HOFFMEISTERI	0.	1.	9.4	0.7	9.4	120.1
HIRUDINEA						
PHARYNGOBDELLIDA						
ERPOBDELLIDAE						
DINA MICROSTOMA	1.	0.	9.4	0.7	9.4	120.1
ARTHROPODA						
INSECTA						
EPHEMEROPTERA						
EPHEMERIAE						
POTAMANTHUS SP.	1.	0.	9.4	0.7	9.4	120.1
CAENIDAE						
TRICORYTHODES SP.	2.	0.	18.9	1.4	18.9	240.1
DIPTERA						
CHIRONOMIDAE						
ORTHOCLADIINAE						
NANOCLADIUS SP.	2.	3.	47.3	3.6	9.4	120.1
CERATOPGONODAE						
UNIDENTIFIED CERATOPOGONIDAE	1.	0.	9.4	0.7	9.4	120.1
TIPULIDAE						
UNIDENTIFIED TIPULIDAE	1.	2.	28.4	2.2	9.4	120.1
TUBIFICIDAE	62.	51.	1067.8	81.3	103.9	1320.8
CHIRONOMIDAE	2.	3.	47.3	3.6	9.4	120.1
INSECTA	7.	5.	113.4	8.6	18.9	240.1
TOTAL BENTHOS	80.	59.	1313.6	100.0	198.4	2521.5
NUMBER OF SPECIES FOUND IN EACH REPLICATE	12	8				

Table E-16. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 7 in Wolf Creek near the Wolf Creek Generating Station, 28 October 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
TUBIFICIDAE						
UNIDENTIFIED IMM. WITH CAPILLIFORMS	1.	0.	9.4	5.6	9.4	120.1
UNIDENTIFIED IMM. WITHOUT CAPILLIFORMS	8.	2.	94.5	55.6	56.7	720.4
LIMNODRILUS CERVIX	1.	0.	9.4	5.6	9.4	120.1
ARTHROPODA						
INSECTA						
DIPTERA						
CHIRONOMIDAE						
CHIRONOMINAE						
CHIRONOMUS SP.	4.	0.	37.8	22.2	37.8	480.3
TANYPODINAE						
PROCLADIUS SP.	1.	0.	9.4	5.6	9.4	120.1
MOLLUSCA						
GASTROPODA						
BASOMATOPHORA						
PHYSIDAE						
PHYSA SP.	1.	0.	9.4	5.6	9.4	120.1
TUBIFICIDAE	10.	2.	113.4	66.7	75.6	960.6
CHIRONOMIDAE	5.	0.	47.3	27.8	47.3	600.4
INSECTA	5.	0.	47.3	27.8	47.3	600.4
TOTAL BENTHOS	16.	2.	170.1	100.0	132.3	1681.0
NUMBER OF SPECIES FOUND IN EACH REPLICATE	6	1				

Table E-17. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 3 in Wolf Creek near the Wolf Creek Generating Station, 16 December 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
TUBIFICIDAE						
UNIDENTIFIED IMM. WITHOUT CAPILLIFORMS	10.	10.	189.0	57.1	0.0	0.0
BRANCHIURA SOWERBYI	4.	0.	37.8	11.4	37.8	480.3
LIMNODRILUS HOFFMEISTERI	7.	0.	66.2	20.0	66.2	840.5
ARTHROPODA						
INSECTA						
EPHEMEROPTERA						
CAENIDAE						
TRICORYTHODES SP.	0.	1.	9.4	2.9	9.4	120.1
BAETIDAE						
UNIDENTIFIED BAETIDAE	0.	1.	9.4	2.9	9.4	120.1
PLECOPTERA						
PERLODIDAE						
NEOPERLA CLYMENE	0.	1.	9.4	2.9	9.4	120.1
TRICHOPTERA						
HYDROPSYCHIDAE						
CHEUMATOPSYCHE SP.	0.	1.	9.4	2.9	9.4	120.1
TUBIFICIDAE	21.	10.	293.0	88.6	103.9	1320.8
CHIRONOMIDAE	-	-	-	-	-	-
INSECTA	0.	4.	37.8	11.4	37.8	480.3
TOTAL BENTHOS	21.	14.	330.8	100.0	66.2	840.5
NUMBER OF SPECIES FOUND IN EACH REPLICATE	3	5				

Table E-18. Summary of benthic macroinvertebrate composition, abundance (No./m^2) and percent occurrence at Location 7 in Wolf Creek near the Wolf Creek Generating Station, 16 December 1980.

ORGANISM	REPLICATES (530 SQ CM) A	B	MEAN/ SQ. METER	%	SE	.95 CONF INT
ANNELIDA						
OLIGOCHAETA						
PLESIOPORA						
TUBIFICIDAE						
LIMNODRILUS CERVIX	1.	0.	9.4	12.5	9.4	120.1
ARTHROPODA						
INSECTA						
EPHEMEROPTERA						
CAENIDAE						
TRICORYTHODES SP.	0.	1.	9.4	12.5	9.4	120.1
HEPTAGENIIDAE						
UNIDENTIFIED HEPTAGENIIDAE	0.	1.	9.4	12.5	9.4	120.1
PLECOPTERA						
PERLODIDAE						
NEOPERLA CLYMENE	0.	1.	9.4	12.5	9.4	120.1
TRICHOPTERA						
HYDROPSYCHIDAE						
CHEUMATOPSYCHE SP.	0.	1.	9.4	12.5	9.4	120.1
POTAMYIA FLAVA	0.	2.	18.9	25.0	18.9	240.1
COLEOPTERA						
ELMIDAE						
STENELMIS SP.	0.	1.	9.4	12.5	9.4	120.1
TUBIFICIDAE	1.	0.	9.4	12.5	9.4	120.1
CHIRONOMIDAE	-	-	-	-	-	-
INSECTA	0.	7.	66.2	87.5	66.2	840.5
TOTAL BENTHOS	1.	7.	75.6	100.0	56.7	720.4
NUMBER OF SPECIES FOUND IN EACH REPLICATE	1	6				

APPENDIX F

FISHERIES DATA

Table F-1 Summary of electroshocking catch data from the Neosho River near Wolf Creek Generating Station, Burlington, Kansas, 1980.[a]

Date/Sampling Location	Species	Number	CPE	Total Length (mm) Average	Total Length (mm) Range	Weight (g) Average	Weight (g) Range
14 April							
1	Gizzard shad	3	3.0	325	293-368	270	160-400
	Carp	7	7.0	454	423-483	1109	880-1300
	River carpsucker	2	2.0	292	160-424	475	50-900
	Bigmouth buffalo	1	1.0	628	-	3660	-
	Black buffalo	1	1.0	382	-	960	-
	White bass	7	7.0	132	113-158	24	10-45
	White crappie	2	2.0	318	294-343	600	360-840
	Freshwater drum	3	3.0	210	172-268	103	45-200
	Total	26	26.0				
10	Longnose gar	6	6.0	651	524-770	675	320-1100
	Gizzard shad	1	1.0	296	-	220	-
	Carp	1	1.0	422	-	1160	-
	Smallmouth buffalo	1	1.0	662	-	4400	-
	Total	9	9.0				
4	Smallmouth buffalo	2	2.5	398	397-400	950	940-960
	Freshwater drum	1	1.2	398	-	840	-
	Total	3	3.7				
28 May							
1	Gizzard shad	24	24.0	206	122-333	124	22-390
	Carp	1	1.0	473	-	1120	-
	River carpsucker	26	26.0	242	160-328	220	60-475
	Smallmouth buffalo	5	5.0	430	374-509	1224	840-1620
	Bigmouth buffalo	6	6.0	475	266-651	2233	360-4060
	Black buffalo	1	1.0	293	-	325	-
	Channel catfish	12	12.0	182	107-263	51	12-138
	Flathead catfish	5	5.0	203	90-286	110	12-246
	White bass	1	1.0	137	-	36	-
	White crappie	7	7.0	129	102-231	38	18-142
	Walleye	2	2.0	354	271-437	558	176-940
	Total	90	90.0				
17 June							
1	Carp	3	3.0	476	426-545	1223	970-1700
	River carpsucker	39	39.0	268	195-369	303	97-765
	Smallmouth buffalo	3	3.0	341	210-442	752	710-1400
	Bigmouth buffalo	1	1.0	481	-	1710	-
	Channel catfish	7	7.0	212	141-267	79	24-150
	Flathead catfish	6	6.0	301	169-464	341	44-1190
	White bass	3	3.0	108	51-146	23	1-40
	Green sunfish	6	6.0	89	83-95	16	13-19
	Longear sunfish	1	1.0	117	-	50	-
	White crappie	8	8.0	142	117-183	39	19-80
	Walleye	2	2.0	292	285-300	190	176-204
	Freshwater drum	7	7.0	233	149-443	324	130-1310
	Total	86	86.0				
10	Longnose gar	1	1.0	600	-	420	-
	Carp	1	1.0	583	-	2330	-
	River carpsucker	6	6.0	361	313-417	675	420-980
	Quillback	1	1.0	396	-	820	-
	Smallmouth buffalo	10	10.0	365	236-481	810	205-1540
	Blue sucker	1	1.0	668	-	2480	-
	Flathead catfish	10	10.0	238	147-377	174	45-600
	Spotted bass	1	1.0	271	-	350	-
	Freshwater drum	3	3.0	208	199-216	140	115-180
	Total	34	34.0				

[a] Number of fish collected during 30 min. of effort.

Table F-1 (continued)

Date/Sampling Location	Species	Number	CPE	Total Length (mm) Average	Total Length (mm) Range	Weight (g) Average	Weight (g) Range
17 June (continued)							
4	Gizzard shad	5	5.0	188	164-203	71	48-86
	Carp	1	1.0	475	-	1370	-
	River carpsucker	3	3.0	370	347-390	700	560-800
	Blue sucker	1	1.0	556	-	1390	-
	Flathead catfish	11	11.0	208	157-412	132	38-1390
	Longear sunfish	1	1.0	127	-	60	-
	Spotted bass	1	1.0	218	-	130	-
	Freshwater drum	3	3.0	182	149-205	88	43-140
	Total	26	26.0				
24 July							
1	Carp	3	3.0	356	285-440	667	280-860
	Red shiner	1	1.0	71	-	-	-
	Ghost shiner	1	1.0	48	-	-	-
	River carpsucker	15	15.0	263	133-327	252	41-430
	Smallmouth buffalo	11	11.0	352	176-672	1108	80-5430
	Channel catfish	11	11.0	200	108-248	61	10-110
	Flathead catfish	10	10.0	202	110-330	128	14-370
	Brook silverside	1	1.0	51	-	-	-
	White bass	1	1.0	156	-	48	-
	Green sunfish	8	8.0	97	72-127	23	10-47
	Longear sunfish	3	3.0	94	68-108	25	9-33
	Largemouth bass	1	1.0	365	-	650	-
	White crappie	11	11.0	144	126-169	37	26-60
	Freshwater drum	4	4.0	136	72-183	38	10-74
	Total	81	81.0				
28 October							
1	Gizzard shad	1	1.0	335	-	420	-
	Carp	17	17.0	474	340-580	1147	540-1680
	River carpsucker	12	12.0	318	208-429	497	120-1000
	Smallmouth buffalo	1	1.0	494	-	1850	-
	Shorthead redhorse	1	1.0	365	-	700	-
	Blue sucker	1	1.0	650	-	2440	-
	Channel catfish	1	1.0	232	-	60	-
	Brook silverside	1	1.0	82	-	-	-
	White bass	2	2.0	105	100-111	16	14-18
	Freshwater drum	7	7.0	215	112-383	196	16-660
	Total	44	44.0				
10	Gizzard shad	1	1.0	190	-	65	-
	Carp	6	6.0	452	415-502	1165	880-1440
	River carpsucker	6	6.0	436	286-424	870	290-980
	Smallmouth buffalo	10	10.0	444	372-507	1334	850-1650
	Shorthead redhorse	1	1.0	325	-	360	-
	Blue sucker	2	2.0	604	556-652	1950	1390-2510
	Channel catfish	3	3.0	198	156-251	59	27-100
	Green sunfish	1	1.0	54	-	2	-
	Spotted bass	1	1.0	127	-	26	-
	Freshwater drum	31	31.0	143	96-324	51	10-360
	Total	62	62.0				
4	Gizzard shad	16	16.0	174	134-298	71	25-300
	River carpsucker	1	1.0	366	-	660	-
	Blue sucker	1	1.0	610	-	2080	-
	Channel catfish	1	1.0	535	-	1710	-
	White bass	1	1.0	276	-	300	-
	Spotted bass	1	1.0	98	-	18	-
	Freshwater drum	1	1.0	125	-	20	-
	Total	22	22.0				

Table F-1 (continued)

Date/Sampling Location	Species	Number	CPE	Total Length (mm) Average	Total Length (mm) Range	Weight (g) Average	Weight (g) Range
15 December							
1	Gizzard shad	4	4.0	297	88-372	457	8-620
	Carp	2	2.0	470	453-486	1180	960-1400
	River carpsucker	27	27.0	344	272-418	580	350-920
	Total	33	33.0				
10	Gizzard shad	1	1.0	272	-	170	-
	Carp	1	1.0	-	-	-	-
	River carpsucker	3	3.0	373	358-392	687	600-760
	Blue sucker	1	1.0	639	-	2400	-
	White crappie	2	2.0	175	-	45	-
	Total	8	8.0				
4	Gizzard shad	6	6.0	94	90-98	11	8-15
	River carpsucker	12	12.0	383	348-432	754	550-980
	Smallmouth buffalo	3	3.0	425	415-437	1130	1020-1240
	Spotted bass	1	1.0	112	-	22	-
	Total	22	22.0				

Table F-2 Summary of electrofishing catch data from the tailwaters of John Redmond Reservoir (Location 1) near Wolf Creek Generating Station, Burlington, Kansas, May through November 1980. Data collected during radiation monitoring collections by Kansas Gas and Electric personnel.

Date	Species	Number	CPE[a]	Total Length (mm) Average	Total Length (mm) Range	Weight (g) Average	Weight (g) Range
14 May[b]	Gizzard shad	9	18.0	176	118-345	99	15-420
	Carp	1	2.0	597	-	2360	-
	River carpsucker	4	8.0	290	246-342	364	200-500
	Bigmouth buffalo	6	12.0	541	498-600	2715	2110-3710
	Channel catfish	2	4.0	162	150-174	33	25-40
	Flathead catfish	1	2.0	330	-	390	-
	White bass	2	4.0	122	116-118	23	20-25
	Orangespotted sunfish	1	2.0	75	-	10	-
	White crappie	6	12.0	111	98-130	13	5-20
	Walleye	2	4.0	329	253-405	390	140-640
	Freshwater drum	1	2.0	198	-	95	-
	Total	35	70.0				
11 Jun[c]	Carp	5	8.3	401	325-464	828	500-1240
	River carpsucker	13	21.7	288	233-375	355	200-600
	Smallmouth buffalo	1	1.7	390	-	915	-
	Blue sucker	2	3.3	605	598-612	1650	1640-1660
	Channel catfish	2	3.3	229	179-278	99	40-158
	Flathead catfish	7	11.7	257	210-327	219	106-450
	White bass	1	1.7	136	-	34	-
	Longear sunfish	2	3.3	122	121-122	45	44-46
	White crappie	4	6.7	140	130-158	36	30-52
	Walleye	1	1.7	297	-	265	-
	Freshwater drum	3	5.0	416	382-436	1047	540-1340
	Total	41	68.4				
9 Jul	Gizzard shad	2	2.0	147	77-216	46	2-90
	Carp	1	1.0	334	-	445	-
	River carpsucker	18	18.0	274	151-368	314	130-600
	Smallmouth buffalo	1	1.0	340	-	510	-
	Golden redhorse	1	1.0	274	-	230	-
	Blue sucker	2	2.0	629	626-632	2130	2060-2300
	Channel catfish	13	13.0	213	155-341	88	35-320
	Flathead catfish	11	11.0	196	105-280	91	5-230
	Green sunfish	1	1.0	193	-	165	-
	White crappie	2	2.0	217	201-233	122	105-140
	Walleye	1	1.0	452	-	915	-
	Freshwater drum	2	2.0	159	145-173	115	60-170
	Total	55	55.0				
29 Aug	River carpsucker	4	4.0	282	227-307	287	154-380
	Smallmouth buffalo	7	7.0	357	200-483	796	110-1680
	Shorthead redhorse	5	5.0	362	305-427	608	340-940
	Channel catfish	7	7.0	239	198-275	105	55-160
	Flathead catfish	4	4.0	322	245-495	479	170-1240
	White bass	2	2.0	162	155-170	53	42-64
	Freshwater drum	1	1.0	165	-	58	-
	Total	30	30.0				

Table F-2 (continued)

Date	Species	Number	CPE[a]	Total Length (mm) Average	Total Length (mm) Range	Weight (g) Average	Weight (g) Range
18 Sep	Carp	1	1.0	394	-	780	-
	River carpsucker	8	8.0	293	245-331	334	190-500
	Smallmouth buffalo	3	3.0	436	393-465	1307	880-1600
	Channel catfish	2	2.0	181	178-184	44	40-48
	Brook silversides	1	1.0	74	-	2	-
	Green sunfish	1	1.0	155	-	80	-
	White crappie	5	5.0	156	138-187	49	30-74
	Freshwater drum	2	2.0	97	92-102	5	-
	Total	23	23.0				
30 Sep	Gizzard shad	3	3.0	312	270-334	318	195-405
	Carp	4	4.0	457	433-473	1090	880-1290
	River carpsucker	8	8.0	270	218-405	278	125-820
	Smallmouth buffalo	6	6.0	459	326-662	1847	490-5220
	Blue sucker	1	1.0	611	-	2000	-
	Channel catfish	7	7.0	195	93-277	78	30-190
	White bass	3	3.0	161	114-224	67	25-132
	Green sunfish	1	1.0	98	-	20	-
	White crappie	1	1.0	340	-	800	-
	Walleye	1	1.0	334	-	340	-
	Freshwater drum	7	7.0	147	63-442	208	2-1380
	Total	42	42.0				
21 Oct[d]	Gizzard shad	8	12.0	220	162-279	120	42-238
	Red shiner	1	1.5	71	-	1	-
	River carpsucker	16	24.0	255	158-335	207	52-500
	Smallmouth buffalo	3	4.5	298	227-428	470	150-1090
	Blue sucker	1	1.5	610	-	2100	-
	Channel catfish	8	12.0	269	162-520	303	34-1290
	White bass	7	10.5	139	110-185	38	13-80
	Longear sunfish	1	1.5	102	-	26	-
	Freshwater drum	11	16.5	185	96-382	115	10-690
	Total	56	84.0				
20 Nov	Carp	1	1.0	560	-	1830	-
	River carpsucker	4	4.0	341	307-390	490	365-720
	Blue sucker	1	1.0	560	-	1830	-
	Brook silversides	12	12.0	74	52-84	-	-
	Green sunfish	3	3.0	121	95-149	41	18-68
	Orangespotted sunfish	2	2.0	53	52-54	4	-
	Total	23	23.0				

[a] Number of fish collected during 30 min. of effort.
[b] Electroshocking conducted for 15 min.
[c] Electroshocking conducted for 18 min.
[d] Electroshocking conducted for 20 min.

Table F-3 Summary of seine data collected from the Neosho River and Wolf Creek near Wolf Creek Generating Station, Burlington, Kansas, 1980.

Sampling Date	Location	Species	Number	Total Length (mm) Average	Range
15 April	Neosho River	High water conditions prevented sampling at Locations 1, 4, 10, and 11.			
	Wolf Creek				
	7	Golden shiner	19	89	60-117
		Red shiner	2	38	35-42
		Green sunfish	6	34	26-40
		Orangespotted sunfish	2	49	42-56
		Total	29		
	3	Stoneroller	1	52	-
		Red shiner	14	37	22-62
		Suckermouth minnow	6	83	70-92
		Fathead minnow	1	45	-
		Black bullhead	1	115	-
		Orangespotted sunfish	1	52	-
		Total	24		
28 May	Neosho River				
	1	Golden shiner	3	65	57-71
		Ghost shiner	3	44	41-47
		Red shiner	94	50	34-63
		Sand shiner	1	44	-
		Orangespotted sunfish	2	48	41-55
		Total	103		
17 June	Neosho River				
	1	Gizzard shad	27	39	21-50
		Golden shiner	2	60	59-61
		Red shiner	6	56	42-65
		Sand shiner	7	43	33-52
		Ictiobus sp.	1	45	-
		White bass	10	46	41-52
		Orangespotted sunfish	2	52	50-55
		White crappie	5	36	30-43
		Total	60		
	10	Longnose gar	1	47	-
		Ghost shiner	2	39	38-41
		Red shiner	70	43	29-58
		Spotted bass	2	27	25-30
		Total	75		
	11	Neosho madton	1	47	-
		Total	1		
	4	Longnose gar	5	46	39-51
		Gizzard shad	37	29	22-36
		Red shiner	163	42	30-58
		Suckermouth minnow	2	44	28-60
		Carpoides sp.	18	19	18-24
		Smallmouth buffalo	17	38	-
		Bigmouth buffalo	4	39	36-45
		Shorthead redhorse	5	32	27-33
		Spotted bass	21	28	20-34
		Slenderhead darter	1	24	-
		Total	273		
	Wolf Creek				
	7	Golden shiner	5	97	87-112
		Black bullhead	1	59	-
		Green sunfish	1	126	-
		Orangespotted sunfish	2	58	36-81
		Total	9		

Table F-3 (continued)

Sampling Date	Location	Species	Number	Total Length (mm) Average	Range
17 June (continued)					
	3	Golden shiner	15	77	58-106
		Red shiner	144	50	32-70
		Suckermouth minnow	1	34	-
		Fathead minnow	3	56	42-66
		Unidentified cyprinid	3	23	23-24
		Black bullhead	3	82	71-88
		Green sunish	6	61	54-66
		Orangespotted sunfish	2	66	64-69
		Bluegill	2	46	46-77
		Total	179		
24 July	Neosho River				
	1	Gizzard shad	2	41	38-44
		Golden shiner	1	62	-
		Red shiner	5	32	21-50
		Bullhead minnow	5	25	22-31
		Brook silverside	31	49	37-59
		Orangespotted sunfish	11	31	21-46
		Total	55		
28 October	Neosho River				
	1	Golden shiner	6	68	63-81
		Ghost shiner	13	29	23-42
		Red shiner	97	41	22-61
		Bluntnose minnow	3	34	31-36
		Bullhead minnow	12	42	36-56
		Mosquitofish	4	31	29-36
		Brook silverside	7	60	52-77
		Orangespotted sunfish	3	43	38-51
		Longear sunfish	1	61	-
		Bluegill	2	57	51-63
		Total	148		
	10	Red shiner	1228	34	19-49
		Suckermouth minnow	1	94	-
		Bullhead minnow	173	33	25-47
		Channel catfish	1	81	-
		Flathead catfish	1	71	-
		Brook silverside	5	62	47-74
		Slenderhead darter	9	61	48-72
		Total	1418		
	11	Neosho madtom	1	52	-
		Slenderhead darter	1	48	-
		Total	2		
	4	Red shiner	427	29	22-42
		Bullhead minnow	4	32	31-34
		Brook silverside	1	57	-
		Bluegill	1	32	-
		Total	433		
	Wolf Creek				
	3	NO FISH TAKEN			
	7	NO FISH TAKEN			

Table F-3 (continued)

Sampling Date	Location	Species	Number	Total Length (mm) Average	Range
15 December	Neosho River				
	1	Ghost shiner	2	30	29-31
		Red shiner	982	31	19-53
		Total	990		
	10	Gravel chub	1	89	-
		Ghost shiner	1	32	-
		Red shiner	689	36	21-59
		Suckermouth minnow	5	83	77-93
		Slim minnow	5	31	25-41
		Bullhead minnow	42	28	21-35
		Neosho madtom	4	70	65-73
		Freckled madtom	1	47	-
		Orangethroat darter	4	63	60-66
		Slenderhead darter	4	54	52-56
		Total	756		
	11	NO FISH TAKEN			
	4	Red shiner	47	21	13-42
		Slim minnow	1	25	-
		Orangespotted sunfish	1	43	-
		Total	49		
	Wolf Creek				
	3	Orangespotted sunfish	1	35	-
		Total	1		
	7	NO FISH TAKEN			

APPENDIX G

VEGETATION DATA

Table G-1 Phylogenetic list of species sampled in Communities 1, 2, and 8 near the WCGS Site, Burlington, Kansas, 1980.

ORDER	FAMILY	SCIENTIFIC NAME	COMMON NAME
GRAMINALES			
	GRAMINEAE (GRASS FAMILY)		
		FESTUCA OBTUSA BIEHLER.	FESCUE
		POA PRATENSIS L.	KENTUCKY BLUEGRASS
		ELYMUS VIRGINICUS L.	VIRGINIA WILD RYE
		MUHLENBERGIA FRONDOSA (POIR) FERN.	MUHLY
		LEERSIA VIRGINICA WILLD.	WHITE GRASS
		PANICUM VIRGATUM L.	SWITCH GRASS
		PANICUM SCRIBNERIANUM NASH.	SCRIBNER PANICUM
		ANDROPOGON SCOPARIUS MICHX.	LITTLE BLUESTEM
		ANDROPOGON GERARDI VITM.	BIG BLUESTEM
		SORGHASTRUM NUTANS (L.) NASH	INDIAN GRASS
	CYPERACEAE (SEDGE FAMILY)		
		CAREX SP. L.	SEDGE
LILIALES			
	LILIACEAE (LILY FAMILY)		
		SMILAX HISPIDA MUHL.	GREENBRIER
JUGLANDALES			
	JUGLANDACEAE (WALNUT FAMILY)		
		JUGLANS NIGRA L.	BLACK WALNUT
		CARYA CORDIFORMIS (WANG.) K. KOCH.	BITTERNUT HICKORY
		CARYA LACINIOSA (MICHX. F.) LOUD	SHELLBARK HICKORY
FAGALES			
	FAGACEAE (BEECH FAMILY)		
		QUERCUS SP. L.	OAK
		QUERCUS MACROCARPA MICHX.	BUR OAK
		QUERCUS PALUSTRIS MUENCHH.	PIN OAK
		QUERCUS SHUMARDII BUCKL.	SHUMARD'S OAK
URTICALES			
	ULMACEAE (ELM FAMILY)		
		ULMUS AMERICANA L.	AMERICAN ELM
		ULMUS RUBRA MUHL.	SLIPPERY ELM
		CELTIS OCCIDENTALIS L.	HACKBERRY
	MORACEAE (MULBERRY FAMILY)		
		MACLURA POMIFERA (RAF.) SCHNEID	OSAGE-ORANGE
		MORUS RUBRA L.	RED MULBERRY
	URTICACEAE (NETTLE FAMILY)		
		LAPORTEA CANADENSIS (L.) WEDD.	WOOD-NETTLE
POLYGONALES			
	POLYGONACEAE (SMARTWEED FAMILY)		
		POLYGONUM VIRGINIANUM L.	SMARTWEED
RANALES			
	MENISPERMACEAE (MOONSEED FAMILY)		
		MENISPERMUM CANADENSE L.	CANADA MOONSEED

Table G-1 (continued)

ORDER	FAMILY	SCIENTIFIC NAME	COMMON NAME
ROSALES			
	SAXIFRAGACEAE (SAXIFRAGE FAMILY)		
		RIBES MISSOURIENSE NUTT.	MISSOURI GOOSEBERRY
	PLATANACEAE (PLANE-TREE FAMILY)		
		PLATANUS OCCIDENTALIS L.	SYCAMORE
	ROSACEAE (ROSE FAMILY)		
		GEUM CANADENSE JACQ.	WHITE AVENS
		CRATAEGUS SP. L.	HAWTHORN
	CAESALPINIACEAE (CAESALPINIA FAMILY)		
		CERCIS CANADENSIS L.	REDBUD
		GLEDITSIA TRIACANTHOS L.	HONEY-LOCUST
		GYMNOCLADUS DIOICA (L.) K. KOCH	KENTUCKY COFFEE-TREE
SAPINDALES			
	ANACARDIACEAE (CASHEW FAMILY)		
		RHUS RADICANS L.	POISON IVY
	CELASTRACEAE (STAFF-TREE FAMILY)		
		EUONYMUS ATROPURPUREUS JACQ.	WAHOO
	ACERACEAE (MAPLE FAMILY)		
		ACER SACCHARINUM L.	SILVER MAPLE
		ACER NEGUNDO L.	BOXELDER
RHAMNALES			
	VITACEAE (GRAPE FAMILY)		
		VITIS SP. L.	GRAPE
		PARTHENOCISSUS QUINQUEFOLIA (L.) PLANCH.	VIRGINIA CREEPER
UMBELLALES			
	UMBELLIFERAE (PARSLEY FAMILY)		
		SANICULA GREGARIA BICKN.	BLACK SNAKEROOT
	CORNACEAE (DOGWOOD FAMILY)		
		CORNUS SP. L.	DOGWOOD
GENTIANALES			
	OLEACEAE (OLIVE FAMILY)		
		FRAXINUS PENNSYLVANICA MARSH.	GREEN ASH
POLEMONIALES			
	POLEMONIACEAE (PHLOX FAMILY)		
		PHLOX DIVARICATA L.	PHLOX
	LABIATAE (MINT FAMILY)		
		SALVIA REFLEXA HORNEM	SAGE
	ACANTHACEAE (ACANTHUS FAMILY)		
		RUELLIA STREPENS L.	RUELLIA
RUBIALES			
	CAPRIFOLIACEAE (HONEYSUCKLE FAMILY)		
		SYMPHORICARPOS ORBICULATUS MOENCH	CORALBERRY
ASTERALES			
	COMPOSITAE (COMPOSITE FAMILY)		
		VERBESINA ALTERNIFOLIA (L.) BRITT.	WINGSTEM
		AMBROSIA TRIFIDA L.	GIANT RAGWEED
		SOLIDAGO CANADENSIS L.	CANADA GOLDENROD
		SOLIDAGO GRAMINIFOLIA (L.) SALISB.	NARROWLEAF GOLDENROD

APPENDIX H

FLINT HILLS NATIONAL WILDLIFE REFUGE
FY 80 REFUGE OUTPUT REPORTS

Table H-1 Average monthly waterfowl populations, Flint Hills National Wildlife Refuge, Burlington, Kansas, October 1979 through September 1980.[a]

Species	Oct 79	Nov 79	Dec 79	Jan 80	Feb 80	Mar 80	Apr 80	May 80	Jun 80	Jul 80	Aug 80	Sep 80
Geese												
Snow Goose	600	6000	8000	4000	5000	1000	150	0	0	0	0	0
White-fronted Goose	400	1500	1200	800	4000	1200	75	0	0	0	0	0
Canada Goose	300	5000	4000	3500	3000	700	40	0	0	0	0	0
Ducks												
Common Merganser	0	0	1000	800	50	500	0	0	0	0	0	0
Mallard	800	15000	20000	15000	10000	1000	1500	80	80	80	60	20
Black Duck	5	0	5	10	0	0	0	0	0	0	0	0
Gadwall	80	100	20	0	0	20	50	0	0	0	0	2
American Wigeon	100	300	5	10	70	50	0	0	0	0	0	0
Green-winged Teal	400	900	100	0	50	100	400	0	0	0	0	80
Blue-winged Teal	40	0	0	0	30	20	600	40	40	25	250	50
Northern Shoveler	5	5	0	0	0	500	350	0	0	0	0	0
Pintail	200	200	5	50	700	1200	500	0	0	5	5	10
Wood Duck	50	20	5	0	0	75	300	150	250	275	400	100
Redhead	5	15	20	0	0	10	0	0	0	0	0	0
Canvasback	5	15	20	0	0	10	0	0	0	0	0	0
Lesser Scaup	5	50	50	0	0	20	0	0	0	0	0	0
Ring-necked Duck	20	20	20	0	0	20	10	0	0	0	0	0
Common Goldeneye	0	5	10	20	50	3	0	0	0	0	0	0
Bufflehead	5	10	10	0	0	3	0	0	0	0	0	0
Ruddy Duck	5	25	0	0	0	5	0	0	0	0	0	0
Marsh and Water Birds												
American Coot	250	50	0	0	0	50	800	0	0	0	0	50
Total Geese	1300	12500	13200	8300	12000	2900	265	0	0	0	0	0
Total Ducks	1725	16665	21270	15890	10950	3536	3710	270	370	385	715	262
Total Waterfowl	3025	29165	34470	24190	22950	6436	3975	270	370	385	715	262

[a] Source: USDI 1981.

Table H-2 Waterfowl use days, Flint Hills National Wildlife Refuge, Burlington, Kansas, October 1979 through September 1980.[a]

Species	Oct-Dec 1979	Jan-Mar 1980	Apr-Jun 1980	Jul-Sep 1980	12 Month Total
Geese					
Snow Goose	438,000	300,000	4,500	0	742,500
White-fronted Goose	93,000	180,000	2,250	0	275,250
Canada Goose	279,000	216,000	1,200	0	496,200
Ducks					
Common Merganser	30,000	40,500	0	0	70,500
Mallard	1,074,000	780,000	49,800	4,800	1,908,600
Black Duck	300	300	0	0	600
Gadwall	6,060	600	1,500	60	8,160
American Wigeon	12,150	3,900	0	0	16,050
Green-winged Teal	42,000	4,500	12,000	2,400	60,900
Blue-winged Teal	1,200	1,500	20,400	9,750	32,850
Northern Shoveler	300	15,000	10,500	0	25,800
Pintail	12,150	58,500	15,000	600	86,250
Wood Duck	2,250	2,250	21,000	23,250	48,750
Redhead	1,200	300	0	0	1,500
Canvasback	1,200	300	0	0	1,500
Lesser Scaup	3,150	600	0	0	3,750
Ring-necked Duck	1,800	600	300	0	2,700
Common Goldeneye	450	2,190	0	0	2,640
Bufflehead	750	90	0	0	840
Ruddy Duck	900	150	0	0	1,050
Marsh and Water Birds					
American Coot	9,000	1,500	24,000	1,500	36,000
Total Geese	810,000	696,000	7,950	0	1,513,950
Total Ducks	1,230,660	911,280	130,500	40,860	2,272,440
Total Waterfowl	2,008,800	1,608,780	162,450	42,360	3,822,390

[a] Source: USDI 1981.

Table H-3 Special recognition species use days, production, harvest, and peak population, Flint Hills National Wildlife Refuge, Burlington, Kansas, October 1979 through September 1980.[a]

Species	Use Days Oct-Dec 1979	Jan-Mar 1980	Apr-Jun 1980	Jul-Sep 1980	Total	Number Produced	Number Harvested	Peak Population
Mammals								
White-tailed deer	-[a]	-	-	-	80000	50	5	250
Total Mammals	-	-	-	-	80000	50	5	
Threatened Species (Endangered)								
Bald Eagle	1000	2100	0	0	3100	0	0	47
Total Endangered	1000	2100	0	0	3100	0	0	
Status-Undetermined								
Northern Greater Prairie Chicken	-	-	-	-	7000	0	10	150
Total Status-Undetermined	-	-	-	-	7000	0	10	
Marsh and Water Birds								
Pied-billed Grebe	10000	0	20000	0	30000	0	0	700
Double-crested Cormorant	60000	0	16000	0	76000	0	0	2000
White Pelican	70000	0	30000	0	100000	0	0	2000
Great Blue Heron	12000	300	12000	0	24300	0	0	200
Great Egret	0	0	900	0	900	0	0	30
Snowy Egret	500	0	900	0	1400	0	0	20
Green Heron	0	0	6500	0	6500	0	0	100
Sora	1000	0	6000	0	7000	0	0	200
Total Marsh and Water Birds	153500	300	92300	0	246100	0	0	
Shorebirds, Gulls, Terns								
Unidentified Gull	0	200000	0	0	200000	0	0	15000
Ring-billed Gull	100000	0	150000	0	250000	0	0	40000
Franklin's Gull	150000	0	160000	0	310000	0	0	50000
Bonaparte's Gull	70000	0	0	0	70000	0	0	30000
Black Tern	10000	0	15000	0	25000	0	0	1000
Wilson's Phalarope	8000	0	4500	0	12500	0	0	750
Long-billed Dowitcher	10000	0	3000	0	13000	0	0	550
Stilt Sandpiper	0	0	10000	0	10000	0	0	500
Pectoral Sandpiper	5000	0	0	0	5000	0	0	750
Least Sandpiper	9000	0	0	0	9000	0	0	800
Semipalmated Sandpiper	7500	0	0	0	7500	0	0	575
Greater Yellowlegs	10000	700	18000	0	28700	0	0	900
Lesser Yellowlegs	15000	1000	10000	0	26000	0	0	1500
Upland Sandpiper	9000	0	0	0	9000	0	0	600
Spotted Sandpiper	8000	0	10000	0	18000	0	0	1000
Killdeer	45000	15000	35000	0	95000	0	0	2500
Semipalmated Plover	0	0	9000	0	9000	0	0	300
Total Shorebirds, Gulls, Terns	456500	216700	424500	0	1097700	0	0	
Raptorial Birds								
Turkey Vulture	700	0	12000	0	12700	0	0	200
Marsh Hawk	1800	450	1200	0	3450	0	0	30
Sharp-shinned Hawk	50	0	450	0	500	0	0	10
Cooper's Hawk	40	0	450	0	490	0	0	15
Red-tailed Hawk	5400	0	3000	0	8400	0	0	60
Rough-legged Hawk	1100	0	0	0	1100	0	0	12
American Kestrel	1000	900	4800	0	6700	0	0	80
Barn Owl	0	0	900	0	900	0	0	10
Barred Owl	450	900	650	0	2000	0	0	10
Screech Owl	0	0	1350	0	1350	0	0	15
Great Horned Owl	600	1800	3600	0	6000	0	0	40
Total Raptorial Birds	11140	4050	28400	0	43590	0	0	
Other Birds								
Mourning Dove	-	-	-	-	350000	2500	500	20000
Total Other Birds	-	-	-	-	350000	2500	500	

[a] Source: USDI 1981.

APPENDIX I

AVIAN COMMUNITY AND WILDLIFE SURVEY ROUTE DATA, 1980-1981

Table I-1 The number observed, number per hour, and relative frequency of avifauna in two communities near Wolf Creek Generating Station, Burlington, Kansas, 5-7 May 1980.

Species	Number Observed May 5	6	7	Number/Hour	Relative Frequency
North Floodplain Woods					
Barred Owl	1	-	-	0.5	1.00
Common Flicker	-	-	1	0.5	1.00
Red-bellied Woodpecker	1	2	1	2.1	4.21
Red-headed Woodpecker	2	-	-	1.0	2.00
Hairy Woodpecker	-	1	-	0.5	1.00
Downy Woodpecker	-	3	-	1.6	3.21
Great Crested Flycatcher	-	3	2	2.6	5.21
Eastern Phoebe	-	1	-	0.5	1.00
Least Flycatcher	-	-	1	0.5	1.00
Eastern Wood Pewee	-	-	1	0.5	1.00
Blue Jay	6	4	4	7.3	14.63
Common Crow	-	-	1	0.5	1.00
Black-capped Chickadee	3	2	4	4.7	9.42
Tufted Titmouse	3	2	2	3.7	7.41
White-breasted Nuthatch	-	-	1	0.5	1.00
House Wren	3	4	4	5.7	11.42
Wood Thrush	-	-	2	1.0	2.00
Blue-gray Gnatcatcher	2	2	3	3.7	7.41
Red-eyed Vireo	2	4	2	4.2	8.42
Black-and-white Warbler	2	1	2	2.6	5.21
Summer Tanager	-	-	2	1.0	2.00
Cardinal	1	1	3	2.6	5.21
Indigo Bunting	1	1	2	2.1	4.21
Total	27	31	38	49.9	99.97
Abandoned Railroad Right-of-Way					
Bobwhite	-	1	-	1.1	3.54
Killdeer	-	1	-	1.1	3.54
Mourning Dove	2	2	1	5.4	17.36
Common Flicker	-	1	1	2.1	6.75
Blue Jay	1	-	-	1.1	3.54
Eastern Meadowlark	-	1	-	1.1	3.54
Red-winged Blackbird	1	-	1	2.1	6.75
Brown-headed Cowbird	3	-	-	3.2	10.29
Dickcissel	-	1	-	1.1	3.54
Grasshopper Sparrow	-	-	2	2.1	6.75

Table I-1 (continued)

Species	Number Observed May 5	6	7	Number/Hour	Relative Frequency
	Abandoned Railroad Right-of-Way				
Field Sparrow	-	3	-	3.2	10.29
Harris' Sparrow	-	-	5	5.4	17.36
Sparrow sp.	2	-	-	2.1	6.75
Total	9	10	10	31.1	100.00

Table I-2 The number observed, number per hour, and relative frequency of avifauna in two communities near Wolf Creek Generating Station, 16-18 June 1980.

Species	Number Observed June 16	17	18	Number/Hour	Relative Frequency
		North Floodplain Woods			
Yellow-billed Cuckoo	3	1	1	4.5	10.64
Red-bellied Woodpecker	1	1	0	1.8	4.26
Red-headed Woodpecker	0	0	2	1.8	4.26
Hairy Woodpecker	1	0	0	0.9	2.13
Downy Woodpecker	0	2	2	3.6	8.51
Great Crested Flycatcher	2	3	1	5.4	12.77
Eastern Wood Pewee	2	2	2	5.4	12.77
Blue Jay	0	1	1	1.8	4.26
Common Crow	1	0	0	0.9	2.13
Tufted Titmouse	0	1	1	1.8	4.26
White-breasted Nuthatch	2	1	0	2.7	6.38
House Wren	1	1	2	3.6	8.51
Red-eyed Vireo	1	2	2	4.5	10.64
Common Grackle	0	1	0	0.9	2.13
Cardinal	0	0	2	1.8	4.26
Indigo Bunting	0	1	0	0.9	2.13
Total	14	17	16	42.3	100.04
		Abandoned Railroad Right-of-Way			
Mourning Dove	0	0	1	1.3	3.33
Eastern Kingbird	0	0	1	1.3	3.33
Black-capped Chickadee	1	0	2	4.0	10.00
Mockingbird	1	0	0	1.3	3.33
Brown Thrasher	0	0	1	1.3	3.33
American Robin	0	1	1	2.7	6.67
Western Meadowlark	1	0	0	1.3	3.33
Red-winged Blackbird	2	2	5	12.0	30.00
Orchard Oriole	0	0	1	1.3	3.33
Common Grackle	2	1	2	6.7	16.67
Brown-headed Cowbird	0	0	2	2.7	6.67
Lark Sparrow	1	0	0	1.3	3.33
Field Sparrow	1	1	0	2.7	6.67
Total	9	5	16	39.9	99.99

Table I-3 The number observed, number per hour, and relative frequency of avifauna in two communities near Wolf Creek Generating Station, Burlington, Kansas, 3-5 September 1980.

Species	Number Observed September 3	4	5	Number/Hour	Relative Frequency
North Floodplain Woods					
Yellow-billed Cuckoo	-	-	1	1.0	1.54
Common Flicker	-	-	1	1.0	1.54
Red-bellied Woodpecker	3	3	-	5.7	8.77
Red-headed Woodpecker	-	-	2	1.9	2.92
Downy Woodpecker	-	1	2	2.9	4.46
Great Crested Flycatcher	1	4	1	5.7	8.77
Eastern Wood Pewee	3	2	1	5.7	8.77
Blue Jay	3	1	2	5.7	8.77
Common Crow	2	-	5	6.7	10.31
Black-capped Chickadee	4	2	5	10.5	16.15
Tufted Titmouse	-	-	5	4.8	7.38
White-breasted Nuthatch	3	3	2	7.6	11.69
House Wren	2	-	-	1.9	2.92
Red-eyed Vireo	-	-	1	1.0	1.54
American Goldfinch	1	1	1	2.9	4.46
Total	22	17	29	65.0	99.99
Abandoned Railroad Right-of-Way					
Killdeer	-	1	-	1.2	2.87
Mourning Dove	2	3	2	8.1	19.38
Black-billed Cuckoo	1	-	-	1.2	2.87
Common Flicker	1	-	-	1.2	2.87
Red-headed Woodpecker	1	-	-	1.2	2.87
Barn Swallow	4	-	2	6.9	16.51
Blue Jay	1	1	2	4.6	11.00
Mockingbird	1	-	-	1.2	2.87
Brown Thrasher	1	-	1	2.3	5.50
Eastern Meadowlark	-	1	-	1.2	2.87
Orchard Oriole	1	-	-	1.2	2.87
Brown-headed Cowbird	8	-	2	11.5	27.51
Total	21	6	9	41.8	99.99

Table I-4 The number observed, number per hour, and relative frequency of avifauna in two communities near Wolf Creek Generating Station, Burlington, Kansas, 21-23 January 1981.

Species	Number Observed January 21	22	23	Number/Hour	Relative Frequency
		North Floodplain Woods			
Common Flicker	2	1	1	3.2	8.70
Red-bellied Woodpecker	1	1	-	1.6	4.35
Red-headed Woodpecker	2	2	1	4.0	10.87
Downy Woodpecker	1	1	-	1.6	4.35
Blue Jay	-	3	2	4.0	10.87
Common Crow	-	2	1	2.4	6.52
Black-capped Chickadee	3	5	4	9.6	26.09
Tufted Titmouse	1	4	-	4.0	10.87
White-breasted Nuthatch	2	2	1	4.0	10.87
American Robin	1	-	-	0.8	2.17
Cardinal	-	-	2	1.6	4.35
Total	13	21	12	36.8	100.01
		Abandoned Railroad Right-of-Way			
Mourning Dove	6	-	-	7.1	3.77
Common Flicker	1	-	1	2.4	1.27
Eastern Meadowlark	10	1	-	12.9	6.85
Cardinal	1	-	6	8.2	4.35
Dark-eyed Junco	-	-	9	10.6	5.63
Tree Sparrow	21	30	39	105.9	56.24
Harris' Sparrow	2	2	19	27.1	14.39
White-crowned Sparrow	1	2	9	14.1	7.49
Total	42	35	83	188.3	99.99

Table I-5 Avifauna observations along a 20-mile survey route near Wolf Creek Generating Station, Burlington, Kansas, 5 May 1980.

Species	Number of Birds Observed Per Mile																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Great Blue Heron	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Green Heron	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Blue-winged Teal	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
Cooper's Hawk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Red-tailed Hawk	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Bobwhite	-	-	-	-	1	2	2	-	-	-	-	-	-	-	-	-	-	-	1	-	6
Killdeer	2	-	1	-	1	-	1	2	-	1	-	1	-	-	-	-	-	-	-	-	9
Rock Dove	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Mourning Dove	1	10	-	-	-	1	1	4	3	8	-	3	-	1	3	-	4	-	-	2	41
Great Horned Owl	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Chimney Swift	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	3
Common Flicker	-	1	-	1	-	-	1	-	-	-	1	-	1	-	-	-	-	-	-	-	5
Red-bellied Woodpecker	-	-	-	-	-	-	-	3	1	2	2	-	1	1	2	-	-	-	-	-	12
Red-headed Woodpecker	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	3
Hairy Woodpecker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Eastern Kingbird	-	-	-	2	1	-	-	2	1	-	-	-	-	-	-	-	-	1	-	-	7
Western Kingbird	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Great Crested Flycatcher	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Eastern Phoebe	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Flycatcher sp.	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Horned Lark	1	-	3	2	-	-	1	-	-	-	-	-	-	3	-	-	-	-	3	-	13
Barn Swallow	-	-	-	-	-	-	2	-	5	1	1	-	-	2	2	1	-	-	-	-	14
Blue Jay	-	-	-	-	-	1	-	-	1	-	-	2	1	1	-	-	-	-	1	-	7
Common Crow	-	-	-	-	-	1	1	-	1	-	1	2	-	-	-	-	-	-	-	-	6
Black-capped Chickadee	-	-	-	-	-	-	-	1	-	-	1	2	-	-	-	-	-	-	-	-	4
Tufted Titmouse	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
House Wren	-	-	-	-	-	-	-	1	-	1	1	-	-	-	1	-	-	-	-	-	4
Mockingbird	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	1	4
Brown Thrasher	-	-	-	-	1	-	-	-	-	1	-	-	1	-	-	-	1	-	-	1	5
American Robin	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	2	-	-	-	4
Eastern Bluebird	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2
Loggerhead Shrike	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
Starling	-	2	-	-	2	-	-	4	-	1	-	-	-	-	-	3	-	-	-	1	13
Red-eyed Vireo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Warbling Vireo	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1

Table I-5 (continued)

Species	Number of Birds Observed Per Mile																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Common Yellowthroat	-	-	3	-	-	1	-	1	-	-	-	-	-	1	1	-	-	1	1	1	10
House Sparrow	-	-	-	1	1	1	8	21	2	5	1	30	1	-	5	5	1	1	-	20	103
Eastern Meadowlark	2	4	1	2	6	4	7	4	5	7	2	6	10	4	2	6	5	3	4	4	88
Red-winged Blackbird	12	8	11	9	6	55	20	7	16	1	1	13	4	1	8	7	3	4	4	4	194
Northern Oriole	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Common Grackle	1	-	-	-	-	-	1	13	1	-	-	8	1	-	-	7	-	1	-	1	34
Brown-headed Cowbird	1	2	5	-	4	-	5	-	4	-	1	2	1	2	2	-	1	-	1	1	32
Cardinal	2	1	2	2	5	2	-	5	1	6	4	1	2	-	2	1	1	-	-	2	39
Dickcissel	1	12	3	8	8	4	12	5	3	-	-	-	2	1	-	1	1	-	2	2	65
American Goldfinch	-	-	-	-	-	-	-	-	-	33	-	-	-	6	-	-	-	-	-	-	39
Grasshopper Sparrow	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	2	1	1	6
Vesper Sparrow	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Field Sparrow	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	1	1	-	1	-	6
Harris' Sparrow	1	-	1	-	2	3	3	-	5	1	2	8	2	2	1	-	-	2	-	-	33
White-crowned Sparrow	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Song Sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Totals	34	42	30	29	41	75	66	76	49	74	21	80	31	25	35	34	22	16	20	41	841

Table 1-6 Avifauna observations along a 20-mile survey route near Wolf Creek Generating Station, Burlington, Kansas, 6 May 1980.

Species	Number of Birds Observed Per Mile																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Double-crested Cormorant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Blue-winged Teal	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Turkey Vulture	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Cooper's Hawk	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
American Kestrel	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
American Coot	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	3
Killdeer	4	-	-	-	-	-	1	-	3	-	-	-	-	1	-	-	-	-	-	-	9
Greater Yellowlegs	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Mourning Dove	4	3	1	1	-	1	4	1	-	6	-	3	-	-	2	1	2	1	-	1	31
Chimney Swift	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Common Flicker	1	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	1	-	-	4
Red-bellied Woodpecker	-	-	-	-	1	-	-	-	1	-	1	-	-	1	-	-	-	-	-	-	4
Red-headed Woodpecker	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	3
Eastern Kingbird	-	-	-	-	-	-	-	-	-	1	-	1	-	1	-	-	-	-	1	1	5
Scissor-tailed Flycatcher	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Great Crested Flycatcher	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	2
Eastern Phoebe	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Least Flycatcher	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Horned Lark	-	1	-	-	-	-	3	-	-	-	-	-	-	-	-	2	1	-	-	-	7
Barn Swallow	-	-	2	-	7	-	2	-	2	-	1	2	-	1	1	-	-	1	1	2	22
Blue Jay	1	9	-	1	-	1	-	-	-	2	1	-	-	-	4	-	3	-	-	1	23
Common Crow	-	-	-	1	2	-	1	-	-	1	-	2	-	-	-	-	-	1	-	3	11
Black-capped Chickadee	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Tufted Titmouse	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	1	-	-	-	3
House Wren	-	-	-	-	1	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	3
Mockingbird	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	3	1	1	1	8
Brown Thrasher	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	1	3
American Robin	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1	-	5
Loggerhead Shrike	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Starling	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Nashville Warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Northern Waterthrush	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1

Table I-6 (continued)

Species	Number of Birds Observed Per Mile																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Common Yellowthroat	-	1	1	-	-	-	-	1	-	-	-	1	-	1	-	-	-	-	-	-	5
House Sparrow	-	2	-	-	2	-	20	15	-	-	5	30	5	7	7	10	-	5	1	-	109
Eastern Meadowlark	1	1	-	-	3	2	2	1	-	1	-	1	5	-	1	-	3	3	3	3	30
Red-winged Blackbird	12	12	7	1	2	3	8	6	5	1	1	10	6	5	3	10	8	4	1	2	107
Northern Oriole	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	1	1	-	-	-	4
Common Grackle	2	-	2	-	5	-	6	1	-	-	-	1	4	-	-	7	-	2	-	-	30
Brown-headed Cowbird	11	-	2	-	2	3	-	1	-	1	1	-	6	5	-	8	3	-	5	1	49
Cardinal	1	-	-	1	1	-	-	-	-	-	1	1	-	2	1	-	-	-	1	-	9
Dickcissel	-	7	2	6	5	2	6	2	-	5	-	-	2	1	-	-	-	-	-	1	39
Indigo Bunting	-	-	-	-	-	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	3
American Goldfinch	-	1	-	-	-	-	-	-	-	-	1	-	-	-	1	-	2	-	10	4	19
Lark Sparrow	-	3	-	-	-	-	-	-	1	1	4	1	-	-	-	1	1	-	-	-	12
Field Sparrow	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	1	1	-	1	5
Harris' Sparrow	-	-	-	-	1	-	-	-	-	-	8	10	-	-	3	-	-	1	-	-	23
Totals	44	41	17	15	33	16	54	28	15	21	31	66	33	26	24	42	31	23	26	23	609

Table I-7 Avifauna observations along a 20-mile survey route near Wolf Creek Generating Station, Burlington, Kansas, 17 June 1980[a].

Species	Number of Birds Observed Per Mile																				Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Great Blue Heron	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Turkey Vulture	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Red-tailed Hawk	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2
Bobwhite	1	-	-	5	2	3	3	-	1	2	4	1	1	-	2	-	3	2	-	-	30
Killdeer	-	-	-	-	2	-	1	-	-	-	-	-	1	-	-	-	-	-	-	1	5
Upland Plover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	2	-	-	5
Rock Dove	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Mourning Dove	1	-	2	6	10	1	-	-	-	-	3	1	-	2	-	7	4	14	1	1	53
Yellow-billed Cuckoo	-	1	-	1	-	2	-	-	-	1	1	-	-	-	1	1	-	1	-	-	9
Chimney Swift	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Common Flicker	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Red-bellied Woodpecker	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	2
Red-headed Woodpecker	-	-	-	-	-	-	-	1	1	-	1	-	1	1	1	-	-	-	-	-	6
Eastern Kingbird	1	-	-	-	-	-	-	-	-	1	-	1	-	-	-	2	1	1	-	-	7
Scissor-tailed Flycatcher	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	1	-	-	3
Great Crested Flycatcher	1	-	-	-	-	-	-	-	2	1	1	-	-	-	1	-	-	-	-	-	6
Eastern Wood Pewee	-	-	-	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	3
Horned Lark	-	-	-	2	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	5
Barn Swallow	-	-	1	-	2	-	1	-	4	-	-	2	-	-	-	-	2	2	-	2	16
Blue Jay	-	-	-	1	1	1	-	1	2	-	1	1	-	-	-	-	-	-	1	-	9
Common Crow	-	-	1	-	-	1	-	1	-	-	1	2	-	2	-	-	-	-	-	-	8
Black-capped Chickadee	1	-	-	-	-	-	-	-	-	2	-	4	-	-	-	-	1	-	1	-	9
House Wren	-	-	-	-	-	1	-	1	1	-	1	-	-	-	-	-	-	-	-	-	4
Mockingbird	-	-	-	-	1	2	-	1	-	1	-	2	-	1	2	1	3	1	1	1	17
Brown Thrasher	-	-	1	-	-	-	-	-	-	-	-	1	1	1	-	-	2	-	-	-	6
American Robin	1	-	-	-	-	-	-	-	-	-	-	2	-	-	1	1	2	-	-	1	8
Loggerhead Shrike	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	4	-	-	7
Starling	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2
Red-eyed Vireo	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2
Warbling Vireo	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2

[a] Wildlife survey route was performed using a different technique than in May.

Table I-7 (continued)

Species	Number of Birds Observed Per Mile																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Common Yellowthroat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
House Sparrow	-	1	-	-	15	-	5	15	1	-	-	10	15	-	10	-	20	5	-	5	102
Eastern Meadowlark	1	-	-	-	8	3	8	-	-	3	1	1	8	2	3	3	2	6	2	3	54
Red-winged Blackbird	2	6	11	5	5	9	7	4	5	5	2	1	7	1	4	12	2	5	6	4	103
Northern Oriole	1	1	-	1	-	2	-	2	-	-	-	-	-	-	-	-	-	2	-	-	9
Common Grackle	1	-	-	-	-	-	1	7	1	2	-	3	-	-	4	5	-	2	1	2	29
Brown-headed Cowbird	-	4	-	-	1	1	-	1	-	2	-	-	2	-	-	1	3	-	4	1	20
Cardinal	1	-	1	1	2	-	-	1	1	1	1	3	1	2	-	-	-	-	1	1	17
Indigo Bunting	2	1	-	-	2	-	-	1	-	-	1	1	-	-	-	-	-	-	1	-	9
Dickcissel	-	12	6	4	2	-	5	3	2	2	1	1	1	1	-	4	-	2	3	1	50
American Goldfinch	-	-	-	-	-	2	-	-	-	-	-	7	-	2	-	-	1	-	-	1	13
Grasshopper Sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Lark Sparrow	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Field Sparrow	-	-	-	1	-	1	-	-	-	-	-	1	-	-	1	-	-	-	-	-	4
Totals	14	27	23	29	54	32	31	43	27	24	23	45	41	15	33	39	46	51	23	26	646

Table I-8 Avifauna observations along a 20-mile survey route near Wolf Creek Generating Station, Burlington, Kansas, 18 June 1980[a].

Species	Number of Birds Observed Per Mile																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Great Blue Heron	-	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	3
Red-tailed Hawk	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	3
Bobwhite	-	-	-	3	4	2	4	-	-	3	2	-	1	2	1	1	2	1	2	-	28
Killdeer	1	-	-	1	1	1	-	-	1	1	-	-	-	-	1	-	-	-	-	-	7
Upland Plover	-	-	-	-	-	1	-	-	-	-	-	-	1	-	1	-	-	-	-	-	3
Rock Dove	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Mourning Dove	4	6	12	19	11	4	4	-	-	2	-	1	-	-	3	4	6	4	2	-	82
Yellow-billed Cuckoo	-	1	-	1	1	-	-	-	2	-	1	1	-	1	-	1	-	2	1	-	12
Chimney Swift	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Belted Kingfisher	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Common Flicker	-	1	-	-	-	-	-	1	-	1	-	-	-	-	1	-	1	-	-	-	5
Red-headed Woodpecker	-	-	-	2	-	-	-	1	2	3	1	1	-	-	1	-	-	-	-	-	11
Downy Woodpecker	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Eastern Kingbird	-	1	-	1	-	-	-	-	-	1	-	-	2	-	1	-	-	2	-	-	8
Scissor-tailed Flycatcher	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	2
Great Crested Flycatcher	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2
Eastern Phoebe	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Eastern Wood Pewee	-	-	-	1	-	1	-	-	1	-	1	-	1	-	-	-	-	1	-	-	6
Flycatcher sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Horned Lark	1	-	2	3	-	-	-	-	1	2	-	-	-	-	1	-	-	-	-	2	12
Barn Swallow	-	-	1	-	1	-	3	1	3	-	2	7	3	-	-	1	2	1	-	2	27
Cliff Swallow	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Blue Jay	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	1	-	3
Common Crow	-	-	-	-	-	1	-	-	2	-	1	1	-	-	-	-	-	-	-	-	5
Black-capped Chickadee	1	2	-	-	-	-	-	1	-	1	-	-	-	-	1	-	1	-	-	-	7
Tufted Titmouse	-	-	-	-	-	-	-	-	1	1	1	-	-	-	1	-	-	-	-	-	4
House Wren	-	-	-	-	3	4	1	2	-	-	1	-	-	-	1	-	-	-	-	-	12
Mockingbird	-	-	-	-	1	1	-	-	-	2	-	-	-	-	2	-	4	4	1	-	15
Brown Thrasher	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	3
American Robin	-	-	1	-	5	-	2	-	-	-	-	-	1	-	2	3	-	-	-	-	14
Loggerhead Shrike	-	-	-	4	-	-	-	-	4	-	1	-	3	-	1	-	2	-	-	-	15
Starling	-	-	-	-	-	-	-	3	-	4	-	-	-	-	-	-	-	-	-	-	7
Red-eyed Vireo	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Warbling Vireo	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2

[a] Wildlife survey route was performed using a different technique than in May.

Table I-8 (continued)

Species	Number of Birds Observed Per Mile																				Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Common Yellowthroat	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
House Sparrow	-	-	-	-	32	-	50	20	3	10	-	30	30	15	-	20	-	10	-	40	260
Eastern Meadowlark	2	2	-	2	1	1	3	-	2	1	2	-	6	2	1	2	2	2	2	2	35
Red-winged Blackbird	7	11	6	9	7	6	14	-	7	7	10	-	2	6	3	8	3	-	18	-	124
Northern Oriole	1	-	-	1	-	1	1	1	-	-	-	-	2	-	-	-	-	-	1	-	8
Common Grackle	1	-	-	-	1	-	1	1	7	-	-	26	18	-	1	1	1	3	21	5	87
Brown-headed Cowbird	1	4	2	3	-	5	-	-	-	3	-	3	4	-	4	5	1	-	1	1	37
Cardinal	2	3	-	2	1	2	-	-	2	1	1	4	-	1	1	-	-	-	1	-	21
Indigo Bunting	1	1	-	2	1	-	-	3	-	2	3	1	-	1	1	-	-	-	1	-	17
Dickcissel	1	8	4	6	11	-	11	-	3	3	3	2	1	-	1	2	1	1	-	2	60
American Goldfinch	-	-	-	-	-	-	-	-	-	1	-	2	2	-	-	1	-	-	-	-	6
Grasshopper Sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Lark Sparrow	-	-	-	-	1	2	-	-	-	1	1	-	-	1	-	-	-	-	-	-	6
Field Sparrow	-	-	-	1	-	1	-	-	-	2	-	1	-	-	1	-	-	-	-	-	6
Totals	25	42	28	61	86	35	94	40	42	54	32	81	79	30	31	49	28	32	52	55	976

Table I-9 Avifauna observations along a 20-mile survey route near Wolf Creek Generating Station, Burlington, Kansas, 3 September 1980.

Species	Number of Birds Observed Per Mile																				Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Duck sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Turkey Vulture	-	-	-	-	1	-	-	1	-	-	-	1	3	-	-	-	-	-	-	-	6
Black Vulture	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Red-tailed Hawk	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	3
Marsh Hawk	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Hawk sp.	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
American Kestrel	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Killdeer	-	1	-	-	1	-	5	-	1	-	-	-	1	-	-	-	-	-	-	-	9
Upland Sandpiper	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Sandpiper sp.	-	-	-	-	1	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-	13
Rock Dove	-	12	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	13
Mourning Dove	-	3	-	2	4	1	2	-	4	1	-	1	3	-	1	1	1	-	-	1	25
Black-billed Cuckoo	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Chimney Swift	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Common Flicker	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Red-bellied Woodpecker	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	2
Red-headed Woodpecker	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	2	-	-	4
Hairy Woodpecker	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Downy Woodpecker	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2
Eastern Kingbird	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	1	-	2	6
Scissor-tailed Flycatcher	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	-	-	-	3
Eastern Phoebe	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	1	-	-	4
Rough-winged Swallow	-	105	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	107
Barn Swallow	-	-	-	-	6	-	5	3	4	-	-	2	-	-	-	5	-	-	-	1	26
Cliff Swallow	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Blue Jay	-	-	-	-	1	-	-	-	-	2	-	-	-	-	1	-	2	1	-	-	7
Common Crow	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	2
Black-capped Chickadee	-	2	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	1	-	-	9
Mockingbird	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Brown Thrasher	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	2
Starling	-	-	-	2	4	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	7
House Sparrow	-	-	-	-	10	-	10	-	-	-	-	-	1	-	-	10	-	-	-	-	31
Eastern Meadowlark	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	3
Red-winged Blackbird	-	-	-	-	-	2	-	-	-	-	-	-	30	-	-	-	-	-	-	-	32
Orchard Oriole	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Northern Oriole	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	1	1	-	-	8
Brown-headed Cowbird	-	-	-	150	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	154
Cardinal	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	2
Indigo Bunting	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
American Goldfinch	-	-	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Sparrow sp.	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Total	1	129	0	157	32	19	39	7	10	6	4	16	44	1	2	16	11	8	1	4	507

Table I-10 Avifauna observations along a 20-mile survey route near Wolf Creek Generating Station, Burlington, Kansas, 4 September 1980.

Species	Number of Birds Observed Per Mile																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
Red-tailed Hawk	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1	-	-	3
Swainson's Hawk	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	3
Marsh Hawk	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
American Kestrel	-	-	-	-	-	-	-	1	-	-	2	-	1	-	-	-	-	-	-	-	4
Killdeer	-	-	-	-	-	-	12	-	-	-	-	-	1	1	-	-	-	1	-	-	15
Upland Sandpiper	-	3	-	-	-	-	21	-	-	-	-	-	3	-	-	-	-	-	-	-	27
Rock Dove	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Mourning Dove	-	14	4	57	27	5	3	4	-	14	4	1	1	2	4	2	4	2	2	-	150
Yellow-billed Cuckoo	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Common Nighthawk	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Common Flicker	-	-	-	-	1	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	6
Red-headed Woodpecker	-	-	-	-	4	-	-	3	-	2	1	1	3	-	-	-	-	-	-	-	14
Hairy Woodpecker	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Downy Woodpecker	-	-	-	-	2	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	3
Woodpecker sp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Eastern Kingbird	-	-	-	-	-	2	6	-	-	-	-	-	-	-	-	-	-	-	2	-	10
Scissor-tailed Flycatcher	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Great Crested Flycatcher	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Eastern Phoebe	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	3
Eastern Wood Pewee	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	2
Rough-winged Swallow	-	7	200	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	209
Barn Swallow	-	-	-	-	-	-	5	-	-	-	16	-	2	-	-	-	2	-	-	-	25
Blue Jay	1	-	-	-	1	1	-	-	-	-	3	-	-	-	-	-	-	-	1	-	7
Common Crow	-	-	-	-	-	5	-	-	-	1	-	1	-	-	1	-	-	-	-	-	8
Black-capped Chickadee	-	-	-	-	-	3	-	-	1	2	11	-	2	2	-	-	-	-	-	1	22
Mockingbird	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	3
Gray Catbird	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Brown Thrasher	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Loggerhead Shrike	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2
Starling	-	-	-	11	10	-	2	4	-	-	-	-	-	-	3	-	-	-	-	-	30
Bell's Vireo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Red-eyed Vireo	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Wilson's Warbler	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Warbler sp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	2
House Sparrow	-	5	-	-	-	-	50	10	-	-	-	-	10	-	15	-	45	-	-	-	135
Eastern Meadowlark	-	-	-	-	-	-	5	-	-	1	-	2	1	-	-	-	-	-	-	-	9
Red-winged Blackbird	-	-	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	20
Northern Oriole	-	-	-	3	-	-	-	-	-	-	-	-	1	-	1	-	-	2	-	-	7
Brewer's Blackbird	-	-	-	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	250
Common Grackle	-	-	-	-	-	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	400
Brown-headed Cowbird	-	-	-	-	5	-	30	-	-	-	-	-	2	-	-	-	50	-	-	-	87
Cardinal	-	-	-	-	1	-	-	-	-	-	2	2	-	-	-	-	-	-	1	-	7
Dickcissel	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
American Goldfinch	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	2
Lark Sparrow	-	-	-	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	4
Sparrow sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Total	1	31	205	327	52	419	135	23	2	23	55	7	32	26	25	2	102	9	8	1	1485

Table I-11 Avifauna observations along a 20-mile survey route near Wolf Creek Generating Station, Burlington, Kansas, 22 January 1981.

Species	Number of Birds Observed Per Mile																				Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Red-tailed Hawk	-	-	1	-	1	-	-	1	1	1	-	1	-	-	-	-	1	-	-	1	8
Bald Eagle	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Marsh Hawk	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
American Kestrel	1	-	-	-	-	-	1	1	-	-	-	1	-	-	-	-	-	-	-	-	4
Rock Dove	-	-	-	-	3	-	-	-	-	1	-	6	-	-	-	-	-	-	-	-	10
Common Flicker	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	1	-	-	-	3
Red-bellied Woodpecker	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Red-headed Woodpecker	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	3
Downy Woodpecker	-	1	-	-	-	-	-	-	3	2	-	3	-	-	-	-	-	-	-	-	9
Horned Lark	-	3	-	1	-	35	5	-	-	30	-	-	-	-	1	-	-	-	-	-	75
Blue Jay	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	3
Common Crow	-	1	-	-	5	4	-	-	-	3	1	3	6	3	-	-	-	-	-	-	26
Black-capped Chickadee	2	-	-	-	1	-	-	-	-	12	1	10	-	-	-	-	-	-	-	-	26
Tufted Titmouse	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Mockingbird	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
American Robin	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Loggerhead Shrike	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Starling	-	-	-	-	9	-	1	6	-	3	-	7	2	-	-	-	-	-	-	-	28
House Sparrow	-	-	-	-	5	-	-	-	-	5	-	20	20	-	-	50	-	-	-	-	100
Eastern Meadowlark	-	-	-	-	15	-	-	-	10	-	-	10	-	1	-	2	-	-	3	2	43
Red-winged Blackbird	-	138	-	-	-	-	-	9	300	35	6	-	-	-	-	-	-	-	-	8	496
Cardinal	-	1	-	-	-	-	-	2	-	7	1	-	-	-	-	1	-	-	1	-	13
American Goldfinch	-	1	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	13
Dark-eyed Junco	-	-	-	-	-	-	-	-	-	50	-	-	-	20	-	5	-	-	-	-	75
Tree Sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	10	6	-	-	-	-	-	16
Harris' Sparrow	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	20	-	-	-	15	45
White-crowned Sparrow	-	-	-	-	30	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	31
Sparrow sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	5	-	-	-	-	20
Totals	3	146	1	1	69	39	7	20	327	157	9	74	28	36	22	83	2	0	4	26	1054

Table I-12 Avifauna observations along a 20-mile survey route near Wolf Creek Generating Station, Burlington, Kansas, 23 January 1981.

Species	Number of Birds Observed Per Mile																				Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Red-tailed Hawk	-	-	-	-	2	-	-	-	1	1	-	-	1	1	-	-	-	-	-	1	7
Rough-legged Hawk	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	2
American Kestrel	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	2
Rock Dove	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Mourning Dove	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Great Horned Owl	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Belted Kingfisher	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Common Flicker	-	-	1	-	1	-	-	-	1	-	1	-	1	-	-	-	-	-	-	-	5
Red-bellied Woodpecker	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	3
Downy Woodpecker	-	-	-	-	-	-	-	-	-	-	1	1	1	1	-	-	-	-	-	1	5
Horned Lark	-	2	1	1	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	6
Blue Jay	-	-	-	-	-	-	-	-	2	-	3	1	-	-	-	-	-	-	-	-	6
Common Crow	-	-	-	40	3	1	-	-	-	3	2	3	1	-	-	1	-	-	-	-	54
Black-capped Chickadee	-	-	-	-	1	-	-	-	-	-	5	4	-	3	-	1	3	-	-	2	19
White-breasted Nuthatch	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2
Mockingbird	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
American Robin	-	3	-	-	1	36	-	-	-	-	8	-	-	-	-	-	-	-	-	-	48
Eastern Bluebird	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	6
Loggerhead Shrike	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	1	-	3
Starling	-	-	-	-	2	3	2	2	4	2	3	-	10	-	3	25	1	2	4	-	63
House Sparrow	1	-	-	-	-	-	10	-	-	15	10	-	35	-	10	30	-	-	-	5	116
Eastern Meadowlark	-	-	-	-	-	-	-	-	-	-	-	2	50	-	7	7	-	-	-	1	67
Red-winged Blackbird	-	-	-	-	-	55	-	-	20	300	-	-	-	25	-	-	-	-	-	-	400
Cardinal	3	1	-	-	3	-	-	-	1	-	6	1	-	1	-	1	-	-	-	1	18
American Goldfinch	-	-	-	-	5	-	-	-	-	-	-	-	-	30	-	-	-	-	5	20	60
Dark-eyed Junco	2	-	-	-	-	-	-	-	-	-	18	-	-	-	-	-	-	-	-	-	20
Tree Sparrow	5	-	-	-	-	-	-	-	-	-	10	-	15	-	15	-	-	-	-	2	47
Harris' Sparrow	3	-	-	-	3	-	-	-	-	-	12	-	25	50	-	25	-	-	-	-	118
White-crowned Sparrow	-	-	-	-	-	-	-	-	-	-	-	2	10	15	-	-	-	-	-	-	27
Totals	16	7	2	41	22	95	13	2	31	321	83	15	151	127	33	90	4	2	11	34	1100

55b

EA, 1982. WCGS Construction Environmental Monitoring Program, February 1981 - January 1982, EA Report KGE11.

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EA Report KGE11

WOLF CREEK GENERATING STATION CONSTRUCTION ENVIRONMENTAL MONITORING PROGRAM, FEBRUARY 1981-JANUARY 1982

Prepared for

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4 June 1982

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3. PHYTOPLANKTON

3.1 FIELD AND ANALYTICAL METHODS

Duplicate water samples for phytoplankton analyses were collected in April, June, October, and December at Locations 1, 4, and 10 in the Neosho River and at Locations 2 and 6 in the cooling lake for Wolf Creek Generating Station (WCGS). The locations in the cooling lake were also sampled for phytoplankton in February and August. Subsamples were stored in prelabeled, 8-oz bottles containing five milliliters of M^3 preservative (Meyer 1971) for later algae identification, enumeration, and biovolume determination. Carbon fixation rate and chlorophyll a concentration were assessed from unpreserved portions of the samples and were used as indices of primary productivity.

The inverted microscope method (Lund et al. 1958; Weber 1973) was used to determine phytoplankton species composition and abundance. Identification and enumeration of phytoplankton were performed under oil immersion at 1,000X magnification. Approximately 400 reporting units per duplicate sample were identified to the lowest positive taxa and quantitatively reported using various reporting units:

Algal form	Reporting Units (units/ml)
Diatoms	Each frustule
Unicellular	Each cell
Colonial	4 cells (50 cells for some blue-green algae)
Filamentous	100-µm lengths

Taxonomic keys used as identification aids included Hustedt (1930), Huber-Pestalozzi (1941, 1961, 1968), Smith (1950), Cleve-Euler (1951), Tiffany and Britton (1952), Drouet and Daily (1956), Edmondson (1959), Prescott (1962, 1964), Patrick and Reimer (1966, 1975), Drouet (1968), Stoermer and Yang (1969), Taft and Taft (1971), and Whitford and Schumacher (1973). Additional references were consulted as needed for specific taxa.

Density data were used to calculate diversity and evenness (Shannon 1948 using natural logarithms; Pielou 1966; Zar 1968) at each location on each sampling date. Biovolume determinations were made following the procedures described by Cowell (1960) and Hohn (1969). Cell volumes were calculated using the geometrical configuration that best suited each taxon and expressed as microliters per liter (µl/liter).

The rate of carbon fixation was estimated with the light bottle/dark bottle C-14 method (Wetzel 1964; Parkos et al. 1969; Strickland and Parsons 1972). Six 50-ml light bottle subsamples (three per duplicate water sample) and one 50-ml dark bottle subsample per location were inoculated with 4-6 microcuries of aqueous C-14 bicarbonate solution. Dark bottle subsamples were wrapped in aluminum foil to exclude light, and all subsamples were incubated for 3 hours at a constant temperature (near ambient) and light intensity in an environmental chamber. Subsamples were filtered onto membrane filters

(0.45-µm pore size), which then were air-dried under dark conditions. Upon return to the laboratory, the filters were dried further in a desiccator, fumed with concentrated HCl for 10 minutes (Wetzel 1965), and placed in low potassium scintillation vials. After 17 milliliters of scintillation fluid were added to each vial, C-14 activity was measured with a refrigerated liquid scintillation counter. Primary productivity was expressed as carbon fixed per cubic meter of water per hour (mg $C/m^3/hr$) at each location.

Six 50-ml subsamples per location (three per duplicate water sample) were filtered through a thin layer of $MgCO_3$ on glass-fiber filters for chlorophyll a analysis. Filters were placed in centrifuge tubes and stored on ice under dark conditions, until further processing. The filters later were eluted in 10 milliliters of 90 percent aqueous acetone for 24 hours at 4 C under dark conditions, then subjected to ultrasonic disruption. After samples were clarified by centrifugation, their fluorescence was determined before and after the addition of 1N HCl (Lorenzen 1966). Standard equations (Strickland and Parsons 1972; APHA 1976) were used to calculate chlorophyll a concentrations. These concentrations, corrected for phaeopigments, were reported per cubic meter of water (mg Chl a/m^3) at each location.

3.2 RESULTS AND DISCUSSION

Phytoplankton collected in the Neosho River and WCGS cooling lake during 1981 consisted of 149 taxa representing 73 genera and 7 algal divisions (Table 3-1). More taxa were observed in the cooling lake than in the river, probably because two additional collections were made in the cooling lake and because river populations were pumped to the cooling lake (near Location 2) as the lake was filled. Of the 149 taxa identified, most (81) were common to both the river and cooling lake. The Chlorophyta (green algae), Bacillariophyta (diatoms), and Cyanophyta (blue-green algae) were well represented in phytoplankton collections (51, 38, and 25 taxa, respectively). The total number of taxa observed in the river was very similar in 1980 and 1981 (100 vs. 103). Density and biovolume for each taxon are presented by sampling date and location in Appendix B, along with summaries of phytoplankton data for the Neosho River from 1973 through 1980.

Phytoplankton standing crops, as estimated by total density, total biovolume, and chlorophyll a concentrations, were generally similar in the Neosho River and cooling lake (Table 3-2). An exception occurred in April when standing crops were much higher in the river than in the cooling lake. Phytoplankton productivity as estimated by carbon fixation rates exhibited spatial patterns similar to those observed for standing crop. Differences between the river and cooling lake diversity indices were generally less pronounced than those for standing crop (Table 3-3).

3.2.1 Neosho River

During 1981, total phytoplankton densities in the Neosho River ranged from 3,244 to 73,714/ml; total biovolumes ranged from 0.76 to 8.78 µl/l (Table 3-2). Values for both standing crop parameters were within the respective ranges observed for the river during previous studies (Tables B-1 and B-2),

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TABLE 3-1 ALGAE IDENTIFIED IN PHYTOPLANKTON SAMPLES FROM THE NEOSHO RIVER AND THE COOLING LAKE OF WOLF CREEK GENERATING STATION, BURLINGTON, KANSAS, 1981

Taxa	Neosho River	Cooling Lake
BACILLARIOPHYTA (Diatoms)		
Centrales		
Cyclotella atomus Hustedt	X	X
Cyclotella meneghiniana Kuetzing	X	X
Cyclotella stelligera (Cleve and Grunow *ex* Cleve) VanHeurck	-	X
Melosira ambigua (Grunow) O. Mueller	X	X
Melosira distans (Ehrenberg) Kuetzing	X	X
Melosira granulata (Enrenberg) Ralfs	X	X
Melosira varians C.A. Agardh	X	-
Skeletonema potamos (Weber) Hasle	-	X
Stephanodiscus astraea (Ehrenberg) Grunow	X	X
Stephanodiscus hantzschii Grunow	X	X
Stephanodiscus invisitatus Hohn and Hellerman	X	X
Stephanodiscus niagarae Ehrenberg	X	X
Stephanodiscus spp.	-	X
Small unidentified centrics	X	X
Pennales		
Achnanthes minutissima Kuetzing	-	X
Cocconeis placentula Ehrenberg	X	-
Fragilaria capucina DesMazieres	-	X
Fragilaria construens (Ehrenberg) Grunow	-	X
Fragilaria vaucheriae (Kuetzing) Petersen	-	X
Gomphonema parvulum (Kuetzing) Kuetzing	-	X
Navicula capitata Ehrenberg	X	-
Navicula cryptocephala Kuetzing	X	X
Navicula rhynchocephala Kuetzing	X	-
Navicula spp.	X	X
Nitzschia acicularis (Kuetzing) W. Smith	X	X
Nitzschia capitellata Hustedt	X	-
Nitzschia dissipata (Kuetzing) Grunow	X	X
Nitzschia fonticola Grunow	X	X
Nitzschia frustulum (Kuetzing) Grunow	X	-
Nitzschia longissima (Brebisson) Ralfs	X	X
Nitzschia palea (Kuetzing) W. Smith	X	X
Nitzschia subcapitellata Hustedt	X	X
Nitzschia tryblionella Hantzsch	X	X
Nitzschia spp.	X	X
Rhoicosphenia curvata	X	X
Synedra rumpens	X	X
Synedra ulna	X	-
Synedra spp.	-	X

TABLE 3-1 (CONT.)

Taxa	Neosho River	Cooling Lake
CHLOROPHYTA (Green Algae)		
Actinastrum hantzschii Lagerheim	X	X
Ankistrodesmus convolutus Corda	-	X
Ankistrodesmus falcatus (Corda) Ralfs	X	X
Carteria cordiformis (Carter) Deising	X	X
Carteria spp.	-	X
Chlamydomonas spp.	X	X
Chlorogonium elongatum Dangeard	X	-
Chlorogonium spp.	X	-
Closteriopsis longissima Lemmermann	X	X
Coelastrum microporum Naegeli ex A. Braun	X	X
Cosmarium spp.	X	X
Crucigenia quadrata Morren	X	X
Crucigenia tetrapedia (Kirchner) West and G.S. West	X	X
Dictyosphaerium ehrenbergianum Naegeli	X	X
Dictyosphaerium pulchellum Wood	X	X
Elakatothrix gelatinosa Wille	X	X
Gloeocystis gigas (Kuetzing) Lagerheim	X	X
Golenkinia radiata (Chodat) Wille	X	X
Kirchneriella subsolitaria G.S. West	X	X
Lagerheimia quadriseta (Lemmermann) G.M. Smith	X	X
Micractinium pusillum Fresenius	X	X
Nephrocytium agardhianum Naegeli	-	X
Oocystis borgei Snow	X	X
Oocystis gloeocystiformis Borge	X	X
Oocystis pusilla Hansgirg	X	X
Pandorina morum (Mueller) Bory	-	X
Pediastrum boryanum (Turpin) Meneghini	X	-
Pediastrum duplex Meyen	X	X
Pediastrum tetras (Ehrenberg) Ralfs	X	-
Quadrigula lacustris (Chodat) G.M. Smith	X	-
Scenedesmus abundans (Kirschner) Chodat	X	X
Scenedesmus acuminatus (Lagerheim) Chodat	X	-
Scenedesmus arcuatus Lemmermann	-	X
Scenedesmus bijuga (Turpin) Lagerhaim	X	X
Scenedesmus dimorphus (Turpin) Kuetzing	X	X
Scenedesmus longus Meyen	-	X
Scenedesmus quadricauda (Turpin) Brebisson	X	X
Scenedesmus spp.	X	-
Schroederia setigera (Schroeder) Lemmermann	X	X
Selenastrum gracile Reinsch	-	X
Selenastrum minutum (Naegeli) Collins	X	X
Selenastrum westii G.M. Smith	-	X
Sphaerocystis schroeteri Chodat	-	X
Staurastrum spp.	X	X

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TABLE 3-1 (CONT.)

Taxa	Neosho River	Cooling Lake
Tetraedron minimum (A. Braun) Hansgirg	X	-
Tetraedron muticum (A. Braun) Hansgirg	X	X
Tetraedron regulare Kuetzing	-	X
Tetrastrum staurogeniaeforme (Schroeder) Lemmermann	-	X
Treubaria setigerum (Archer) G.M. Smith	-	X
Trochiscia zachariasii Lemmermann	-	X
Unidentified coccoid greens	X	X
CHRYSOPHYTA (Yellow-green Algae)		
Arachnochloris minor Pascher	X	X
Chromulina spp.	X	X
Chrysochromulina spp.	X	X
Chrysococcus punctiformis Pascher	X	X
Chrysococcus spp.	-	X
Dinobryon bavaricum Imhof	-	X
Dinobryon sertularia Ehrenbeg	-	X
Mallomonas akrokomas Ruttner	-	X
Mallomonas spp.	-	X
Ochromonas spp.	-	X
Ophiocytium capitatum Wolle	X	X
Pseudokephyrion spp.	-	X
Unidentified chrysophyte	X	X
CRYPTOPHYTA (Cryptomonads)		
Chroomonas spp.	-	X
Cryptomonas spp.	X	X
Rhodomonas minuta Skuja	X	X
CYANOPHYTA (Blue-green Algae)		
Anabaena spp.	-	X
Aphanocapsa delicatissima West and West	X	X
Aphanocapsa elachista West and West	X	X
Aphanocapsa spp.	X	X
Aphanothece nidulans P. Richter	X	X
Aphanothece spp.	-	X
Chroococcus dispersus (Keissler) Lemmermann	X	X
Chroococcus minor (Kuetzing) Naegeli	X	X
Chroococcus prescottii Drouet and Daily *ex* Drouet	-	X
Chroococcus spp.	-	X
Coelosphaerium kuetzingianum Naegeli	X	X
Coelosphaerium pallidum Lemmermann	X	X
Gloeocapsa punctata Naegeli	-	X
Gloeocapsa spp.	X	-
Gloeothece linearis Naegeli	-	X
Gloeothece palea (Kuetzing) Rabenhorst	X	X

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TABLE 3-1 (CONT.)

Taxa	Neosho River	Cooling Lake
Gomphosphaeria lacustris Chodat	X	X
Lyngbya diguetii Gomont *ex* Hariot	X	X
Lyngbya taylorii Drouet and Stuckland	X	-
Lyngbya spp.	X	-
Marssoniella elegans Lemmermann	X	X
Merismopedia tenuissima Lemmermann	X	X
Microcystis incerta Lemmermann	X	X
Unidentified blue-green coccoids	X	X
Unidentified blue-green filaments	-	X
EUGLENOPHYTA (Euglenoids)		
Euglena deses Ehrenberg	X	X
Euglena gracilis Klebs	X	X
Euglena minuta Prescott	-	X
Euglena proxima Dangeard	-	X
Euglena tripteris (DuJardin) Klebs	X	-
Lepocinclis acuta Prescott *ex* Prescott, Silva, and Wade	X	X
Phacus acuminatus Stokes	-	X
Phacus caudatus Huebner	X	-
Phacus spp.	X	X
Trachelomonas hispida (Perty) Stein	-	X
Trachelomonas robusta Swirenko	X	-
Trachelomonas schauinslandii Lemmermann	X	X
Trachelomonas volvocina Ehrenberg	-	X
Trachelomonas spp.	-	X
PYRRHOPHYTA (Dinoflagellates)		
Ceratium hirundinella (O.F. Mueller) DuJardin	-	X
Glenodinium spp.	-	X
Gymnodinium spp.	X	X
Peridinium spp.	X	-
Unidentified Microflagellates	-	X
Total Taxa	103	127
	149	

TABLE 3-2 STANDING CROP AND PRODUCTIVITY OF PHYTOPLANKTON IN THE NEOSHO RIVER AND THE COOLING LAKE OF WOLF CREEK GENERATING STATION, BURLINGTON, KANSAS, 1981

Parameter/Sampling Date	Sampling Locations				
	Neosho River			Cooling Lake	
	1	10	4	2	6
Total Density (units/ml)					
24 FEB 81	-[a]	-	-	38,449	24,627
28 APR 81	37,322	67,182	73,714	20,635	3,170
23 JUN 81	5,394	4,579	3,244	8,506	6,895
25 AUG 81	-	-	-	22,356	25,133
20 OCT 81	12,706	9,873	10,645	18,887	16,073
15 DEC 81	7,469	6,625	9,792	30,908	13,997
Total Biovolume (µl/liter)					
24 FEB 81	-	-	-	3.53	1.78
28 APR 81	4.91	8.78	7.79	2.60	0.85
23 JUN 81	1.36	1.29	0.76	2.14	0.52
25 AUG 81	-	-	-	2.22	0.99
20 OCT 81	3.68	2.73	2.85	1.85	1.93
15 DEC 81	2.74	2.42	4.42	5.26	2.64
Chlorophyll a Concentration (mg Chl a/m^3)					
24 FEB 81	-	-	-	25.49	10.20
28 APR 81	30.57	44.28	33.74	11.50	4.92
23 JUN 81	9.28	10.20	10.85	10.33	2.73
25 AUG 81	-	-	-	11.50	6.01
20 OCT 81	13.71	18.33	21.52	14.45	6.99
15 DEC 81	17.28	14.30	15.87	16.50	11.15
Carbon Fixation Rate (mg C/m^3/hr)					
24 FEB 81	-	-	-	115.76	40.20
28 APR 81	18.39	30.42	22.39	4.07	2.83
23 JUN 81	22.58	21.64	23.15	24.50	5.18
25 AUG 81	-	-	-	2.80	2.39
20 OCT 81	13.81	14.34	13.80	14.76	7.05
15 DEC 81	48.90	40.09	43.35	32.33	23.87

[a] Sampling in the Neosho River was not scheduled for February and August.

TABLE 3-3 DIVERSITY INDICES FOR PHYTOPLANKTON IN THE NEOSHO RIVER AND THE COOLING LAKE OF WOLF CREEK GENERATING STATION, BURLINGTON, KANSAS, 1981

Index[a]/Sampling Date	Sampling Locations				
	Neosho River			Cooling Lake	
	1	10	4	2	6
Species Diversity[b]					
24 FEB 81	-[c]	-	-	2.46	2.07
28 APR 81	2.90	2.93	2.78	2.77	1.42
23 JUN 81	3.10	3.12	3.02	3.08	2.43
25 AUG 81	-	-	-	2.48	2.15
20 OCT 81	2.70	2.84	2.86	2.91	2.87
15 DEC 81	2.59	2.49	2.31	1.98	2.66
Evenness Value[d]					
24 FEB 81	-	-	-	0.66	0.60
28 APR 81	0.77	0.78	0.75	0.67	0.44
23 JUN 81	0.79	0.81	0.81	0.80	0.70
25 AUG 81	-	-	-	0.65	0.58
20 OCT 81	0.72	0.76	0.77	0.79	0.73
15 DEC 81	0.76	0.75	0.69	0.60	0.73
Number of Taxa					
24 FEB 81	-	-	-	42	31
28 APR 81	44	42	40	63	25
23 JUN 81	51	46	41	46	32
25 AUG 81	-	-	-	44	40
20 OCT 81	43	41	40	40	50
15 DEC 81	30	28	29	28	39

(a) Combined results of duplicate analyses.
(b) Based on Shannon (1948) using natural logarithms.
(c) Sampling in the Neosho River was not scheduled for February and August.
(d) Zar (1968).

even though the method of analysis was changed from modified Lackey microtransects (Lackey 1938; Mackenthun 1969) to the inverted microscope beginning in 1980. Densities and biovolumes in 1981 were generally similar at upstream (1) and downstream locations (4 and 10) except in April when downstream values were approximately twice those observed upstream. Most of the spatial and temporal differences in phytoplankton appeared related to the flow regime in the Neosho River. Highest values and greatest spatial differences occurred in April when flows were lowest; reduced values and spatial differences in remaining collections corresponded to flows greater than 1,000 cfs (Table 2-2).

No single algal group numerically dominated the river phytoplankton in 1981 although diatoms (primarily centrics) always composed at least 30 percent of total numbers (Table 3-4). Green algae, cryptomonads, and blue-green algae composed at least 20 percent of total density at various times during the year, and these groups were considered seasonal codominants with diatoms. Green and blue-green algae codominated (with diatoms) in April and June, blue-green algae codominated in October, and cryptomonads codominated in December. Biovolumes were more clearly dominated by diatoms, but green and blue-green algae were relatively important in April, as were cryptomonads in June and December. Yellow-green algae, euglenoids, and dinoflagellates were minor components of the river phytoplankton, both in terms of density and biovolume.

Twenty phytoplankton taxa were considered important in the river because they composed at least 5 percent of total density or biovolume during 1981 (Table 3-5). Important centric diatoms included species of Cyclotella, Melosira, and Stephanodiscus, as well as small forms (<5-µm diameter) that could not be positively identified by the analytical technique employed. Previous studies have attributed importance of centric diatoms in this portion of the Neosho River to water releases from John Redmond Reservoir because large populations of these diatoms are generally characteristic of lentic (lake) habitats (Repsys 1979a; Bockelman 1980a). Downstream declines in the abundance of several taxa have often provided additional evidence of their origin in the reservoir. However, of the five centric taxa important on 28 April 1981, only Stephanodiscus astraea declined in abundance at the downstream locations. The other centrics exhibited dramatic increases at Locations 4 and 10 that seemed to indicate they either originated in the river (e.g., Stphanodiscus hantzschii) or were well adapted to the lotic (flowing) habitat of the Neosho River (e.g., Cyclotella atomus, C. meneghiniana and small unidentified centrics). The low flow conditions in April may have contributed to population increases of some taxa by creating more lentic (pool) habitats within the river.

Many important nondiatoms also exhibited downstream increases in April. These taxa included Chlamydomonas spp. (Chlorophyta), Chrysochromulina spp. (Chrysophyta), Cryptomonas spp. and Rhodomonas minuta (both Cryptophyta), and Chroococcus dispersus (Cyanophyta). The larger downstream populations of the relatively fragile flagellates Chlamydomonas, Chrysochromulina, and Rhodomonas provided additional evidence that quiet, pool-like areas existed near Locations 4 and 10 in April because these taxa typically exhibited downstream

TABLE 3-4 MEAN DENSITY AND BIOVOLUME OF MAJOR ALGAL GROUPS IN PHYTOPLANKTON OF THE NEOSHO RIVER NEAR WOLF CREEK GENERATING STATION, BURLINGTON, KANSAS, 1981

		Density at Sampling Locations						Biovolume at Sampling Locations					
		1		10		4		1		10		4	
Date	Taxa	units/ml	%	units/ml	%	units/ml	%	µl/liter	%	µl/liter	%	µl/liter	%
28 APR	Bacillariophyta	14,307	38.34	30,069	44.76	31,174	42.29	2.42	49.32	3.78	43.03	3.93	50.44
	(Centrales)	(13,319)	(35.69)	(29,022)	(43.20)	(30,767)	(41.74)	(2.28)	(46.48)	(3.62)	(41.24)	(3.87)	(49.63)
	(Pennales)	(989)	(2.65)	(1,047)	(1.56)	(407)	(0.55)	(0.14)	(2.84)	(0.16)	(1.79)	(0.06)	(0.80)
	Chlorophyta	11,472	30.74	17,463	25.99	14,787	20.06	1.28	26.08	1.71	19.49	1.54	19.81
	Chrysophyta	1,047	2.81	2,792	4.16	4,420	6.00	0.06	1.22	0.14	1.59	0.24	3.14
	Cryptophyta	1,047	2.81	4,188	6.23	4,188	5.68	0.37	7.57	2.25	25.69	1.58	20.24
	Cyanophyta	9,274	24.85	12,381	18.43	19,145	25.97	0.50	10.18	0.28	3.18	0.50	6.37
	Euglenophyta	174	0.47	291	0.43	0	0.00	0.28	5.63	0.62	7.02	0.00	0.00
	Pyrrhophyta	0	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23 JUN	Bacillariophyta	1,774	32.89	1,910	41.70	989	30.48	0.74	54.68	0.67	52.82	0.49	64.49
	(Centrales)	(1,590)	(29.47)	(1,658)	(36.20)	(882)	(27.19)	(0.70)	(51.62)	(0.59)	(46.49)	(0.46)	(61.39)
	(Pennales)	(184)	(3.41)	(252)	(5.50)	(107)	(3.29)	(0.04)	(3.06)	(0.08)	(6.33)	(0.02)	(3.10)
	Chlorophyta	1,328	24.62	964	21.06	960	29.58	0.19	14.12	0.18	14.35	0.11	14.31
	Chrysophyta	58	1.08	39	0.85	48	1.49	<0.01	0.36	<0.01	0.28	<0.01	0.59
	Cryptophyta	795	14.74	553	12.07	388	11.95	0.27	20.02	0.28	22.02	0.14	19.04
	Cyanophyta	1,400	25.96	1,075	23.48	860	26.49	0.03	2.39	0.02	1.69	0.01	1.58
	Euglenohyta	29	0.54	39	0.85	0	0.00	0.07	4.96	0.11	8.84	0.00	0.00
	Pyrrhophyta	10	0.18	0	0.00	0	0.00	0.05	3.47	0.00	0.00	0.00	0.00
20 OCT	Bacillariophyta	4,829	38.01	3,513	35.58	3,795	36.65	3.24	87.93	2.27	83.11	2.40	84.15
	(Centrales)	(4,524)	(35.60)	(3,149)	(31.89)	(3,501)	(32.89)	(3.20)	(86.88)	(2.19)	(79.96)	(2.33)	(81.62)
	(Pennales)	(305)	(2.40)	(364)	(3.69)	(294)	(2.76)	(0.04)	(1.05)	(0.09)	(3.16)	(0.07)	(2.53)
	Chlorophyta	1,751	13.78	1,733	17.55	1,815	17.05	0.16	4.41	0.20	7.47	0.16	5.76
	Chrysophyta	23	0.18	47	0.48	153	1.43	<0.01	0.05	<0.01	0.15	0.01	0.41
	Cryptophyta	1,433	11.28	1,621	16.42	1,786	16.78	0.19	5.04	0.21	7.66	0.23	8.08
	Cyanophyta	4,657	36.66	2,959	29.97	3,096	29.08	0.06	1.75	0.04	1.61	0.05	1.60
	Euglenophyta	12	0.09	0	0.00	0	0.00	0.03	0.81	0.00	0.00	0.00	0.00
	Pyrrhophyta	0	0.00	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15 DEC	Bacillariophyta	2,736	36.64	2,802	42.30	4,256	43.47	1.37	50.06	1.41	58.07	2.45	55.35
	(Centrales)	(2,683)	(35.93)	(2,736)	(41.30)	(4,217)	(43.06)	(1.31)	(47.97)	(1.41)	(58.04)	(2.45)	(55.34)
	(Pennales)	(53)	(0.71)	(66)	(1.00)	(40)	(0.40)	(0.06)	(2.09)	(<0.01)	(0.04)	(<0.01)	(0.01)
	Chlorophyta	783	10.49	691	10.43	1,001	10.23	0.13	4.78	0.11	4.54	0.15	3.33
	Chrysophyta	767	10.26	542	8.18	357	3.64	0.05	1.94	0.04	1.60	0.02	0.52
	Cryptophyta	1,983	26.55	1,599	24.14	2,697	27.54	1.11	40.46	0.84	34.76	1.74	39.24
	Cyanophyta	1,147	15.36	977	14.75	1,454	14.85	0.02	0.76	0.02	0.67	0.02	0.51
	Euglenophyta	13	0.18	0	0.00	13	0.13	0.03	1.05	0.00	0.00	0.04	0.86
	Pyrrhophyta	0	0.00	13	0.20	13	0.13	0.00	0.00	<0.01	0.36	<0.01	0.20

Note: Values for centric and pennate diatoms are presented separately in parentheses because of their relative importance in phytoplankton.

TABLE 3-5 MEAN DENSITY (units/ml) OF IMPORTANT TAXA IN PHYTOPLANKTON AT LOCATIONS 1, 10, AND 4 IN THE NEOSHO RIVER NEAR WOLF CREEK GENERATING STATION, BURLINGTON, KANSAS, 1981

Taxa	28 APR			23 JUN			20 OCT			15 DEC		
	1	10	4	1	10	4	1	10	4	1	10	4
Bacillariophyta												
Centrales												
Cyclotella atomus	1,803	5,525	6,107	39	58	0	576	435	352	93	172	13
Cyclotella meneghiniana	640	5,002	5,700	136	165	19	364	329	317	317	251	330
Melosira distans	0	0	0	330	252	165	94	94	0	172	0	66
Melosira granulata	0	0	0	271	417	223	59	82	82	0	0	0
Melosira varians	0	0	0	0	0	19	0	0	0	0	0	0
Stephanodiscus astraea	5,176	2,908	3,141	582	572	397	2,315	1,598	1,704	1,044	1,269	2,075
Stephanodiscus hantzschii	0	3,024	4,885	0	0	0	0	0	0	0	0	0
Stephanodiscus niagarae	0	0	0	19	0	0	0	0	0	0	0	0
Small unidentified centrics	5,700	12,272	12,388	213	223	58	928	587	1,046	912	1,018	1,454
Chlorophyta												
Chlamydomonas spp.	174	3,664	2,734	10	19	10	12	23	35	264	198	159
Dictyosphaerium pulchellum	2,574	2,559	1,817	68	44	155	502	520	488	225	188	380
Kirchneriella subsolitaria	3,417	2,414	3,039	405	189	330	200	214	320	43	50	76
Oocystis borgei	131	73	44	0	7	10	9	0	6	0	0	3
Chrysophyta												
Chrysochromulina spp.	872	2,268	3,548	10	0	0	0	0	23	687	463	357
Cryptophyta												
Cryptomonas spp.	349	2,385	1,512	194	233	107	576	764	881	1,428	1,057	2,366
Rhodomonas minuta	698	1,803	2,675	601	320	281	858	858	905	555	542	330
Cyanophyta												
Chroococcus dispersus	4,057	7,619	14,424	0	58	70	0	41	117	430	380	479
Merismopedia tenuissima	0	0	0	480	582	320	1,618	887	1,075	0	26	0
Microcystis incerta	257	372	470	35	24	17	585	488	591	24	10	21
Unidentified blue-green coccoids	3,417	3,737	2,835	632	303	308	2,271	1,436	1,092	677	539	952

Note: Taxa composing at least 5 percent of total phytoplankton density or biovolume at any location on any date were considered important.

reductions during periods of high river flow. Other important nondiatoms had inconsistent spatial distribution (e.g., the blue-green alga Merismopedia tenuissima) or had higher densities at Location 1 (e.g., the green alga Kirchneriella subsolitaria).

Annual maximum phytoplankton abundance has occurred in a different month during almost every year since 1973. The effects of physical factors such as water temperature, light intensity, and day length that normally control seasonal algal cycles were modified by seasonal differences in discharge regimes from John Redmond Reservoir (Bockelman 1980a). Annual climatic differences in length and severity of winters, and the pattern and amount of yearly rainfall were factors that indirectly affected phytoplankton densities in the Neosho River because they influence turbidity, retention time, and algal standing crops in the reservoir. Wilde and Reetz (1976) and Farrell (1978) associated increases in phytoplankton densities and chlorophyll a concentrations with concurrent declines in annual precipitation within the John Redmond Reservoir watershed from 1973 to 1976.

During 1981, chlorophyll a concentrations ranged from 9.28 to 44.28 mg Chl a/m^3, and carbon fixation rates ranged from 13.80 to 48.90 mg C/m^3/hr (Table 3-2). Previous ranges in the Neosho River were 0.70 - 50.96 mg Chl a/m^3 and 0.15 - 130.65 mg C/m^3/hr (Tables B-4 and B-5). In the present study, chlorophyll a concentrations were highest in April, whereas carbon fixation rates were greatest in December. The chlorophyll peak corresponded to large phytoplankton densities and biovolumes in April. There was no apparent reason for the December peak in carbon fixation rates. All standing crop estimates at that time were well below the yearly peak values, and water temperatures were seasonally low (approximately 3.0 C). Spatial and temporal differences in diversity indices were minor in the river (Table 3-3), and all values for Shannon's Diversity Index were within the previously reported range (0.19 - 3.34) for phytoplankton in the Neosho River (Table B-3).

As in previous years, no adverse effects of WCGS construction on phytoplankton composition, abundance, diversity, biovolume, chlorophyll a standing crop, or carbon fixation rate were evident in the Neosho River. Values for these parameters have generally been similar at all three river locations and especially at Locations 10 (upstream from Wolf Creek) and 4 (downstream from Wolf Creek). Wolf Creek, the drainage system through which most runoff from construction-related activities is carried to the Neosho River, has exhibited intermittent flow throughout the monitoring studies and has had only minor effects on flow regimes and phytoplankton in the river. Closure of the WCGS cooling lake main dam was completed in September 1980, and no flow was observed in Wolf Creek during 1981. As previously stated, phytoplankton communities in this portion of the Neosho River have been influenced most directly by water releases from John Redmond Reservoir.

3.2.2 Cooling Lake

Total phytoplankton densities in the cooling lake ranged from 3,170 to 38,449/ml in 1981; total biovolumes ranged from 0.52 to 5.26 µl/l (Table 3-2). Values for both parameters were generally greater at Location 2 than at

Location 6. Densities at Location 2 exceeded 30,000/ml in February and December, whereas densities at Location 6 were greater than 20,000/ml in February and August. Chlorophyll a concentrations ranged from 2.73 to 25.49 mg Chl a/m^3 and were always greater at Location 2. Carbon fixation rates were also consistently greater at Location 2 and ranged from 2.39 to 115.76 mg C/m^3/hr (Table 3-2). On most sampling dates, phytoplankton communities in the cooling lake were moderately diverse. However, diversity values were less than 2.00 in April (1.42 at Location 6) and in December (1.98 at Location 6, Table 3-3).

Numerical dominance of cooling lake phytoplankton by major algal groups varied both temporally and spatially in 1981. Diatoms (primarily centrics), green algae, and blue-green algae codominated at both locations in February (Table 3-6). Blue-green algae codominated with four other groups at Location 2 in April, whereas cryptomonads clearly dominated total phytoplankton numbers at Location 6. In June, diatoms ,green algae, cryptomonads, and blue-green algae were present at approximately equal densities at Location 2, but blue-green algae alone dominated the phytoplankton at Location 6. Blue-green algae were most important in terms of relative abundance at both locations in August, and their numerical dominance, although somewhat reduced, continued in October when diatoms and green algae again became relatively important. The cooling lake in December was composed primarily of yellow-green algae with diatoms and green algae continuing to be relatively important at Location 6. Similar temporal and spatial variations in the relative contribution of these five algal groups were evident for phytoplankton biovolumes, but for this standing crop parameter, the relative importance of diatoms and cryptomonads generally increased while that of yellow-green algae and blue-green algae was often reduced (Table 3-6).

During the present study, 28 taxa were considered important constituents of the cooling lake phytoplankton because they composed at least 5 percent of total density or biovolume (Table 3-7). For some taxa (e.g., Ankistrodesmus falcatus and Rhodomonas minuta), density differences between the two locations were less pronounced than was expected from the differences observed in major group densities. However, several taxa (e.g., Melosira distans, Stephanodiscus astraea, Dictyosphaerium pulchellum, Chrysochromulina spp., and unidentified coccoid blue-greens) were restricted to Location 2 or were much more abundant there, especially during the first half of the study. This spatial trend disappeared or was reversed for some of these taxa in the second half of 1981. Blue-green algae (e.g., Chroococcus dispersus, Marssoniella elegans, and Merismopedia tenuissima) attained maximum abundance at Location 6.

Distinct phytoplankton communities were initially apparent at Location 2 and 6 in the cooling lake. In April and June, not only were standing crops reduced at Location 6, but diversity values were also lower. There was little evidence that these differences resulted from spatial variations in water quality (Tables 2-3 through 2-7). Instead, most of the variation in phytoplankton probably resulted from the combined effects of differences in water depth (shallow at Location 2 vs. relatively deep at Location 6) and introductions of river (Location 1) populations near Location 2 through the

TABLE 3-6 MEAN DENSITY AND BIOVOLUME OF MAJOR ALGAL GROUPS IN PHYTOPLANKTON OF THE COOLING LAKE OF WOLF CREEK GENERATING STATION, BURLINGTON, KANSAS, 1981

		Density at Sampling Locations				Biovolume at Sampling Locations			
		2		6		2		6	
Date	Taxa	units/ml	%	units/ml	%	µl/liter	%	µl/liter	%
24 FEB	Bacillariophyta	13,243	34.44	4,683	19.01	1.76	49.86	0.74	41.77
	(Centrales)	(11,423)	(29.71)	(4,504)	(18.29)	(1.55)	(43.76)	(0.73)	(41.14)
	(Pennales)	(1,819)	(4.73)	(179)	(0.73)	(0.22)	(6.11)	(0.01)	(0.62)
	Chlorophyta	16,613	43.21	9,253	37.57	1.38	39.16	0.72	40.32
	Chrysophyta	477	1.24	895	3.63	0.11	3.13	0.02	1.40
	Cryptophyta	477	1.24	209	0.85	0.06	1.72	0.03	1.82
	Cyanophyta	7,549	19.63	9,259	37.60	0.21	5.93	0.23	12.73
	Euglenophyta	0	0.00	30	0.12	0.00	0.00	0.01	0.64
	Pyrrhophyta	0	0.00	0	0.00	0.00	0.00	0.00	0.00
28 APR	Bacillariophyta	3,203	15.52	74	2.32	0.53	20.55	<0.01	1.16
	(Centrales)	(3,164)	(15.33)	(62)	(1.96)	(0.53)	(20.37)	(<0.01)	(0.82)
	(Pennales)	(39)	(0.19)	(12)	(0.37)	(<0.01)	(0.18)	(<0.01)	(0.34)
	Chlorophyta	2,871	13.91	206	6.51	0.31	11.82	0.03	3.28
	Chrysophyta	3,051	14.79	237	7.46	0.31	11.74	0.01	1.50
	Cryptophyta	3,238	15.69	2,582	81.47	1.05	40.43	0.78	91.24
	Cyanophyta	8,144	39.47	44	1.38	0.23	8.65	0.02	2.16
	Euglenophyta	81	0.39	0	0.00	0.10	3.76	0.00	0.00
	Pyrrhophyta	31	0.15	0	0.00	0.08	2.97	0.00	0.00
23 JUN	Bacillariophyta	2,147	25.25	318	4.61	1.00	46.62	0.09	16.61
	(Centrales)	(1,853)	(21.79)	(277)	(4.02)	(0.94)	(43.93)	(0.07)	(13.30)
	(Pennales)	(294)	(3.46)	(41)	(0.59)	(0.06)	(2.69)	(0.02)	(3.31)
	Chlorophyta	2,036	23.93	798	11.57	0.26	12.01	0.06	12.08
	Chrysophyta	128	1.50	128	1.86	<0.01	0.43	<0.01	0.99
	Cryptophyta	1,994	23.44	1,008	14.61	0.62	29.12	0.27	52.57
	Cyanophyta	2,099	24.68	4,643	67.34	0.03	1.30	0.09	17.76
	Euglenophyta	102	1.20	0	0.00	0.23	10.52	0.00	0.00
	Pyrrhophyta	0	0.00	0	0.00	0.00	0.00	0.00	0.00
25 AUG	Bacillariophyta	3,364	15.05	1,084	4.31	1.09	49.15	0.44	43.90
	(Centrales)	(2,798)	(12.52)	(1,005)	(4.00)	(1.03)	(46.47)	(0.42)	(42.45)
	(Pennales)	(566)	(2.53)	(79)	(0.32)	(0.06)	(2.68)	(0.01)	(1.45)
	Chlorophyta	1,132	5.06	2,002	8.05	0.17	7.86	0.21	21.60
	Chrysophyta	4,684	20.95	1,269	5.05	0.10	4.64	0.03	2.75
	Cryptophyta	2,106	9.42	846	3.37	0.56	25.01	0.17	17.43
	Cyanophyta	11,007	49.23	19,912	79.23	0.07	3.13	0.14	14.32
	Euglenophyta	31	0.14	0	0.00	0.04	2.01	0.00	0.00
	Pyrrhophyta	31	0.14	0	0.00	0.18	8.20	0.00	0.00
20 OCT	Bacillariophyta	4,217	22.33	2,986	18.58	0.82	44.47	0.60	31.01
	(Centrales)	(3,988)	(21.22)	(2,772)	(17.25)	(0.82)	(44.17)	(0.59)	(30.62)
	(Pennales)	(288)	(1.21)	(213)	(1.33)	(<0.01)	(0.30)	(<0.01)	(0.39)
	Chlorophyta	3,967	21.01	3,577	22.25	0.34	18.25	0.48	24.70
	Chrysophyta	291	1.54	271	1.69	0.02	0.84	0.01	0.71
	Cryptophyta	2,160	11.44	1,435	8.93	0.58	31.43	0.33	16.89
	Cyanophyta	8,231	43.58	7,707	47.95	0.06	3.06	0.06	3.06
	Euglenophyta	21	0.11	58	0.36	0.04	1.95	0.07	3.77
	Pyrrhophyta	0	0.00	19	0.12	0.00	0.00	0.38	19.84
15 DEC	Bacillariophyta	4,410	14.27	3,490	24.93	0.92	17.59	0.87	32.99
	(Centrales)	(4,265)	(13.80)	(3,362)	(24.02)	(0.90)	(17.16)	(0.86)	(32.63)
	(Pennales)	(145)	(0.47)	(127)	(0.91)	(0.02)	(0.43)	(<0.01)	(0.36)
	Chlorophyta	4,931	15.96	3,312	23.66	0.35	6.74	0.29	10.86
	Chrysophyta	15,606	50.49	4,398	31.42	1.12	21.37	0.31	11.61
	Cryptophyta	4,944	15.99	1,618	11.56	2.70	51.34	0.90	34.23
	Cyanophyta	919	2.97	1,034	7.39	0.01	0.28	0.02	0.94
	Euglenophyta	97	0.31	36	0.26	0.14	2.68	0.06	2.41
	Pyrrhophyta	0	0.00	109	0.78	0.00	0.00	0.18	6.96

Note: Values for centric and pennate diatoms are presented separately in parentheses because of their relative importance in phytoplankton.

TABLE 3-7 MEAN DENSITY (units/ml) OF IMPORTANT TAXA IN PHYTOPLANKTON AT LOCATIONS 2 AND 6 IN THE COOLING LAKE OF WOLF CREEK GENERATING STATION, BURLINGTON, KANSAS, 1981

Taxa	24 FEB		24 APR		23 JUN		25 AUG		20 OCT		15 DEC	
	2	6	2	6	2	6	2	6	2	6	2	6
Bacillariophyta												
Centrales												
Cyclotella atomus	60	30	648	0	0	14	157	26	2,389	1,532	824	418
Cyclotella meneghiniana	0	0	295	0	243	68	314	53	166	116	679	545
Melosira distans	239	0	0	0	435	0	1,446	582	104	78	97	200
Melosira granulata	0	0	0	0	268	14	252	264	0	19	97	0
Stephanodiscus astraea	1,163	298	1,136	8	626	54	189	0	665	485	485	327
Stephanodiscus niagarae	0	0	0	0	38	0	0	0	0	0	0	0
Stephanodiscus spp.	9,186	0	0	0	0	0	0	0	0	0	0	0
Small unidentified centrics	328	3,937	1,027	54	179	128	314	26	623	543	2,036	1,563
Chlorophyta												
Ankistrodesmus falcatus	7,814	6,055	407	31	89	81	189	53	561	485	1,890	382
Crucigenia tetrapedia	149	239	477	15	16	83	94	53	327	228	606	900
Dictyosphaerium ehrenbergianum	1,864	60	16	20	0	0	0	0	436	300	170	704
Dictyosphaerium pulchellum	3,713	753	318	39	278	139	63	1,216	706	911	1,575	700
Kirchneriella subsolitaria	336	306	567	0	604	132	86	139	769	533	109	186
Oocystis pusilla	485	537	100	0	131	12	63	112	166	39	145	105
Schroederia setigera	0	0	12	23	0	304	0	53	0	0	0	0
Unidentified coccoid greens	261	104	70	5	185	19	118	172	31	199	145	73
Chrysophyta												
Chrysochromulina spp.	149	775	2,260	19	51	128	4,684	1,190	145	136	15,315	4,217
Mallomonas akrokomos	0	0	23	190	0	0	0	0	0	0	0	0
Cryptophyta												
Cryptomonas spp.	209	60	954	682	422	169	503	106	291	136	3,441	1,163
Rhodomonas minuta	209	149	2,284	1,900	1,572	839	1,603	740	1,869	1,299	1,502	454
Cyanophyta												
Chroococcus dispersus	4,951	8,411	5,471	5	200	1,266	126	258	846	1,081	339	336
Gloeocapsa punctata	0	0	0	0	0	439	0	0	0	0	0	0
Marssoniella elegans	0	0	97	0	179	1,506	0	192	717	78	0	0
Merismopedia tenuissima	0	0	0	0	955	108	2,853	6,992	2,654	1,565	0	55
Unidentified blue-green coccoids	1,737	693	1,284	0	518	1,033	6,052	8,869	2,576	3,742	557	427
Euglenophyta												
Trachelomonas hispida	0	0	0	0	51	0	0	0	0	0	0	0
Pyrrhophyta												
Ceratium hirundinella	0	0	0	0	0	0	0	0	0	19	0	0
Glenodinium spp.	0	0	31	0	0	0	31	0	0	0	0	109

Note: Taxa composing at least 5 percent of total phytoplankton density or biovolume at either location on any date were considered important.

makeup water pumphouse. Taxa, such as S. astraea, that have historically been important at Location 1 in the river (e.g., Table 3-5) and probably originate in John Redmond Reservoir were much more abundant early in 1981 at Location 2 than at Location 6 in the cooling lake. As the year progressed, phytoplankton differences at the two locations became less distinctive because, as the cooling lake filled, makeup water from the river composed a lower proportion of the total lake volume and because introduced river taxa had become established in the cooling lake. Additionally, Location 2 was in the old Wolf Creek channel that was not completely inundated until October. For these reasons, the data from Location 6 probably more accurately represented typical phytoplankton of the cooling lake.

3.3 SUMMARY AND CONCLUSIONS

During 1981, 149 taxa representing 73 genera and 7 algal divisions were identified in phytoplankton samples from the Neosho River and WCGS cooling lake. The Chlorophyta (green algae), Bacillariophyta (diatoms), and Cyanophyta (blue-green algae) were well represented in the collections (51, 38, and 25 taxa, respectively).

Total densities and biovolumes in the river were within the respective ranges observed for the river during previous studies. Highest values and greatest differences between river locations occurred in April when flows were lowest; reduced values and spatial differences in June, October, and December corresponded to flows greater than 1,000 cfs. Diatoms, green algae, cryptomonads, and blue-green algae were numerically important at various times during the year, but no single algal group clearly dominated the phytoplankton on any sampling date.

Most of the twenty taxa considered important in the river have historically been important and probably originated in John Redmond Reservoir. This was especially true at Location 1. Many taxa exhibited a downstream increase in abundance during the low flow conditions of April, which seemed to indicate that quiet, pool-like areas existed near Locations 4 and 10. In other months, densities of important taxa generally declined at the downstream locations, as has often been observed in previous studies.

Chlorophyll a concentrations, carbon fixation rates, and diversity values in 1981 were also within previously reported ranges for river phytoplankton. There was no apparent explanation for the unusual December peak in carbon fixation rates. No major differences in any parameter existed between Location 10 (upstream of Wolf Creek) and Location 4 (downstream of Wolf Creek). As in previous years, no adverse effects of WCGS construction were evident in phytoplankton composition, abundance, diversity, biovolume, chlorophyll a standing crop, or carbon fixation rate in the Neosho River. Construction effects were not expected in 1981 because most construction had been completed and because there was essentially no discharge from Wolf Creek into the river during the year.

Phytoplankton populations in the cooling lake exhibited considerable spatial and temporal variability, especially during the first half of 1981. Values

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for most parameters (including diversity) were generally greater at Location 2 than at Location 6. Most of the observed spatial variation in phytoplankton probably resulted from the combined effects of differences in water depth and introductions of river populations near Location 2. As the cooling lake filled during the year, spatial differences became less pronounced. For several reasons, the data from Location 6 was considered a more accurate representation of cooling lake phytoplankton in 1981.

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4. PERIPHYTON

4.1 FIELD AND ANALYTICAL PROCEDURES

Periphyton was scheduled to be sampled from plexiglass artificial substrates in the Neosho River in April, June, October, and December 1981. Fluctuating river flows caused siltation and immersion problems and loss of platforms. Periphyton was sampled at Locations 10 and 4 in the Neosho River on 27 April 1981. Only Location 4 was sampled on 29 June because of siltation problems with the substrates at Location 10. No August collections were made because a sharp drop in river flow resulted in improper immersion of the substrates at both sites. On the remaining two sampling dates, 29 September and 19 October, only Location 10 was sampled due to the loss of the substrate platform at Location 4 during September.

Periphytic algae were allowed to colonize and grow on the artificial substrates for 27 days prior to collection for the first three collections and 20 days for the October collection. On each sampling date, duplicate samples were collected for identification, enumeration, and biovolume determination and preserved with M^3 (Meyer 1971). Four replicate samples were taken for biomass and chlorophyll a measurements. These were stored on ice under dark conditions until further processing.

Periphytic algae were identified to the lowest positive taxon and enumerated. Diatoms were cleaned chemically (Hohn and Hellerman 1963) and analyzed from Hyrax mounts under oil immersion at 1250X magnification. Nondiatoms were analyzed from wet mounts at 500X magnification. Taxonomic references used for identifications were similar to those used for the phytoplankton (Section 3.1). Algal abundance was expressed as the number of units per square millimeter ($No./mm^2$) using reporting units similar to those used for phytoplankton except for filamentous algae which were reported in 10-µm lengths. Biovolume was determined by methods described for phytoplankton and expressed as microliters per square decimeter ($\mu l/dm^2$). Shannon's (1948) diversity index and evenness indices (Zar 1968) were calculated using base 2 logarithms.

Biomass was used at each location as an index of the organic content of the periphyton community, and chlorophyll a concentrations provided an index of the algal component. Biomass (ash-free dry weight, gravimetric method) and chlorophyll a (corrected for pheophytin, spectrophotometric method) were measured in accordance with Standard Methods for the Examination of Water and Wastewater (APHA 1976). Production rates were reported as milligrams per square decimeter per day ($mg/dm^2/day$) and micrograms per square decimeter per day ($\mu g/dm^2/day$) for biomass and chlorophyll a, respectively.

4.2 RESULTS AND DISCUSSION

During 1981 one hundred sixteen taxa were identified from periphyton samples collected in the Neosho River near WCGS (Table 4-1). Diatoms (Bacillariophyta) were the most abundant algal group, making up more than 80 percent of the total density and biovolume of the algal assemblages on all

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TABLE 4-1 PERIPHYTIC ALGAE IDENTIFIED IN THE NEOSHO RIVER NEAR WOLF CREEK GENERATING STATION, BURLINGTON, KANSAS, 1981

BACILLARIOPHYTA
- Centrales
  - Cyclotella atomus Hustedt
  - Cyclotella kutzingiana Thwaites
  - Cyclotella meneghiniana Kuetzing
  - Melosira ambigua (Grunow) O. Mueller
  - Melosira distans (Ehrenberg) Kuetzing
  - Melosira distans var. lirata (Ehrenberg) Bethge
  - Melosira granulata (Ehrenberg) Ralfs
  - Melosira varians C.A. Agardh
  - Skeletonema potamos (Weber) Hasle
  - Stephanodiscus astraea var. minutula Grunow
  - Stephanodiscus invisitatus Hohn and Hellerman
  - Stephanodiscus spp.
- Pennales
  - Achnanthes exigua Grunow
  - Achnanthes lanceolata (Brebisson) Grunow
  - Achnanthes lanceolata var. dubia Grunow
  - Achnanthes linearis (W. Smith) Grunow
  - Achnanthes minutissima Kuetzing
  - Amphora perpusilla Grunow
  - Amphora veneta Kuetzing
  - Caloneis bacillum (Grunow) Cleve
  - Cocconeis pediculus Ehrenberg
  - Cocconeis placentula Ehrenberg
  - Cymbella minuta Hilse ex Rabenhorst
  - Cymbella prostrata var. auerswaldii (Rabenhorst) Reimer
  - Cymbella sinuata Gregory
  - Denticula elegans Kuetzing
  - Diploneis puella (Schumann) Cleve
  - Fragilaria vaucheriae (Kuetzing) Petersen
  - Gomphonema olivaceum (Lyngbye) Kuetzing
  - Gomphonema parvulum (Kuetzing) Kuetzing
  - Gomphonema subclavatum var. mexicanum (Grunow) Patrick
  - Gyrosigma obtusatum (Sullivan and Wormley) Boyer
  - Navicula arvensis Hustedt
  - Navicula auriculata Hustedt
  - Navicula capitata var. hungarica (Grunow) Ross
  - Navicula cryptocephala Kuetzing
  - Navicula cryptocephala var. veneta (Kuetzing) Rabenhorst
  - Navicula gracilloides A. Mayer
  - Navicula heufleri var. leptocephala (Brebisson ex Grunow) Patrick
  - Navicula menisculus var. upsaliensis (Grunow) Grunow
  - Navicula minima Grunow
  - Navicula minuscula Grunow
  - Navicula minusculiodes Hustedt
  - Navicula pelliculosa (Brebisson ex Kuetzing) Hilse
  - Navicula pupula Kuetzing
  - Navicula rhynchocephala Kuetzing
  - Navicula rhynchocephala var. germainii (Wallace) Patrick
  - Navicula symmetrica Patrick
  - Navicula tenera Hustedt
  - Navicula thienemannii Hustedt
  - Navicula tripunctata var. schizonemoides (Van Heurck) Patrick
  - Navicula utermoehlii Hustedt
  - Navicula vaucheriae Petersen
  - Navicula vitabunda Hustedt
  - Navicula spp.
  - Nitzschia acicularis (Kuetzing) W. Smith
  - Nitzschia acicularis var. adelos Hohn and Hellerman
  - Nitzschia amphibia Grunow
  - Nitzschia apiculata (Gregory) Grunow
  - Nitzschia calida Grunow

BACILLARIOPHYTA (continued)
- Nitzschia dissipata (Kuetzing) Grunow
- Nitzschia filiformis (W. Smith) Schutt
- Nitzschia fonticola Grunow
- Nitzschia frustulum var. perminuta Hustedt
- Nitzschia hungarica Grunow
- Nitzschia kutzingiana Hilse
- Nitzschia linearis (Agardh) W. Smith
- Nitzschia microcephala Grunow
- Nitzschia palea (Kuetzing) W. Smith
- Nitzschia romana Grunow
- Nitzschia subcapitellata Hustedt
- Nitzschia tryblionella var. debilis (Arnott) A. Mayer
- Nitzschia spp.
- Pleurosigma delicatulum W. Smith
- Rhoicosphenia curvata (Kuetzing) Grunow ex Rabenhorst
- Surirella angusta Kuetzing
- Surirella suecica Grunow

CHLOROPHYTA
- Ankistrodesmus falcatus (Corda) Ralfs
- Chlamydomonas spp.
- Chlorogonium elongatum Dangeard
- Cosmarium spp.
- Dictyosphaerium pulchellum Wood
- Kirchneriella subsolitaria G.S. West
- Micractinum pusillum Fresenius
- Oocystis borgei Snow
- Oocystis pusilla Hansgirg
- Pediastrum duplex Meyen
- Pediastrum tetras (Ehrenberg) Ralfs
- Quadrigula lacustris (Chodat) G.M. Smith
- Scenedesmus bijuga (Turpin) Lagerheim
- Scenedesmus dimorphus (Turpin) Kuetzing
- Scenedesmus quadricauda (Turpin) Brebisson
- Schroederia setigera (Schroeder) Lemmermann
- Selenastrum minutum (Naegeli) Collins
- Stigeoclonium tenue (C.A. Agardh) Kuetzing
- Ulothrix subtilissima Rabenhorst
- Unidentified green coccoid

CRYPTOPHYTA
- Cryptomonas spp.
- Rhodomonas spp.

CYANOPHYTA
- Anabaena spp.
- Chroococcus dispersus (Keissler) Lemmermann
- Chroococcus spp.
- Lyngbya diguetii Gomont in Hariot
- Lyngbya limnetica Lemmermann
- Lyngbya versicolor (Wartmann) Gomont
- Lyngbya spp.
- Merismopedia tenuissima Lemmermann
- Microcystis incerta Lemmermann
- Oscillatoria limnetica Lemmermann
- Oscillatoria spp.
- Phormidium tenue (Meneghini) Gomont
- Unidentified blue-green coccoid

EUGLENOPHYTA
- Euglena gracilis Klebs
- Phacus acuminatus Stokes
- Phacus spp.
- Trachelomonas spp.

four sampling dates (Table 4-2). Blue-green algae (Cyanophyta) and green algae (Chlorophyta) were always present in low numbers, while euglenoids (Euglenophyta) and cryptophytes (Cryptophyta) occurred sporadically and always in very low numbers. Detailed information on periphyton densities, biovolumes, and relative abundance is presented in Appendix C.

Periphyton densities and biovolumes were highest in April at both Locations 4 and 10. Total density at Location 10 was 10,694/mm^2 while total biovolume was 18.79 µl/dm^2. Location 4 had a higher total density (11,437/mm^2) but a lower biovolume (13.61 µl/dm^2). This resulted from differences in the major taxa (those composing at least five percent of the total density or biovolume; Table 4-3). Small taxa, such as Achnanthes lanceolata, Achnanthes minutissima, and Skeletonema potamos, were more abundant at Location 4, while somewhat larger forms, such as Cocconeis pediculus and Navicula cryptocephala, were more common at Location 10. The relative abundance of small centric diatoms at both locations resulted in part from upstream water releases from John Redmond Reservoir. Several of the taxa at both locations were typical of those found in rivers and streams (Lowe 1974; Patrick 1948; Round 1973), particularly alkaline streams (Table 2-3; Hynes 1972).

Chlorophyll a concentration, an index of algal production on the artificial substrates, was lower at Location 4 than at Location 10 in April (Table 4-4) because the former had more small taxa which contain lower amounts of chlorophyll a. Biomass production, however, was higher at Location 4 than 10. Greater production apparently was due to the nonalgal component (e.g., bacteria, protozoa, and other microorganisms) of periphyton at Location 4, as shown by differences in the Autotrophic Index at Location 4 (451) and at Location 10 (233). Considerable nonalgal production was actually occurring at both locations because values greater than 100 generally indicate that periphyton is dominated by heterotrophic (nonphotosynthetic) forms (Weber 1973).

Only Location 4 was sampled in June. Total density was 36 percent of that in April, and biovolume was less than half (Table 4-2). Pennate diatoms were the dominant group (Appendix C), and species of Navicula and Nitzschia were common (Table 4-3). Biomass and chlorophyll a concentrations also were much lower, as was the Autotrophic Index (Table 4-4) which indicated that considerable nonalgal production was still occurring. Lower densities and production in June probably resulted from greatly increased flow in the river (Table 2-2), a seven-fold increase in turbidity (Table 2-3), and increased shading caused by seasonal canopy development.

Only Location 10 was sampled in September because of the loss of the artificial substrates at Location 4. Small Achnanthes species (A. exigua, A. lanceolata, and A. minutissima) were the most important taxa numerically, while Cocconeis placentula was the most important taxon in terms of biovolume, making up 28.5 percent of the total (Table 4-3). Biomass production was approximately half that of April, while the mean chlorophyll a concentration was more than twice as high (Table 4-4). The Autotrophic Index was quite low (39) indicating that most of the production occurring on the artificial substrates was algal.

TABLE 4-2 MEAN DENSITY, BIOVOLUME AND PERCENT COMPOSITION OF MAJOR TAXONOMIC GROUPS IN PERIPHYTON SAMPLES COLLECTED FROM ARTIFICIAL SUBSTRATES IN THE NEOSHO RIVER NEAR WOLF CREEK GENERATING STATION, BURLINGTON, KANSAS, 1981

		Density at Sampling Locations				Biovolume at Sampling Locations			
		10		4		10		4	
Exposure Period	Taxon	No./mm^2	%	No./mm^2	%	µl/dm^2	%	µl/dm^2	%
1 APR - 27 APR	Bacillariophyta	8,677	81.1	10,154	89.5	15.59	83.0	11.54	84.8
	Chlorophyta	712	6.7	817	7.2	2.12	11.3	1.80	13.2
	Cryptophyta	48	0.4	19	0.2	0.20	1.1	0.08	0.6
	Cyanophyta	1,255	11.7	358	3.2	0.49	2.6	0.19	1.4
	Euglenophyta	3	<0.1	0	0	0.38	2.0	0	0
	Total Periphyton	10,694	100.0	11,347	100.0	18.79	100.0	13.61	100.0
26 MAY - 22 JUN	Bacillariophyta	-[a]	-	3,436	84.0	-	-	5.17	93.0
	Chlorophyta	-	-	77	1.9	-	-	0.15	2.7
	Cryptophyta	-	-	0	0	-	-	0	0
	Cyanophyta	-	-	580	14.2	-	-	0.24	4.4
	Euglenophyta	-	-	0	0	-	-	0	0
	Total Periphyton	-	-	4,092	100.0	-	-	5.57	100.0
3 SEP - 29 SEP	Bacillariophyta	8,270	94.9	-	-	12.64	96.0	-	-
	Chlorophyta	123	1.4	-	-	0.38	2.9	-	-
	Cryptophyta	0	0	-	-	0	0	-	-
	Cyanophyta	315	3.6	-	-	0.11	0.8	-	-
	Euglenophyta	3	<0.1	-	-	0.03	0.3	-	-
	Total Periphyton	8,711	100.0	-	-	13.17	100.0	-	-
30 SEP - 19 OCT	Bacillariophyta	208	84.2	-	-	0.93	93.5	-	-
	Chlorophyta	7	2.8	-	-	0.02	2.0	-	-
	Cryptophyta	0	0	-	-	0	0	-	-
	Cyanophyta	31	12.7	-	-	0.02	2.4	-	-
	Euglenophyta	1	0.3	-	-	0.02	2.1	-	-
	Total Periphyton	247	100.0	-	-	0.99	100.0	-	-

[a] Not sampled.

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TABLE 4-3 ALGAL TAXA COMPOSING AT LEAST 5 PERCENT OF TOTAL DENSITY OR BIOVOLUME OF PERIPHYTON COLLECTED FROM ARTIFICIAL SUBSTRATES IN THE NEOSHO RIVER NEAR WOLF CREEK GENERATING STATION, BURLINGTON, KANSAS, 1981

	Location 10		Location 4	
Exposure Period and Taxa	Density (No./mm^2)	Biovolume (µl/dm^2)	Density (No./mm^2)	Biovolume (µl/dm^2)
01 APR - 27 APR				
Achnanthes lanceolata	0	0	989*	0.81*
Achnanthes minutissima	247	0.08	691*	0.22
Cocconeis pediculus	190	3.40*	32	0.57
Cyclotella atomus	1,832*	0.59	1,914*	0.61
Cyclotella kutzingiana	1,096*	0.48	539	0.24
Cyclotella meneghiniana	1,255*	3.23*	1,794*	4.61*
Lyngbya spp.	1,015*	0.32	160	0.05
Navicula cryptocephala	437	2.19*	222	1.11*
Skeletonema potamos	342	0.10	1,559*	0.47
Stephanodiscus astraea var. minutula	767*	1.04*	634*	0.86*
Stigeoclonium tenue	329	0.78	326	0.77*
26 MAY - 22 JUN				
Amphora veneta	-(a)	-	159	0.70*
Caloneis bacillum	-	-	76	0.38*
Melosira varians	-	-	9	0.28*
Navicula gracilloides	-	-	180	0.73*
Navicula menisculus var. upsaliensis	-	-	485*	0.65*
Navicula vaucheriae	-	-	228*	0.07
Nitzschia dissipata	-	-	291*	0.36*
Nitzachis frustulum var. penminuta	-	-	682*	0.03
03 SEP - 29 SEP				
Achnanthes exigua	766*	0.55	-	-
Achnanthes lanceolata	2,530*	1.82*	-	-
Achnanthes minutissima	560*	0.36	-	-
Cocconeis placentula	720*	3.75*	-	-
Gomphonema parvulum	872*	1.31*	-	-
Navicula menisculus var. upsaliensis	271	1.23*	-	-
Navicula minuscula	654*	0.25	-	-
Navicula tripunctata var. schizonemoides	213	0.83*	-	-
30 SEP - 19 OCT				
Achnanthes lanceolata	20*	0.02	-	-
Cocconeis placentula	134*	0.63*	-	-
Lyngbya spp.	26*	<0.01	-	-
Stephanodiscus astraea var. minutula	10	0.09*	-	-

(a) Not sampled.

Note: Asterisk (*) designates a value that was at least 5 percent of the total.

TABLE 4-4 MEAN BIOMASS AND CHLOROPHYLL a PRODUCTION, AUTOTROPHIC INDEX, NUMBER OF TAXA, AND DIVERSITY AND EVENNESS MEASURES FOR PERIPHYTON COLLECTED FROM ARTIFICIAL SUBSTRATES IN THE NEOSHO RIVER NEAR WOLF CREEK GENERATING STATION, BURLINGTON, KANSAS, 1981

Parameter	Exposure Period	Sampling Location 10	Sampling Location 4
Biomass production[a] (mg/dm^2 per day)	01 APR - 27 APR	1.30	1.45
	26 MAY - 22 JUN	-[b]	0.16
	03 SEP - 29 SEP	0.68	-
	30 SEP - 19 OCT	0.14	-
Chlorophyll a production[c] ($\mu g/dm^2$ per day)	01 APR - 27 APR	8.16	3.55
	26 MAY - 22 JUN	-	0.75
	03 SEP - 29 SEP	19.20	-
	30 SEP - 19 OCT	1.70	-
Autotrophic Index[d]	01 APR - 27 APR	233	451
	26 MAY - 22 JUN	-	331
	03 SEP - 29 SEP	39	-
	30 SEP - 19 OCT	91	-
Number of Taxa[e]	01 APR - 27 APR	64	55
	26 MAY - 22 JUN	-	53
	03 SEP - 29 SEP	44	-
	30 SEP - 19 OCT	52	-
Diversity[f]	01 APR - 27 APR	4.43	4.13
	26 MAY - 22 JUN	-	4.64
	03 SEP - 29 SEP	3.77	-
	30 SEP - 19 OCT	2.99	-
Evenness[g]	01 APR - 27 APR	0.74	0.71
	26 MAY - 22 JUN	-	0.81
	03 SEP - 29 SEP	0.69	-
	30 SEP - 19 OCT	0.53	-

(a) Ash-free dry weight.
(b) Not sampled.
(c) Corrected for pheophytin.
(d) Weber 1973.
(e) Total taxa of two replicates.
(f) Shannon 1948, using base two logarithms.
(g) Zar 1968.

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In October, total density and biovolume at Location 10 were only a fraction of that occurring during previously sampled months. Biomass and chlorophyll a levels were also lower. This resulted in part from a seven-day shorter exposure time for the artificial substrates. Also, some nutrients such as phosphorus and silica, were present in lower concentrations (Table 2-5). Most of the production in October was algal, based on the Autotrophic Index (91).

Diversity values at Location 10 decreased through the 1981 sampling period (Table 4-4). Diversity in April was 4.43 and then dropped gradually to 2.99 in October. Location 4, which was sampled only twice, had diversities of 4.13 in April and 4.64 in June. Evenness values followed a pattern similar to that for the diversity. All diversity and evenness values reported during 1981 were within the range of values reported in 1980 for periphyton communities on artificial substrates with the exception of the low October values (Ecological Analysts 1981).

Many of the same periphytic taxa were observed during 1981 and 1980 (Ecological Analysts 1981), and diatoms were always the most abundant algal group during both years. However, fewer taxa were identified in 1981. Green algae and blue-green algae were less numerous in 1981, and chrysophytes, which were present in low numbers in June and August 1980, were not observed in 1981. Differences in major taxa were also noted between the two years.

4.3 SUMMARY AND CONCLUSIONS

Many of the periphytic taxa observed during 1981 in the Neosho River near the Wolf Creek Generating Station were typical of those found in alkaline rivers and streams. John Redmond Reservoir, which is upstream from the sampling locations, also influenced the periphyton composition by contributing some of the small centric diatoms which were observed. Many of these taxa were observed during past studies (Hazleton Environmental Sciences 1980; Ecological Analysts 1981), but densities, biovolumes, and composition of the major taxa differed. Problems with the artificial substrates precluded most comparisons between the sampling locations and conclusions about seasonality of the periphyton.

Hydrological conditions in the Neosho River related to variable water releases from John Redmond Reservoir has hampered the collection of periphyton samples from both natural (1973-1979) and artificial substrates (1980-1981) during environmental studies for WCGS. Periphyton has been eliminated through scouring, siltation, or desiccation depending on the flow conditions which preceded scheduled collections. Retrieved samples have provided an extensive qualitative data base for periphyton community composition and productivity but quantitative temporal and spatial information has been limited because of missed samples. Further attempts to provide this data are not felt to be warranted at this time.

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5. ZOOPLANKTON

5.1 FIELD AND ANALYTICAL PROCEDURES

Duplicate zooplankton samples were collected quarterly from the Neosho River at Locations 1, 10, and 4 (Figure 1-1). Each replicate consisted of a stationary horizontal surface sample of 0.5 to 3.0 minutes duration with a metered No. 25 mesh (64-μm aperture) plankton net with a 437-cm^2 aperture. When flow was minimal or absent, the net was towed at a speed sufficient to provide reliable flowmeter readings. The zooplankton community in the cooling lake was sampled bimonthly with bottom to surface tows utilizing a 30-cm diameter No. 25 (65-μm) mesh conical plankton net. Each sample was placed in an appropriately labeled glass jar containing menthol crystals to relax the body structure of rotifers which facilitated identification. Within one hour of collection, samples were preserved with 5 percent formalin, then transported to the laboratory for analysis.

Samples were concentrated or diluted in the laboratory to a workable density of organisms (≈100-200/ml), and thoroughly mixed to obtain a representative subsample, which was withdrawn and placed in a Bogorov counting chamber. Stratified counts of zooplankton in the subsample were made using a binocular dissecting microscope at 10-70X magnification. Difficult specimens were identified at 100-1000X with a compound microscope. All organisms were counted in the first two subsamples. As progressively larger aliquots were withdrawn, abundant taxa were eliminated from consideration. Subsampling was continued until a sufficient number of organisms was enumerated to estimate population densities, usually after counting at least 5 percent of the total sample. Subsequent to quantitative analysis of cooling lake zooplankton samples, additional aliquots were examined qualitatively to identify additional taxa. Microcrustacea were identified to species with the exception of taxonomically indistinct immature copepods and cladocerans which were identified to the lowest positive taxon. Rotifers were identified to genus, except certain littoral benthic genera in the order Bdelloidea. Identifications were made using appropriate taxonomic keys, including Brooks (1957, 1959), Wilson and Yeatman (1959), Ruttner-Kolisko (1972), Smirnov (1974), and Pennak (1978).

To determine wet, dry, and ash-free zooplankton biomass standing crop estimates in the cooling lake, four bottom to surface tows were collected at each location and placed on ice for transport to the laboratory. Each replicate was filtered by suction and blotted on paper towelling. Samples were then weighed to the nearest 0.1 milligram on a Mettler H10T balance to obtain wet weight estimates. Samples were then washed into a crucible and dried at 60 C for 24 hours to obtain dry weight values (Lovegrove 1962). Ash-free weights were determined by incinerating the sample in a muffle furnace at 500 C for 1 hour. Each parameter was expressed as mg/m^3 of water sampled.

5.2 RESULTS AND DISCUSSION

5.2.1 Neosho River

Zooplankton populations in the Neosho River were dominated by rotifers, primarily by the rotifer genera *Brachionus*, *Keratella*, *Polyarthra*, and

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Synchaeta (Table 5-1). These taxa have been dominant groups in the river since studies began in 1973 and are among the most frequently encountered rotifers in other midwestern rivers as well as throughout the United States (Williams 1966). Copepods, primarily immature forms, were numerically important throughout the year. Cyclops vernalis and Diaptomus siciloides were the most common adult copepods identified; however, both exhibited low mean densities (generally <2,500 organisms/m^3). D. siciloides has been the most common adult copepod in the river since 1973 while densities of C. vernalis have varied annually. Cladocerans, basically immature daphnids, were insignificant contributors to the mean total river population and never comprised more than 1.6 percent of the mean total zooplankton (Table 5-2). The remaining 48 taxa identified from the Neosho River (Table 5-3) generally comprised <1.0 percent of the total zooplankton standing crop (Appendix D).

Mean total zooplankton density in the tailwaters of John Redmond Reservoir (Location 1) ranged from 42,018 organisms/m^3 in April to 234,312 organisms/m^3 in October (Table 5-1). The zooplankton community in April, June, and October was dominated primarily by copepod nauplii and Keratella which, when combined, represented 81.6, 71.6, and 87.8 percent of the total zooplankton, respectively. Populations of copepod nauplii peaked at 32,208 organisms/m^3 in June while Keratella peaked at 177,308 organisms/m^3 in October. Maximum densities of the rotifers Synchaeta (49,966 organisms/m^3) and Polyarthra (11,408 organisms/m^3) at Location 1 occurred in December and when combined with copepod nauplii and Keratella accounted for 96.9 percent of the mean total zooplankton.

Annual microcrustacean density at Location 1 declined 35 percent from 1980 to 1981 (Table 5-4). This decline, which began in 1980, affected most microcrustacean taxa. The reasons for reduced microcrustacean density are obscure, but complex biotic and abiotic factors influencing John Redmond Reservoir may result in changes in zooplankton abundance. Year to year differences in reservoir water exchange rates (Brook and Woodward 1956, Tonolli 1961), predator-prey relationships between zooplankton and young of the year and juvenile fish (Johnson 1964, Thayer et al. 1974) as well as the influence of zooplankton recruitment from the discharges of upstream reservoirs (Tonolli 1955, Cowell 1970, Martin and Novotny 1977) may create annual variation in zooplankton standing crops. Dominant fish species in John Redmond Reservoir are known to feed selectively on Cyclops, Bosmina, and Daphnia in other midwest waters (Kutkuhn 1957, Cramer and Marzolf 1970) and the feeding preference for these dominant microcrustacean groups in John Redmond may partially account for the reduced microcrustacean densities observed at Location 1 during the past two years.

Zooplankton density and composition at downstream Locations 10 and 4 generally reflected the seasonal zooplankton trends at Location 1. During April, zooplankton populations at Locations 10 and 4 were dominated primarily by the rotifers Keratella, Brachionus, Synchaeta, and Polyarthra (Table 5-1). These four taxa accounted for 91.2 and 93.7 percent of the total zooplankton at Locations 10 and 4, respectively (Table 5-2). The relationship of Neosho River flows to the contribution and movement of reservoir zooplankton to the downstream locations was apparent. Low river flow in April (29 cfs) resulted

TABLE 5-1 MEAN DENSITY (No./m^3)[a] OF CODOMINANT ZOOPLANKTON IDENTIFIED FROM SAMPLES COLLECTED IN THE NEOSHO RIVER NEAR WOLF CREEK GENERATING STATION, APRIL THROUGH DECEMBER 1981

Taxa	27 APR			22 JUN			20 OCT			15 DEC		
	1	10	4	1	10	4	1	10	4	1	10	4
Copepoda	17,951	284	1,210	44,700	20,528	17,832	36,125	11,278	12,959	12,111	11,163	13,343
Nauplii	12,065	195	980	32,208	16,261	14,098	28,337	8,274	9,977	8,944	8,840	10,860
Calanoid copepodites	438	0	3	4,636	1,732	1,244	1,114	332	342	54	114	111
Cyclopoid copepodites	1,708	72	206	3,709	1,250	1,168	4,026	1,458	1,562	2,865	2,011	2,140
Cyclops vernalis	2,286	8	13	1,378	206	244	806	442	344	182	112	137
Diaptomus sicilioides	1,403	4	6	2,501	1,021	1,065	1,478	662	488	26	40	43
Cladocera	546	99	489	1,428	554	434	2,350	1,047	640	408	396	484
Daphnia spp. (immature)	286	0	0	696	195	166	1,834	807	521	274	250	282
Rotifera	23,521	29,589	40,028	41,479	25,104	18,640	195,837	64,425	77,460	112,174	102,544	125,202
Bdelloid rotifers	32	1,093	1,336	49	160	231	0	0	344	0	0	152
Brachionus spp.	946	7,067	11,384	6,295	4,416	4,939	3,096	596	1,617	80	34	51
Keratella spp.	23,352	12,532	11,512	30,500	17,866	11,404	177,308	58,289	66,462	50,442	46,036	57,855
Polyarthra spp.	165	1,982	6,665	1,318	906	590	1,238	530	570	11,408	9,010	9,846
Synchaeta spp.	0	5,745	7,962	98	276	193	12,764	3,728	7,076	49,966	47,396	56,992
Total Zooplankton	42,018	29,972	41,727	87,607	46,186	36,906	234,312	76,750	91,059	124,693	114,103	139,029

[a] Mean of two replicates.

TABLE 5-2 PERCENT COMPOSITION OF DOMINANT ZOOPLANKTON IDENTIFIED FROM SAMPLES COLLECTED IN THE NEOSHO RIVER NEAR WOLF CREEK GENERATING STATION, APRIL THROUGH DECEMBER 1981

Taxa	27 APR			22 JUN			20 OCT			15 DEC		
	1	10	4	1	10	4	1	10	4	1	10	4
Copepoda	42.7	0.9	2.9	51.0	44.4	48.3	15.4	14.7	14.2	9.7	9.8	9.6
Nauplii	28.7	0.6	2.4	36.8	35.2	38.2	12.1	10.8	11.0	7.2	7.7	7.8
Calanoid copepodites	1.0	0	<0.1	5.3	3.8	3.4	0.5	0.4	0.4	<0.1	0.1	0.1
Cyclopoid copepodites	4.0	0.2	0.5	4.2	2.7	3.2	1.7	1.9	1.7	2.3	1.8	1.5
Cyclops vernalis	5.4	<0.1	<0.1	1.6	0.4	0.7	0.3	0.6	0.4	0.1	0.1	0.1
Diaptomus siciloides	3.3	<0.1	<0.1	2.9	2.2	2.9	0.6	0.9	0.5	<0.1	<0.1	<0.1
Cladocera	1.3	0.3	1.2	1.6	1.2	1.2	1.0	1.4	0.7	0.3	0.3	0.3
Daphnia spp. (immature)	0.7	0	0	0.8	0.4	0.4	0.8	1.1	0.6	0.2	0.2	0.2
Rotifera	56.0	98.7	95.9	47.3	54.4	50.5	83.6	83.9	85.1	90.0	89.9	90.1
Bdelloid rotifers	0.1	3.6	3.3	0.1	0.3	0.6	0	0	0.4	0	0	0.1
Brachionus spp.	2.2	23.6	28.4	7.2	9.6	13.4	1.3	0.8	1.8	0.1	<0.1	<0.1
Keratella spp.	53.2	41.8	28.8	34.8	38.7	30.9	75.7	75.9	72.9	40.5	40.3	41.6
Polyarthra spp.	0.4	6.6	16.6	1.5	2.0	1.6	0.5	0.7	0.6	9.1	7.9	7.1
Synchaeta spp.	0	19.2	19.9	0.1	0.6	0.5	5.4	4.9	7.8	40.1	41.5	41.0

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TABLE 5-3 QUALITATIVE DISTRIBUTION OF ZOOPLANKTON TAXA IN THE NEOSHO RIVER AND COOLING LAKE (LOCATIONS 2, 6) NEAR WOLF CREEK GENERATING STATION, KANSAS, FEBRUARY THROUGH DECEMBER 1981

	Neosho River	Cooling Lake	
		2	6
COPEPODA			
Nauplii	X	X	X
Calanoid copepodites	X	X	X
Cyclopoid copepodites	X	X	X
Cyclops bicuspidatus thomasi Forbes	X	X	X
Cyclops varicans rubellus Lilljeborg	X	X	X
Cyclops vernalis Fischer	X	X	X
Diaptomus clavipes Schacht	X	X	X
Diaptomus pallidus Herrick	X	X	X
Diaptomus siciloides Lilljeborg	X	X	X
Eucyclops agilis (Koch)	X	X	
Ergasilus sp. Nordmann	X		X
Ergasilus chautauquaensis Fellows	X	X	X
Harpacticoid copepods	X		X
Mesocyclops edax (Forbes)	X	X	X
Tropocyclops prasinus (Fischer)	X	X	
CLADOCERA			
Alona spp. Baird	X		
Alona circumfimbriata Megard	X	X	X
Bosmina longirostris (O.F. Muller)	X	X	X
Ceriodaphnia spp. (immature)	X	X	
Ceriodaphnia quadrangula (O.F. Muller)	X	X	X
Ceriodaphnia rigaudi Richard		X	
Ceriodaphnia reticulata (Jurine)		X	X
Chydorus sphaericus (O.F. Muller)	X	X	X
Daphnia spp. (immature)	X	X	X
Daphnia ambigua Scourfield		X	X
Daphnia galeata mendotae Birge			X
Daphnia parvula Fordyce	X	X	X
Daphnia pulex Leydig		X	X
Daphnia retrocurva Forbes	X	X	X
Diaphanosoma brachyurum (Lieven)	X		
Diaphanosoma leuchtenbergianum Fischer	X	X	X
Disparalona rostrata (Koch)	X		
Ilyocryptus sordidus (Lieven)	X		
Kurzia latissima (Kurz)		X	
Leptodora kindtii (Focke)	X	X	X
Leydigia acanthocercoides (Fischer)	X		
Leydigia leydigi (Schoedler)	X	X	
Macrothrix laticornis (Jurine)	X	X	
Moina micrura Kurz	X	X	
Moina minuta Hansen		X	
Moina wierzejskii Richard	X		
Pleuroxus denticulatus Birge	X		
Pleuroxus hamulatus Birge	X	X	
Simocephalus sp. Schodler	X		

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TABLE 5-3 (CONT.)

	Neosho River	Cooling Lake 2	Cooling Lake 6
CLADOCERA (CONT.)			
Simocephalus expinosus (Koch)			X
Simocephalus serrulatus (Koch)			X
Simocephalus vetulus (O.F. Muller)			X
ROTIFERA			
Anuraeopsis sp. Lauterborn	X		
Asplanchna spp. Gosse	X	X	X
Bdelloid rotifers	X	X	
Brachionus spp. Pallas	X	X	X
Cephalodella spp. Bory St. Vincent	X	X	
Chromogaster sp. Lauterborn			X
Collotheca sp. Harring	X	X	X
Colurella sp. Bory St. Vincent	X		
Conochiloides sp. Hlava		X	X
Conochilus sp. Hlava		X	X
Filinia spp. Bory St. Vincent	X	X	X
Hexarthra spp. Schmarda	X	X	X
Kellicottia spp. Ahlstrom	X	X	
Keratella spp. Bory St. Vincent	X	X	X
Lepadella spp. Bory St. Vincent	X	X	X
Lophocharis sp. Ehrenberg		X	
Monostyla spp. Ehrenberg	X	X	
Mytilina sp. Bory St. Vincent	X		X
Platyias sp. Harring			X
Ploesoma sp. Herrick		X	
Polyarthra spp. Ehrenberg	X	X	X
Pompholyx sp. Gosse	X		X
Rotaria sp. Scopoli	X		
Synchaeta spp. Ehrenberg	X	X	X
Testudinella sp. Bory St. Vincent		X	
Trichocerca spp. Lamarck	X	X	X
Trichotria sp. Bory St. Vincent	X		
Tripleuchlanis sp. Myers	X		

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in statistically different microcrustacean densities among locations ($F_{2,3}$ = 22.82; $P \leq 0.05$) and a mean 48-fold decrease in density from Location 1 to Location 10. The decrease in abundance was evidenced by the apparent loss of limnetic reservoir taxa present at Location 1 such as Bosmina longirostris, immature daphnids, Daphnia parvula, Diaptomus siciloides, and Cyclops vernalis (Table 5-1). Low river flow apparently prevents effective downstream movement of reservoir zooplankton taxa and downstream populations may be characterized as remnant reservoir populations augmented with taxa resulting from autochthonous production. Autochthonous production has been noted at Locations 4 and 10 in previous studies of the Neosho River (Repsys 1978, 1979b, Rogers 1980, Ecological Analysts 1981). There was a subsequent 4-fold increase in microcrustacean density between Locations 10 and 4 in April, which was due to apparent production of littoral cladoceran taxa such as the Alonids and Chydorus sphaericus and the rotifers Brachionus, Polyarthra, Synchaeta, and Bdelloid rotifers. Microcrustacean production between the downstream Locations 10 and 4 has been most apparent during low river flow and has been related to habitat differences among locations.

During each sampling period dominant taxa were similar between locations although zooplankton abundance generally decreased downstream (Table 5-1). The most dramatic reduction usually occurred during periods of low water releases from John Redmond Reservoir. These downstream decreases have been observed during past Neosho River studies and have been documented by Ward (1975) and Armitage and Capper (1976) for river-reservoir systems in Colorado and Wales. Reservoir discharge (cfs) and annual microcrustacean density was significantly correlated at Locations 10 ($r = +.9330$; $P \leq 0.05$) and 4 ($r = +.9328$; $P \leq 0.05$) suggesting that as flow increased more organisms were transported downstream. Conversely, when a low flow regime exists, reservoir zooplankton decrease in abundance downstream and apparent autochthonous zooplankton production increases.

During June, immature copepods and the rotifers Keratella and Brachionus together composed 83.5 and 82.5 percent of the total zooplankton at Locations 10 and 4, respectively. High river flow (2,367 cfs) resulted in no significant differences in total microcrustacean density among locations ($F_{2,3} = 7.08$; $P > 0.05$); however, all major taxa decreased in abundance at the downstream locations.

Mean total zooplankton at downstream locations increased 10-fold from June to October and reached maximum annual densities in December (Table 5-1). Immature copepods and Keratella comprised the majority of zooplankton in October while Synchaeta combined with the former two groups to represent 98 percent of total zooplankton in December (Table 5-2). There was no significant difference in total microcrustacean density among locations in December ($F_{2,3} = 1.46$; $P > 0.05$) which corresponded to relatively high river flow (1,620 cfs).

Construction of the Wolf Creek Generating Station has had no apparent effect on the zooplankton community in the Neosho River. Zooplankton species composition closely resembled that present during previous years. Although mean annual microcrustacean densities declined during the past two years, the reductions were related to factors independent of construction activities.

TABLE 5-4 ANNUAL MEAN DENSITIES (No./m^3) OF SELECTED MAJOR MICROCRUSTACEAN TAXA FROM JOHN REDMOND RESERVOIR (LOCATION 1), 1973 THROUGH 1981

Taxa	Year 1973	1974	1975	1976	1977	1978	1979	1980	1981
Copepoda									
Calanoid (*Diaptomus*) copepodites	2,635	6,948	8,963	1,698	4,903	5,447	6,376	3,614	1,560
Cyclopoid copepodites	2,546	6,558	9,006	13,182	16,978	21,601	23,220	4,242	3,077
Cyclops vernalis	284	597	443	976	1,106	1,432	1,750	1,400	1,163
Diaptomus pallidus	17[a]	1,006	48	316	266	390	878	339	90
Diaptomus siciloides	1,418[a]	1,171	3,458	1,014	2,502	5,110	6,772	4,529	1,352
All adult *Diaptomus* spp.	2,591	2,177	3,508	1,330	2,810	5,501	7,650	4,879	1,499
Ergasilus chautauquaensis	133	39	756	282	217	154	97	110	16
Total Copepoda[b]	8,188	16,319	22,676	17,468	26,014	34,135	39,093	14,245	8,757
Cladocera									
Bosmina longirostris	4,509	4,247	10,580	20,980	14,923	30,484	7,584	129	90
Ceriodaphnia spp.[c]	1,022	2,483	130	11	28	17	53	0	2
Daphnia parvula	1,271	2,095	2,870	3,547	3,333	1,134	3,889	190	113
All *Daphnia* spp.[d] (juveniles and adults)	14,413	5,089	3,994	3,579	3,343	1,857	7,955	979	928
Diaphanosoma leuchtenbergianum	3,032	2,759	8,418	3,344	4,877	1,391	3,952	14	50
Moina spp.[e]	163	205	7,484	259	1,102	1,921	649	0	8
Total Cladocera[b]	23,139	14,783	30,943	28,173	24,273	35,670	24,082	1,312	1,191
Total microcrustaceans[b]	31,327	31,102	53,619	45,641	50,287	69,805	63,175	15,367	9,948

(a) Males only. Females not identified to species in 1973.
(b) Includes the above selected taxa only.
(c) Mainly *C. lacustris*.
(d) Mainly juveniles and adults of *D. parvula*.
(e) Mainly *M. micrura*.

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5.2.2 Cooling Lake

Sixty taxa representing 41 genera were identified from the cooling lake during 1981 (Table 5-3). All taxa with the exception of Ceriodaphnia rigaudi and Daphnia retrocurva have been recently identified from John Redmond Reservoir and the Neosho River. C. rigaudi has been reported in Kansas (Prophet and Waite 1974) although its distribution has generally been restricted to the southern United States (Brooks 1957; Pennak 1978). D. retrocurva has been identified in Kansas (C. Prophet, personal communication, Emporia State University, Emporia, Kansas) although it occurs seasonally and is never abundant. Dominant taxa were similar between Locations 2 and 6; however, diversity was slightly greater at Location 2 (52 taxa) when compared to Location 6 (45 taxa). Location 2 represented a littoral habitat (≈3 meters depth) conducive to zooplankton production and greater diversity (Hutchinson 1967), whereas Location 6 affords a limnetic habitat (≈10-15 meters depth) less desirable for establishment of a diverse zooplankton assemblage.

Mean annual zooplankton density in the cooling lake was 401,494 organisms/m^3 with a range from 72,160 organisms/m^3 to 1,134,196 organisms/m^3 at Location 6 in August and February, respectively (Table 5-5). Rotifers, primarily Keratella and Polyarthra and copepod nauplii combined to represent 89.3 percent of the annual zooplankton standing crop (Table 5-6). Excluding the February collection, annual total zooplankton density was almost 2-fold higher at Location 2 than at Location 6 due to apparent higher littoral zooplankton production.

Zooplankton population densities are usually high during initial impoundment and filling of new reservoirs. Recently inundated areas favor the transport of suspended and dissolved materials into the reservoir ecosystem which promotes primary and secondary (zooplankton) production (Rodhe 1964, Applegate and Mullen, 1967). The mean annual copepod (148,526 organisms/m^3) and cladoceran (7,026 organisms/m^3) densities in the cooling lake fell within the range of densities reported for these groups in other midwestern reservoirs. Mean annual rotifer densities in the cooling lake (annual mean of 245,946 organisms/m^3) appeared similar to or slightly lower than in other reservoirs.

The mean annual dry-weight biomass in the cooling lake was 155.8 mg/m^3 and ranged from 29.2 to 337.8 mg/m^3 at Location 6 in October and February, respectively (Table 5-7). The mean biomass at Locations 2 and 6 on comparable sampling dates was 156.6 mg/m^3 and 110.7 mg/m^3, respectively. The difference in biomass between locations was reflected by the almost 2-fold higher zooplankton density at Location 2 than at Location 6. A correlation between total zooplankton abundance and dry weight biomass was evident (Figure 5-1) although the relationship was not statistically significant ($r = +.754$; $P > 0.05$). Biomass normally increases when zooplankton density increases (Cowell 1967). However, this trend was not consistently observed in the cooling lake. Disparity in the relationship between density and biomass indicates that the biomass estimates may be biased due to substantial amounts of phytoplankton that were encountered seasonally and retained with the No. 25 netting. The weight bias may be negated by use of a No. 10

TABLE 5-5 DENSITY (No./m^3) OF DOMINANT ZOOPLANKTON IDENTIFIED FROM SAMPLES COLLECTED IN THE COOLING LAKE NEAR WOLF CREEK GENERATING STATION, FEBRUARY THROUGH DECEMBER 1981

Taxa	23 FEB		28 APR		23 JUN		25 AUG		19 OCT		16 DEC		Mean Total	
	2[a]	6	2	6	2	6	2	6	2	6	2	6	2	6
Copepoda	-	214,420	132,989	85,376	508,013	85,529	49,785	59,720	124,537	51,509	160,710	114,510	195,207	101,844
Nauplii	-	163,488	84,888	66,560	386,630	60,352	36,000	42,400	84,044	38,784	142,727	95,982	146,858	77,928
Calanoid copepodites	-	3,301	1,792	2,880	28,917	4,715	6,650	12,000	4,081	269	1,072	786	8,502	3,992
Cyclopoid copepodites	-	22,794	22,636	11,008	67,896	11,316	4,655	1,080	17,264	6,128	12,624	11,651	25,015	10,663
Diaptomus siciloides	-	15,248	6,885	3,328	19,487	4,526	1,700	2,480	11,928	2,626	476	1,867	8,095	5,012
Cladocera	-	943	1,509	6,976	8,110	34,609	6,180	5,520	6,593	3,232	3,334	2,162	5,145	8,907
Bosmina longirostris	-	629	1,132	192	1,132	15,371	60	0	0	0	834	344	632	2,756
Daphnia spp. (immature)	-	0	283	3,712	4,149	11,882	240	2,080	3,767	741	1,310	393	1,950	3,135
Diaphanosoma spp.	-	0	0	0	472	472	5,080	2,400	942	741	0	0	1,299	614
Rotifera	-	918,833	233,159	960	104,984	28,291	57,902	6,920	408,918	290,476	375,554	289,248	236,103	255,788
Brachionus spp.	-	8,803	943	0	25,145	472	7,182	560	4,944	0	0	0	7,643	1,639
Conochilofdes spp.	-	91,176	0	0	1,259	15,842	1,330	0	1,412	0	0	0	800	17,836
Keratella spp.	-	144,624	226,368	896	35,202	4,244	4,655	2,040	275,438	149,480	146,776	144,624	137,688	74,318
Polyarthra spp.	-	669,672	2,830	0	8,803	3,583	18,800	2,800	29,662	46,460	153,862	102,966	42,791	137,580
Pompholyx spp.	-	0	0	0	10,689	0	0	440	9,888	11,312	0	0	4,115	1,959
Synchaeta spp.	-	629	2,358	64	627	0	11,039	160	81,925	81,608	74,906	40,872	34,171	25,556
Total Zooplankton	-	1,134,196	367,657	93,296	621,107	148,429	113,867	72,160	540,048	345,217	539,588	405,920	436,453	366,536

Note: Densities based on a single monthly sample from each location.

[a] Not collected.

TABLE 5-6 PERCENT COMPOSITION OF DOMINANT ZOOPLANKTON IDENTIFIED FROM SAMPLES COLLECTED IN THE COOLING LAKE NEAR WOLF CREEK GENERATING STATION, FEBRUARY THROUGH DECEMBER 1981

Taxa	23 FEB		28 APR		23 JUN		25 AUG		19 OCT		16 DEC		Mean	
	2[a]	6	2	6	2	6	2	6	2	6	2	6	2	6
Copepoda	-	18.9	36.2	91.5	81.8	57.6	43.7	82.8	23.1	14.9	29.8	28.2	44.7	27.8
Nauplii	-	14.4	23.1	71.3	62.2	40.7	31.6	58.8	15.6	11.2	26.4	23.6	33.6	21.3
Calanoid copepodites	-	0.3	0.5	3.1	4.7	3.2	5.8	16.6	0.8	0.1	0.2	0.2	1.9	1.1
Cyclopoid copepodites	-	2.0	6.2	11.8	10.9	7.6	4.1	1.5	3.2	1.8	2.3	2.9	5.7	2.9
Diaptomus siciloides	-	1.3	1.9	3.6	3.1	3.0	1.5	3.4	2.2	0.8	<0.1	0.5	1.9	1.4
Cladocera	-	0.1	0.4	7.5	1.3	23.3	5.4	7.6	1.2	0.9	0.6	0.5	1.2	2.4
Bosmina longirostris	-	<0.1	0.3	0.2	0.2	10.4	0.1	0	0	0	0.2	0.1	0.1	0.8
Daphnia spp. (immature)	-	0	0.1	4.0	0.7	8.0	0.2	2.9	0.7	0.2	0.2	0.1	0.4	0.9
Diaphanosoma spp.	-	0	0	0	0.1	0.3	4.5	3.3	0.2	0.2	0	0	0.3	0.2
Rotifera	-	81.0	63.4	1.0	16.9	19.1	50.8	9.6	75.7	84.1	69.6	71.3	54.1	69.8
Brachionus spp.	-	0.8	0.3	0	4.0	0.3	6.3	0.8	0.9	0	0	0	1.8	0.4
Conochiloides spp.	-	8.0	0	0	0.2	10.7	1.2	0	0.3	0	0	0	0.2	4.9
Keratella spp.	-	12.7	61.6	1.0	5.7	2.9	4.1	2.8	51.0	43.3	27.2	35.6	31.5	20.4
Polyarthra spp.	-	59.0	0.8	0	1.4	2.4	16.5	3.9	5.5	13.4	28.5	25.4	9.8	37.5
Pompholyx spp.	-	0	0	0	1.7	0	0	0.6	1.8	3.3	0	0	0.9	0.5
Synchaeta spp.	-	<0.1	0.6	0.1	0.1	0	9.7	0.2	15.2	23.6	13.9	10.1	7.8	7.0

(a) Not collected.

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TABLE 5-7 MEAN BIOMASS ESTIMATES[a] FOR ZOOPLANKTON COLLECTED IN THE COOLING LAKE (LOCATIONS 2 AND 6) NEAR WOLF CREEK GENERATING STATION, FEBRUARY THROUGH DECEMBER, 1981

Date/Location		Wet Weight	Dry Weight	Ash-free Weight
23 FEB				
	2[b]	-	-	-
	6	1,859.8	337.8	337.7
28 APR				
	2	1,476.3	227.6	195.2
	6	888.7	142.8	127.1
23 JUN				
	2[c]	593.7	92.4	56.2
	6[c]	794.8	100.5	61.6
25 AUG				
	2	1,497.2	205.2	169.0
	6	953.4	153.1	108.2
19 OCT				
	2	426.0	86.4	55.4
	6	176.3	29.2	26.3
16 DEC				
	2[c]	754.6	171.4	112.8
	6	558.0	127.9	99.4
Mean Annual				
	2	791.3	156.6	117.7
	6	871.8	155.2	126.7
	Mean	835.2	155.8	122.6

(a) Each parameter expressed in mg/m^3.
(b) Not collected, location not inundated.
(c) Data based on three replicates.

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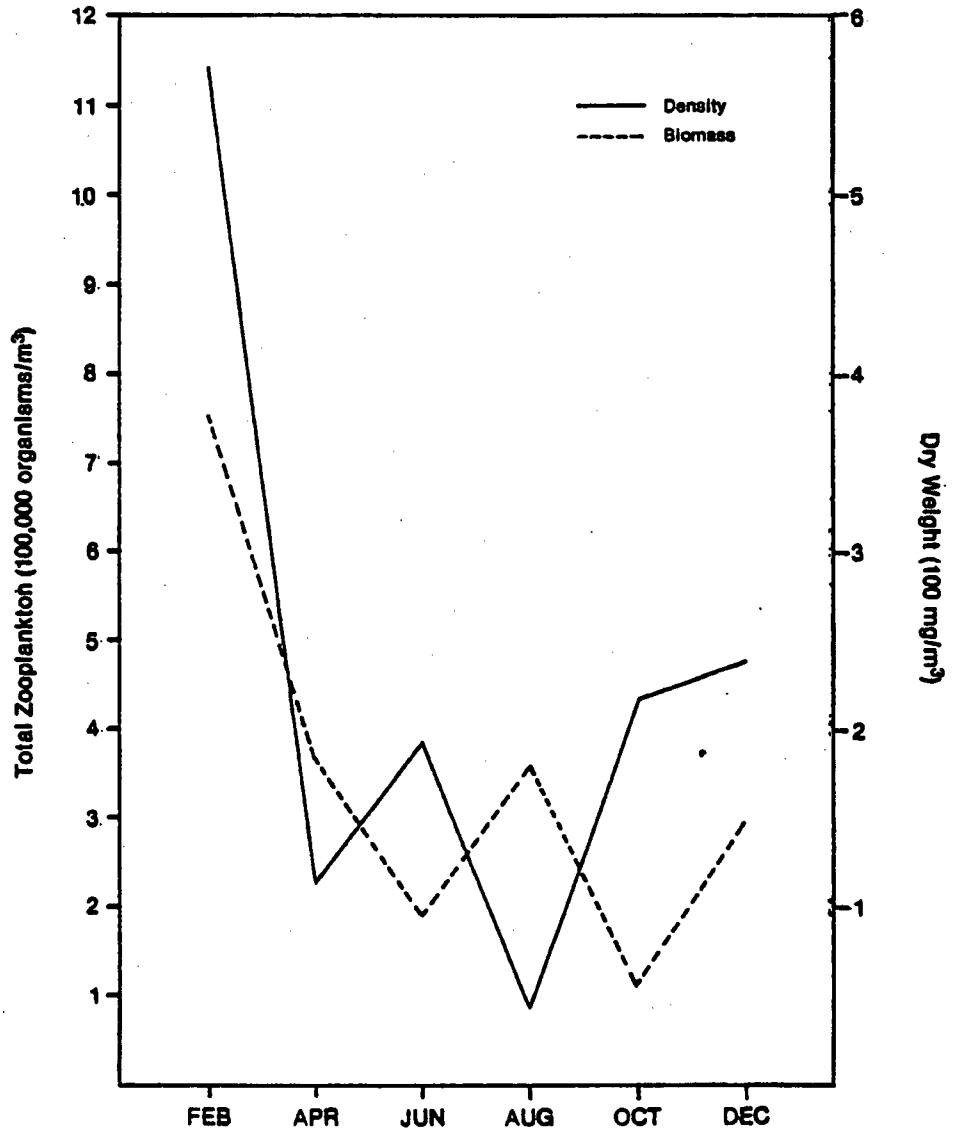

Figure 5-1. Comparison of total zooplankton density and dry weight estimates from the cooling lake for Wolf Creek Generating Station, 1981.

(164-μm) net which should exclude most phytoplankton taxa from biomass samples. Utilization of the No. 10 net would also eliminate most rotifers from biomass estimates; however, rotifers often comprise a small portion of the total zooplankton biomass (Kasymov et al. 1972; Pederson et al. 1976). The resulting relationship between microcrustacean density and biomass is usually well-defined (Cowell 1967) and may provide more reliable biomass estimates for comparison with other reservoirs.

5.3 SUMMARY AND CONCLUSIONS

Zooplankton densities in the tailwaters of John Redmond Reservoir ranged from 42,018/m^3 in April to 234,312/m^3 in October. The community was dominated by rotifers, primarily the genera Brachionus, Keratella, Polyarthra, and Synchaeta. These taxa have been important components in the river zooplankton community during past studies. Immature copepods were seasonally important comprising 42.7 percent and 51.0 percent in April and June, respectively. Principal adult copepods included Cyclops vernalis and Diaptomus siciloides although both generally comprised less than five percent of the mean total zooplankton standing crop. Cladocerans were unimportant contributors to the total zooplankton assemblage in the tailwaters never comprising more than 1.6 percent of the total zooplankton. Immature daphnids accounted for the majority of cladocerans identified. Mean microcrustacean densities in the tailwaters continued to decline during the current study. The reduced densities are probably not related to construction activities at WCGS, but to several biotic and abiotic factors including water exchange rates, food supply, fish predation and the influence of zooplankton recruitment from upstream reservoirs which result in year-to-year variations in zooplankton abundance.

Zooplankton densities generally decreased at downstream Locations 10 and 4 which followed trends established during past studies. A relationship between reservoir water discharge and mean total zooplankton density at the downstream locations was evident although it was not statistically significant ($P > 0.05$). As river flows were increased, reservoir zooplankton were transported downstream resulting in similar zooplankton densities among locations. Decreases in zooplankton abundance were most apparent during periods of low reservoir discharge. Apparent autochthonous zooplankton production occurred between downstream locations when river flows were low since pools conducive to zooplankton production were formed. This resulted in the appearance of several littoral taxa not present in the tailwaters of John Redmond Reservoir.

Mean total annual zooplankton density in the cooling lake was 401,494/m^3. The zooplankton community followed normal seasonal variations in abundance with highest densities observed in early spring and lowest densities occurring in the summer. Rotifers, primarily Keratella and Polyarthra and immature copepods combined to account for over 89 percent of the mean yearly zooplankton standing crop. Sixty-five taxa including 6 copepod, 12 cladoceran, and 23 rotifer genera were identified. Zooplankton abundance and taxa diversity were higher at Location 2 than at Location 6 due primarily to the littoral habitat at Location 2 when compared to the limnetic habitat at Location 6. The mean annual zooplankton dry-weight biomass was 155.8 mg/m^3 with a range from 29.2 mg/m^3 to 337.8 mg/m^3 at Location 6 in October and February, respectively.

55c

Nalco Environmental Sciences,1976. Final Report of Preconstruction Environmental Monitoring Program WCGS, March 1975 - February 1976.

NALCO ENVIRONMENTAL SCIENCES
4010 NORTHWEST 39TH ST., BLDG. 1374 ▫ LINCOLN, NEB. 68524 ▫ AREA 402-799-2411

NALCO CHEMICAL COMPANY

REPORT TO

KANSAS GAS & ELECTRIC COMPANY
WICHITA, KANSAS

FINAL REPORT OF PRECONSTRUCTION ENVIRONMENTAL MONITORING PROGRAM WOLF CREEK GENERATING STATION

MARCH 1975 - FEBRUARY 1976
PROJECT NO. 5501-06814

PREPARED AND SUBMITTED
BY
NALCO ENVIRONMENTAL SCIENCES

Report approved by:

H. S. Lewis
Manager
Lincoln, Nebraska Laboratory

B. G. Johnson
General Manager

14 May 1976

ECOLOGICAL ANALYSTS, INC.

221 OAKCREEK DRIVE, WESTGATE PARK, LINCOLN, NEBRASKA 68528 □ (402) 476-3766

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Mr. Gene Rathbun, Senior Engineer
Kansas Gas and Electric Company
201 N. Market
Post Office Box 208
Wichita, Kansas 67201

Dear Gene:

Enclosed find a copy of the 1976 Final Report of the preconstruction environmental monitoring program for Wolf Creek Generating Station (NALCO Environmental Sciences Project No. 5501-06814). I sent a copy to Gordon Edison at the NRC's Bethesda Office on 16 April 1981.

We retain photo-reading copies of all reports submitted to KG&E. If in the future you should require additional copies, we could provide you with a cost estimate to print and bind past reports.

Sincerely,

Ron King

Ronald G. King
Project Manager

RGK/dm

Enclosure

TABLE OF CONTENTS

Chapter		Page
	PREFACE	ii
	LIST OF FIGURES	iii
	LIST OF TABLES	vi
1.	INTRODUCTION Darell L. Andersen	1
2.	VEGETATION MONITORING Warren J. Buchanan, Jr.	4
3.	WILDLIFE MONITORING Joseph Suchecki and Mel S. Schamberger	34
4.	WATER QUALITY STUDY David J. Byrnes	74
5.	PHYTOPLANKTON STUDIES Edward W. Wilde and Steven D. Reetz	124
6.	PERIPHYTON STUDY James R. Farrell	150
7.	ZOOPLANKTON STUDY Andrew J. Repsys	167
8.	BENTHOS STUDY Darell L. Andersen	192
9.	FISHERIES STUDY Donald C. Szmania	230

Appendices

A.	VEGETATION MONITORING	A-1
B.	WILDLIFE MONITORING	A-10
C.	WATER QUALITY STUDY	A-46
D.	PHYTOPLANKTON STUDIES	A-58
E.	PERIPHYTON STUDY	A-144
F.	FISHERIES STUDY	A-161

PREFACE

This second preconstruction environmental monitoring program for the proposed Wolf Creek Generating Station was conducted from March 1975 through February 1976. The study followed recommendations for the Preconstruction Monitoring Phase presented in subsection 6.1.1.2.2.1 of the Wolf Creek Generating Station Environmental Report. Federal and State comments on the Wolf Creek Environmental Report were reviewed and design changes were incorporated to make improvements over the initial preconstruction program.

The staff of Nalco Environmental Sciences comprised the study group for data acquisition and preparation of this report. The study was directed by D. L. Andersen, Associate Biologist, Aquatic Ecology. H. S. Lewis, Manager, Lincoln, Nebraska Laboratory served as senior advisor for the study program and he and Dr. G. W. Wadley provided the critical review of this manuscript. Dr. G. W. Wadley, Technical Manager, Northbrook, Illinois, was responsible for overall coordination of the program.

LIST OF FIGURES

No.	Caption	Page
2.1	Vegetation sampling locations in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1975	18
2.2	Schematic representation of nested quadrat layout for sampling vegetation in a floodplain woods in the vicinity of the proposed Wolf Creek Generating Station, Burlington, Kansas	19
2.3	Similarity between 1974 and 1975 preoperational monitoring data based on coefficients of community for each plant community sampled in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas	20
3.1	Wildlife sampling locations in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1975	50
3.2	Bird species diversity in four communities in the vicinity of the Wolf Creek Generating Station site, Burlington, Kansas, May 1975-January 1976	51
4.1	Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	91
4.2	Precipitation recorded at the John Redmond Dam, 1975 (U. S. Army, Corps of Engineers 1975)	92
4.3	Hydrological conditions including reservoir storage volume, reservoir inflow and outflow for John Redmond Reservoir, 1975 (U. S. Army, Corps of Engineers 1975)	93
4.4	Water temperature and dissolved oxygen concentrations recorded in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975	94
4.5	Total alkalinity concentrations and pH measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975	95
4.6	Filtrable residue and specific conductance measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975	96
4.7	Relationship between filtrable residue and specific conductance in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975	97
4.8	Nonfiltrable residue and turbidity concentrations measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975	98

LIST OF FIGURES (continued)

No.	Caption	Page
4.9	Relationships between nonfiltrable residue, turbidity, and color in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975	99
4.10	Ammonia and nitrate concentrations measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975	100
4.11	Total organic nitrogen and total organic carbon concentrations measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975	101
4.12	Biochemical oxygen demand and chemical oxygen demand concentrations measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975	102
4.13	Relationships between biochemical oxygen demand (BOD) and chemical oxygen demand (COD) and between COD and total organic carbon (TOC) in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975	103
4.14	Total manganese and iron concentrations measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975	104
4.15	Relationships between total iron, total manganese, and filtrable residue in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975	105
5.1	Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	136
5.2	Seasonal and year-to-year variations of phytoplankton in John Redmond Reservoir (Location 1) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, spring, summer, fall and winter 1973, 1974 and 1975	137
5.3	Seasonal and year-to-year variations of phytoplankton in the Neosho River (mean of Locations 4 and 10) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, spring, summer, fall and winter 1973, 1974 and 1975	138
5.4	Seasonal and year-to-year variation of phytoplankton in Wolf Creek (mean of Locations 2, 3, 5 and 7) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, spring, summer, fall and winter 1973, 1974 and 1975	139
5.5	Total phytoplankton density compared with rainfall in the 30 days prior to sampling in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, spring, summer, fall and winter 1973, 1974 and 1975	140

LIST OF FIGURES (continued)

No.	Caption	Page
6.1	Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	161
7.1	Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	178
8.1	Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	206
8.2	Hydrological conditions including reservoir storage volume, reservoir inflow and outflow for John Redmond Reservoir, 1975 (U. S. Army, Corps of Engineers 1975)	207
8.3	Precipitation recorded at the John Redmond Dam, 1975 (U. S. Army, Corps of Engineers 1975)	208
9.1	Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	240
9.2	Hydrological conditions including reservoir storage volume, reservoir inflow and outflow for John Redmond Reservoir, 1975 (U. S. Army, Corps of Engineers 1975)	241

LIST OF TABLES

No.	Caption	Page
2.1	Phytosociological data summary of trees in a floodplain woods, Community 1, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June 1975	21
2.2	Phytosociological data summary of saplings in a floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1975	22
2.3	Phytosociological data summary of species in the shrub stratum of a floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1975	23
2.4	Frequency of species in the ground layer and average ground layer cover in a floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June and September 1975	24
2.5	Density (stems per hectare) of saplings and trees by diameter classes in a floodplain woods, Community 1, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June 1975	25
2.6	Primary productivity and biomass of representative plant communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June and November 1975	26
2.7	Comparisons of vegetation data from four representative plant communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973, 1974, and 1975	27
2.8	Frequency of species in the ground layer and average ground layer cover in an abandoned railroad right-of-way, Community 2, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June and September 1975	28
2.9	Frequency of species in the ground layer and average ground layer cover in an open pasture, Community 3, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June and September 1975	29
2.10	Phytosociological data summary of species in the shrub stratum of a mixed shrub-grass pasture, Community 4, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June 1975	31
2.11	Frequency of species in the ground layer and average ground layer cover in a mixed shrub-grass pasture, Community 4, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June and September 1975	32

LIST OF TABLES (continued)

No.	Caption	Page
3.1	Number of trapnights, captures, species and small mammal individuals in four communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	52
3.2	Species list and number of small mammal captures in four communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June, September, 1975	53
3.3	Incidental mammal observations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	54
3.4	Monthly summary of number of original captures for small mammal species and each community in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	55
3.5	Density calculations for *Peromyscus leucopus* using mark-recapture data from a floodplain woods in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	36
3.6	Comparison of small mammal capture data from four communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1974-1975	57
3.7	Number of squirrels sighted during 20-minute observation periods at four sites in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 20-21 January 1976	58
3.8	Species list, residency status, and community and monthly occurrence of avifauna in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975-1976	59
3.9	Number per hour and relative abundance of avifauna observed in four communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975-1976	63
3.10	Number of species, birds per hour, and species diversity of avifauna recorded by month in four communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975-1976	66
3.11	Comparison of the numbers of species, birds per hour, and species diversity of the avifauna recorded on a floodplain woods community in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1974-1975	67
3.12	Comparison of the number of species, birds per hour, and species diversity of the avifauna recorded on the abandoned railroad right-of-way community in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1974-1975	68

LIST OF TABLES (continued)

No.	Caption	Page
3.13	Comparison of the number of species, birds per hour, and species diversity of the avifauna recorded on an open pasture community in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1974-1975	69
3.14	Comparison of the number of species, birds per hour, and species diversity of the avifauna recorded on the mixed shrub-grass pasture community in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1974-1975	70
3.15	Comparison of the number of species and individuals observed along a 20-mile survey route in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973, 1974, 1975	71
3.16	Quail call counts and dove observations along a 20-mile census route in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	72
3.17	Reptile and amphibian observations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	73
4.1	Physical measurements and instrumentation used in this study	106
4.2	Water quality parameters measured in surface water samples	107
4.3	Water quality parameters measured in groundwater samples in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas	108
4.4	Methods for analyses of water quality parameters	109
4.5	Numerical water quality criteria for Kansas surface waters	112
4.6	Summary of minimum, maximum and mean values for quality data in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1975	113
4.7	Mean water quality data from John Redmond Reservoir, 1973-75	116
4.8	Mean water quality data from the Neosho River upstream and downstream of the confluence with Wolf Creek, 1973-75	118
4.9	Mean water quality data from Wolf Creek, 1973-75	121
5.1	Phytoplankton density and percent composition of major algal groups in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, April, June, September and December 1975	141

LIST OF TABLES (continued)

No.	Caption	Page
5.2	Phytoplankton biovolume and percent composition of major algal groups in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, April, June, September and December 1975	142
5.3	Taxa which comprised 5% or more of the total phytoplankton density or biovolume of sampling locations near the Wolf Creek Generating Station, Burlington, Kansas, April, June, September and December 1975	143
5.4	Shannon's species diversity indices for phytoplankton collected in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, April, June, September and December 1975	144
5.5	Summary of one-way ANOVA with Tukey's multiple comparisons showing significant differences among phytoplankton populations at sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 16 April 1975	145
5.6	Summary of one-way ANOVA with Tukey's multiple comparisons showing significant differences among phytoplankton populations at sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 10 June 1975	146
5.7	Summary of one-way ANOVA with Tukey's multiple comparisons showing significant differences among phytoplankton populations at sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 9 September 1975	147
5.8	Summary of one-way ANOVA with Tukey's multiple comparisons showing significant differences among phytoplankton populations at sampling locations in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 3 December 1975	148
5.9	Mean carbon fixation rate and chlorophyll a concentration for phytoplankton samples collected in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1975	149
6.1	Percent composition by algal division of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	162
6.2	Periphytic algal taxa comprising 10% or more of the total density or biovolume of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Kansas, 1975	163
6.3	Density (no./cm^2), number of taxa, diversity, and evenness of periphytic algae collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	164

Chapter 1

INTRODUCTION

By

Darell L. Andersen

LIST OF TABLES (continued)

No.	Caption	Page
8.5	Benthic macroinvertebrate densities (no./m^2) in Ponar grab samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 3 December 1975	221
8.6	Diversity indices calculated from Ponar dredge samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	224
8.7	Macroinvertebrates collected qualitatively in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	225
8.8	Numbers of benthic macroinvertebrate taxa in Ponar dredge samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-75	229
9.1	Water temperatures (°C) recorded at each sampling location in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	242
9.2	Checklist of fish species collected by all sampling methods in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-75	243
9.3	Total numbers of fish collected by seining and gill netting in John Redmond Reservoir (Location 1) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-75	245
9.4	Total numbers of fish collected by seining and hoop netting in the Neosho River (Location 4) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-75	246
9.5	Total numbers of fish collected by seining at sampling locations on Wolf Creek in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-75	247
9.6	Age and size distribution of selected species of fish collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, April-December 1975	248
9.7	Relative importance of food items in the stomachs of selected fish collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, April-December 1975	249
9.8	Larval fish collected from John Redmond Reservoir in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 9 June 1975	250

LIST OF TABLES (continued)

No.	Caption	Page
6.4	Biomass standing crop (mg/dm^2), chlorophyll a standing crop ($\mu g/dm^2$), autotrophic index, and biovolume ($\mu l/dm^2$) of periphytic algae collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	165
6.5	Mean differences between locations for biomass and chlorophyll a standing crops from periphytic algae collected from natural substrates near the Wolf Creek Generating Station, Burlington, Kansas, 1975	166
7.1	Zooplankton taxa collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	179
7.2	Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 17 April 1975	181
7.3	Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 10 June 1975	183
7.4	Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 9 September 1975	185
7.5	Zooplankton collected in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 3-4 December 1975	188
7.6	Mean density of major zooplankton groups collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, March 1974 to December 1975	190
7.7	Yearly mean densities ($no./m^3$) of selected major microcrustacean taxa from John Redmond Reservoir (Location 1) March 1973 to December 1975	191
8.1	Occurrence of macroinvertebrates collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975	209
8.2	Benthic macroinvertebrate densities ($no./m^2$) in Ponar grab samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 17 April 1975	213
8.3	Benthic macroinvertebrate densities ($no./m^2$) in Ponar grab samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 10 June 1975	215
8.4	Benthic macroinvertebrate densities ($no./m^2$) in Ponar grab samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 9 September 1975	218

I. The site of the proposed Wolf Creek Generating Station is located near the center of Coffey County, Kansas, approximately 3.5 miles northeast of Burlington, the county seat. The nuclear station is scheduled for completion in 1981 and will produce 1150 megawatts (net output) of electrical power with its pressurized water reactor. The recirculating type cooling system will use the surface of a proposed cooling lake to dissipate the rejected heat.

The site boundary encompasses approximately 10500 acres. Acreages considered irretrievable for the life of the station include about 5960 acres for the cooling lake, 135 acres for the station, and 60 acres for the dam structures. The land use in the site area is typical of rural agriculture in eastern Kansas and consists primarily of range and cropland. Present land usage is expected to continue in undisturbed areas and consideration is being given to implementation of resource management programs to mitigate unavoidable habitat losses.

The proposed cooling lake will have a surface elevation of 1087 ft above sea level and an average depth of 18.2 ft. The main earth rolled dam on Wolf Creek, 5.5 miles upstream from its confluence with the Neosho River, and six perimeter dikes will create the lake basin. Water for the lake will be provided by precipitation and runoff in the Wolf Creek watershed and a makeup line from the Neosho River immediately below John Redmond Dam. Overflow downstream into the Neosho River along Wolf Creek will maintain the lake level during periods of excess water influx.

Biological, chemical, and/or biological studies on surface and subsurface waters as well as the terrestrial habitats in the vicinity of the proposed Wolf Creek Generating Station site were initiated in March 1973. The Wolf Creek Generating Station Environmental Report (Kansas Gas and Electric Company 1974) and the 1974-75 Preconstruction Environmental Monitoring Report (Industrial BIO-TEST Laboratories, Inc. 1975) discuss the information previously gathered. The primary purpose of the monitoring program discussed herein was to assess the aquatic and terrestrial environments as they existed in the area which will, or can, be influenced by construction and operation of the proposed Wolf Creek Generating Station.

II. References Cited

Industrial BIO-TEST Laboratories, Inc. 1975. Final report of preconstruction environmental monitoring program, Wolf Creek Generating Station, March 1974-February 1975. (IBT No. 64304971). Report by Industrial BIO-TEST Laboratories, Inc. for Kansas Gas and Electric Company, Wichita, Kans. 188 pp. + 8 appendices.

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Chapter 2

VEGETATION MONITORING

By

Warren J. Buchanan, Jr.

I. Introduction

Preconstruction monitoring of vegetation in the vicinity of the proposed Wolf Creek Generating Station, Burlington, Kansas, was conducted in June and September 1975. Community structure, composition, productivity, and biomass were quantified in a floodplain woods, an abandoned railroad right-of-way, an open pasture, and a mixed shrub-grass pasture (Figure 2.1). The objectives of the preconstruction monitoring program were to:

1. Evaluate vegetational changes since the baseline study;
2. Supplement baseline data by further documenting community trends;
3. Provide a more accurate basis for comparison with subsequent monitoring surveys; and
4. Provide information pertinent to assessment of environmental effects which might result from construction and operation of the proposed Wolf Creek Generating Station.

Representative community types were selected for baseline and monitoring studies (Figure 2.1); however, sampling locations of the floodplain woods, abandoned railroad right-of-way, open pasture, and mixed shrub-grass pasture were changed since the 1973 baseline survey due to cooling lake design changes, rescinded access to private land, or inaccurate representation of respective community types. The present monitoring locations should remain accessible and thus provide meaningful data for comparison with subsequent monitoring results.

II. Field and Analytical Procedures

A. Study Area

Data have been gathered during baseline and preconstruction monitoring studies from 11 separate vegetation stands, representing floodplain woods, open pastures, mixed shrub-grass pastures, and an abandoned railroad right-of-way. Locations of the four communities sampled in 1975 are shown in Figure 2.1. These data provided considerable information on the floristics and ecology of the site and vicinity; however, monitoring data were sometimes not directly comparable to baseline data even though both represented the same ecosystem.

The problems of comparability have been partially solved because the permanent transects established in September 1974 were intact in 1975. The 1975 sampling provided better continuity than previous studies, and future surveys will more accurately monitor changes.

B. Field Procedures

All vegetational strata within the four plant communities (Figure 2.1) were sampled by the quadrat method (Oosting 1956; Wiegert 1962). Six permanent 400 m^2 circular plots were systematically distributed in the floodplain woods to sample trees (stems greater than 10 cm dbh) and saplings (stems 2.5-10.0 cm dbh).

Five circular plots, each 10 m^2, were nested (Figure 2.2) at the center and tangent to the four cardinal compass points within the circumference of each 400 m^2 plot, to sample the shrub stratum. Herbaceous vegetation and woody seedlings less than 30 cm tall were sampled with 1 m^2 plots centered within each 10 m^2 plot.

The ground layers within the mixed shrub-grass pasture and open pasture were sampled using thirty 0.1 m^2 circular plots distributed at 10 m intervals along three parallel transects. The woody vegetation in the mixed shrub-grass pasture was sampled with ten 10 m^2 circular plots distributed at 20 m intervals along two transects. The abandoned railroad right-of-way was sampled with twenty-five 0.1 m^2 plots distributed at 10 m intervals along one transect.

C. Analytical Procedures

The community structure, composition, and productivity were quantified for each of the four sampling locations. Both absolute and relative values of frequency, density, and dominance were computed for species in the overstory, understory, and shrub strata. Importance values (Curtis and McIntosh 1951) were determined as the sum of the relative indices. Absolute and relative frequency and percent ground layer coverage were calculated for ground layer vegetation. Densities of trees and saplings were calculated for nine stem size classes. All data summaries were performed on a Data General NOVA computer using standard formulas (Curtis and Cottam 1962). Community biomass, litter turnover rate, and primary productivity were determined by the harvest method (Whittaker 1961; Ovington et al. 1963).

Plant voucher specimens were collected, dried, and processed for permanent preservation. Botanical nomenclature followed Gleason and Cronquist (1963).

The coefficient of community (2a/b) was used to quantify similarity between 1974 and 1975 community data; "a" is the number of recorded species common to both years of sampling and "b" is the collective sum of species found each year. Cox (1972) indicated that the maximum expected coefficient of community for replicate samples in a plant community is 0.85. When comparing yearly data from the communities near Wolf Creek, a coefficient greater than 0.75 was considered very similar, a coefficient greater than 0.60 was considered moderately similar, and dissimilarity was indicated by coefficients less than 0.60.

III. Results and Discussion

Land use within the project boundary of the proposed Wolf Creek Generating Station was classified into several types (Kansas Gas and Electric Company 1974). Rangeland, including open and mixed shrub-grass pastures (represented by Communities 3 and 4), comprised 46% of the land within the project boundary. The other major land-use types were cropland (41%) and woodland (11% of the land and represented by Community 1). Abandoned railroad rights-of-way (sampled in Community 2) occupied less than 1% of the land within the project boundary; however, as undisturbed prairie it represented the potential vegetation of

grasslands in the region, and was therefore important to sample.

Although similar community types were sampled in 1973, 1974, and 1975, direct comparisons to the original 1973 baseline survey were limited because of changes in sampling plot locations. The following discussion will largely deal with the present status of each community type and comparisons to previous studies where the sampling locations were not relocated for at least two years.

A. Floodplain Woods (Community 1)

1. Present Status

The floodplain woods along Wolf Creek range from mesic, seldom flooded, well-drained soil on moderate slopes to wet, often inundated alluvium near the creek banks. Most woodlands along Wolf Creek are subjected to periodic flooding; nearly all land that does not flood is now farmed. Community 1 was located within the influence of periodic flooding.

a. Composition

The overstory was composed of 13 species of which bur oak (*Quercus macrocarpa*), hackberry (*Celtis occidentalis*), and black walnut (*Juglans nigra*) were codominant (importance values of 70.4, 55.3, and 46.3, respectively; Table 2.1). The importance of bur oak was based mainly on the occurrence of a few very large individuals (relative dominance of 41.1%), whereas hackberry were generally small-sized but numerous (relative density of 30.3%). Bur oak and hackberry were the only trees with 100% frequency. Species of intermediate importance (importance values ranging from 23.3 to 31.0) included bitternut hickory (*Carya cordiformis*), redbud (*Cercis canadensis*), and Shumard's oak (*Quercus shumardii*). The latter species was mistakenly recorded as pin oak (*Q. palustris*) in June 1975. Minor constituents were green ash (*Fraxinus pennsylvanica*), Kentucky coffee-tree (*Gymnocladus dioica*), American and slippery elm (*Ulmus americana* and *U. rubra*), osage orange (*Maclura pomifera*), red mulberry (*Morus rubra*), and white ash (*Fraxinus americana*). These seven minor species had importance values ranging from 4.8 to 12.5%.

The understory reflected the successful reproduction of most major overstory species with the exception of bur oak and Shumard's oak (Table 2.2). Of the nine sapling species, hackberry was most abundant (importance value of 155). Redbud (importance value of 47.1) had secondary status. Green ash, bitternut hickory, red mulberry, American elm, osage orange, slippery elm, and black walnut were lesser components.

The shrub stratum contained a mixture of shrub species and tree seedlings (Table 2.3). Coralberry (*Symphoricarpos orbiculatus*) was widespread (importance value of 137.4); hackberry and green ash seedlings were also prominent. Missouri gooseberry (*Ribes missouriense*), slippery elm, white ash, poison ivy (*Rhus radicans*), grape (*Vitis* sp.), American elm, eastern wahoo (*Euonymus atropurpureus*), Kentucky coffee-tree, and greenbrier (*Smilax hispida*) were the minor components of the shrub stratum.

The ground layer composition (Table 2.4) included 21 identifiable species in June and 22 species in September; 13 were common to both surveys. The more common species, such as Virginia wild rye (Elymus virginicus), black snakeroot (Sanicula marilandica), Virginia creeper (Parthenocissus quinquefolia), wood nettle (Laportea canadensis), wingstem (Verbesina alternifolia), and sedge (Carex laxiflora), had high frequencies during both June and September. Seasonal variation was demonstrated by fescue (Festuca obtusa) and violet (Viola sp.) which were recorded in June only. Ruellia (Ruellia strepens), smartweed (Polygonum virginianum and P. punctatum) and white grass (Leersia virginica) were among the species recorded in September only.

b. Structure

Overstory and understory structure (Table 2.5) indicated an eventual increase of typical floodplain species such as hackberry, redbud, and green ash; these three species had a cumulative density of 870 stems/ha, representing nearly 90% of the saplings. Most bur oak and Shumard's oak were large trees over 55 cm dbh. The largest bur oak were approximatley 100 years old. These large oaks appeared to be relicts, possibly established during a past drought. Oaks were reproducing insufficiently to play a role in the eventual floodplain climax association. Hackberry will eventually dominate.

The shrub stratum covered 31.7% of the ground and comprised 9041 stems/ha (Table 2.3). Coralberry had the highest density (nearly 6000 stems/ha) but hackberry and green ash seedlings were also numerous (1000 and 700 stems/ha, respectively).

Ground layer coverage decreased from 65% in June to 40% in September; flooding was the evident cause of this reduction. Large areas of herbaceous vegetation had been matted down and defoliated by flooding between June and September.

c. Productivity and Biomass

Primary productivity in 1975 for the floodplain woods was estimated at 8763 kg/ha per yr and community biomass was 189,116 kg/ha (Table 2.6). This biomass estimate correlates fairly well with other estimates of midwestern woodland biomass. Ovington et al. (1963) estimated above-ground biomass for a Minnesota woods to be 165,798 kg/ha, whereas Buchanan (1975a) estimated a biomass of 139,510 kg/ha for a lowland woods in central Illinois. The rate of litter decomposition in Community 1 was 53.1% a year, indicating that less than two years are required for a complete turnover of litter.

2. Baseline Comparisons

The 1975 data for the floodplain woods have limited comparability to previous data from other floodplain woods near Wolf Creek because of changes in sampling locations. The composition of all strata in the floodplain woods correlated closely to that reported by Barker (1969) and Bellah and Hulbert (1974) for other floodplain forests in Kansas.

a. Composition

Data have been gathered from the upper strata of a different stand of floodplain woods during each of the three years of baseline (1973) and monitoring (1974 and 1975) studies. Although differences in structure existed, largely because of human intervention and topographic variance, the composition of the three floodplain stands was similar. The coefficient of community calculated from the 1974 and 1975 data was 0.63 (Figure 2.3) showing moderate similarity. Major tree components common to all three woods included hackberry, black walnut, red mulberry, and American elm. Other species prominent in at least two of the stands included green ash, Kentucky coffee-tree, bitternut hickory, and bur oak. Coralberry shrubs and hackberry seedlings were the primary components of the shrub stratum in the three floodplain woods. The ground layers in four stands of woods were surveyed in the three years of sampling. Virginia wild rye was prominent in all stands along with Virginia creeper, sedges, wingstem, and nettles.

b. Structure

The structure of upper strata in the three stands of floodplain woods varied considerably (Table 2.7). The baseline woods sampled in 1973 had 320 trees/ha and 411 saplings/ha. Densities of 592 trees/ha and 700 saplings/ha were recorded in the second stand of woods which was sampled during the first monitoring year (1974). The 1975 data for the third stand of floodplain woods showed 275 trees/ha and 842 saplings/ha (Table 2.7). The dimensional distribution of the trees and saplings reflected some general trends for the three woods. Hackberry, a predicted dominant for floodplain woods in this region (Kuchler 1974; Bellah and Hulbert 1974), was well represented in the smaller size classes; other typical floodplain species were also represented. Oak species, with the occasional exception of bur oak, were seldom found as saplings. Therefore, the oak components of the floodplain woods along Wolf Creek often appeared as relicts, unlikely to remain.

The shrub stratum and ground layer cover differed between stands and was related to disturbance and topographic variance. Shrub stratum cover was 59.0% in the 1973 stand, 14.1% in the 1974 stand, and 31.7% in the 1975 stand (Table 2.7). The ground layer cover ranged from 30% to 65% in all stands.

c. Productivity and Biomass

Primary productivity in the 1974 stand of floodplain woods was estimated at 8995 kg/ha per yr (Table 2.7); in the 1975 stand, the estimate was 8763 kg/ha per yr, a decrease of 2.5%. Community biomass in the 1975 stand (189,116 kg/ha) was greater by 12% than in the 1974 stand (168,455 kg/ha). These values are quite similar considering that they were estimatd from two different stands of floodplain woods.

B. Abandoned Railroad Right-of-Way (Community 2)

1. Present Status

The abandoned railroad right-of-way represented native bluestem

prairie. Undisturbed prairie remnants are few and scattered throughout the Osage Plains (Barker 1969); most grasslands in this region are degraded prairie. Community 1 represented the potential vegetation of these grasslands. This stand had a thick sod and a flora characteristic of the prairies described by Weaver (1968) and Kuchler (1974). The bisecting railroad ballast promoted the development of plants atypical of native prairie in the center of the right-of-way.

a. Composition

The prairie flora included 26 identifiable species in June and an additional 14 species in September (Table 2.8). Only eight species were common to both sampling periods and reflects seasonal variation. Except for the immature grasses (Gramineae) and composites (Compositae), panic grasses (Panicum scribnerianum and P. lanuginosum) were the most abundant species in June. By September, the immature species that had been collectively placed into family classifications in June, matured and were identifiable. Little bluestem (Andropogon scoparius), switch grass (Panicum virgatum), Indian grass (Sorghastrum nutans), Virginia wild rye, and purple lovegrass (Eragrostis spectabilis) were among the more common grasses. Three-seeded mercury (Acalypha gracilens), heath aster (Aster ericoides), yarrow (Achillea millefolium), wooly croton (Croton capitatus), ironweed (Vernonia baldwini), and sunflowers (Helianthus maximiliana and H. laetiflorus) were among the forbs recorded.

b. Structure

The average community ground layer cover was extensive in June and September (96 and 100%, respectively; Table 2.8). The graminoid population was very dense and generally grew to about 7 dm in height. Occasional tall forbs such as sunflowers, and grasses such as big bluestem (Andropogon gerardi), reached a height of 2 m. Albertson (1937) documented little bluestem prairie with a similar structure.

c. Productivity

The standing crop of the abandoned railroad right-of-way was large in 1975 (7446 kg/ha per yr; Table 2.6). Prairies studied by Koelling and Kucera (1965) and Smeins and Olsen (1970) had standing crops that averaged nearly 35% less than this Kansas prairie. Climatic variance probably accounted for the differences.

2. Baseline Comparisons

The same stand of prairie has been sampled during two years of preoperational monitoring. Although summer drought hindered the compositional and structural development in 1974, favorable climatic conditions in 1975 resulted in good growth.

a. Composition

The coefficient of community was 0.56 (Figure 2.3) between 1974 and 1975 data for the abandoned railroad right-of-way. Most of the prairie grasses that dominated in 1975 (Table 2.8) were poorly developed in

1974. The changes in composition demonstrate the dynamic nature of the prairie. Sampling variability had a minor influence on data.

Although a different stand of prairie was surveyed in 1973 (Kansas Gas and Electric Company 1974), the nine most common fall species reported in that survey were also recorded in the monitoring stand in September 1975. This demonstrates the floristically homogeneous nature of prairies in this area.

b. Structure

As described by Buchanan (1975b), the canopy was generally less than half as tall in 1974 as in 1975. Ground cover was essentially complete both years.

c. Productivity

The effects of drought in 1974 were most evident when comparing the standing crop in 1974 (3811 kg/ha per yr) to that of 1975 (7446 kg/ha per yr); the standing crop increased 95% from 1974 to 1975 (Table 2.7).

C. Open Pasture (Community 3)

1. Present Status

Grazing is the most common land use near Wolf Creek. Most pastures are essentially native prairie maintained in various stages of disclimax.

a. Composition

Depending on the severity of degradation, varying proportions of native prairie species will occur in mixture with noxious weeds (Kucera 1956). Climatic factors also influence the importance of weed species that establish on degraded prairie. Drought favors the establishment of weeds.

Species atypical of original prairie were most prominent in June 1975 (Table 2.9); these included mouse-ear chickweed (*Cerastium vulgatum*), Canada bluegrass (*Poa compressa*), ragweeds (*Ambrosia psilostachya* and *A. artemisiifolia*), and Japanese brome (*Bromus japonicus*). As serotinous prairie species developed, the abundance of many weed species declined. Prairie grasses such as little bluestem, big bluestem, and Indian grass, had increased considerably by September.

b. Structure

Community ground layer cover increased from 89% in June to 97% in September. The taller forbs attained heights of 1.5 m, whereas most of the vegetation was about 1 m in height. Many small patches were grazed to the ground.

c. Productivity

Primary productivity of the open pasture was estimated at 4162 kg/ha per yr (Table 2.6). Grazing that occurred during the year reduced the accuracy of the estimate.

2. Baseline Comparisons

a. Composition

The coefficient of community was 0.73 between 1974 and 1975 data (Figure 2.3). The 15 most common species in 1974 were also recorded in 1975. Most of the compositional changes resulted from the more favorable growing conditions in 1975. Most changes involved minor components of the ground layer. Although 1973 baseline studies (Kansas Gas and Electric Company 1974) were in a different pasture, the composition, particularly of major species, was similar.

b. Structure

The September 1974 ground layer cover (Table 2.7) was 87% and was less than that recorded in 1975 (97%). Climatic factors and grazing were the main influences. Herbaceous vegetation was better developed in 1975 due to more favorable growing conditions.

c. Productivity

Primary productivity in 1975 was 80% greater than in 1974 (Table 2.6) and was the result of favorable growing conditions following a year of drought. Grazing also influenced the estimates.

D. Mixed Shrub-Grass Pasture (Community 4)

1. Present Status

The stand of mixed shrub-grass pasture was extensively grazed. Large patches of weeds occurred among the clumps of trees and shrubs.

a. Composition

The woody invaders constituting the shrub stratum included mainly coralberry, elm, and smooth sumac (*Rhus glabra*) with importance values of 112.1, 82.8, and 52.1, respectively (Table 2.10). Other recorded woody species were rose, redcedar (*Juniper virginiana*), green ash, and honey locust (*Gleditsia triancanthos*). A few large osage orange trees were scattered in the community but outside the sampling plots.

The ground layer (Table 2.11) was composed of a mixture of weeds, prairie forbs, and grasses. Korean lespedeza (*Lespedeza Stipulacea*), Virginia strawberry (*Fragaria virginiana*), and common ragweed had the highest frequencies in the spring and summer. Japanese brome and white dwarf plantain (*Plantago virginica*) were common in June only, whereas broomweed (*Gutierrezia*

dracunculoides), ironweed, paspalum (Paspalum ciliatifolium), and aster were present in September only. Prairie grasses such as little bluestem, big bluestem, and side-oats grama (Bouteloua curtipendula) were infrequent. The abundance of weeds and scarcity of prairie grasses reflected the severity of grazing.

b. Structure

The structure of the mixed shrub-grass pasture was characterized by patches of closely grazed weeds, extensive shrub clones, and scattered trees. Density of woody stems was 9500 stems/ha and shrub cover was 19% (Table 2.10). The ground layer cover, 78% in June and 65% in September, was largely controlled by grazing.

c. Productivity

The herbaceous standing crop of the mixed shrub-grass pasture was 2055 kg/ha per yr (Table 2.6). The low productivity was largely the result of grazing influences and the shading by woody vegetation that reduced herbaceous growth.

2. Baseline Comparisons

a. Composition

The coefficient of community for 1974 and 1975 data from the mixed shrub-grass pasture was 0.70 (Figure 2.3). This indicates few significant compositional changes since 1974. Those changes that did occur involved minor constituents of the vegetation.

b. Structure

Ingrowth of woody species was ongoing. As trees and shrubs developed, the vertical stratification increased along with crown cover. This in turn reduced the herbaceous ground layer because of shading; however, grazing and climatic factors more immediately affected the ground layer. In September 1974, the ground layer cover was 57% (Table 2.7), whereas in September 1975 it was 65%. Favorable climatic conditions were probably the main cause of the increase.

c. Productivity

The standing crop of the mixed shrub-grass pasture was 13% greater in 1975 than 1974 (Table 2.7). The increase in primary productivity reflected better growing conditions in 1975 compared to 1974.

E. Relationship of Plant Communities to the Environment

The sensitivity of terrestrial communities to alterations of environment will be discussed to provide information pertinent to the assessment of eventual construction and operation impacts of the proposed Wolf Creek Generating Station.

1. Floodplain Woods (Community 1)

The floodplain woods will be more affected by construction and

operation than other terrestrial communities because of its close association with Wolf Creek. Most woods are presently within the influence of periodic floods; however, the elevation of the woods above the normal creek level provides fairly well drained conditions between floods. The character of the floodplain woods is largely controlled by the fluctuations between flooded and drained conditions.

The monitoring plots in the floodplain woods are located just above the proposed northern perimeter of the cooling lake. Conversion of Wolf Creek below Community 1 to a cooling lake will probably moderate flood periodicity and change the local moisture regime. Changes in the moisture regime (raising or lowering the water table) can interfere with reproductive strategies or edaphic requirements of present plant species (Johnson and Bell 1975). Some changes in community composition may occur along with physiological changes in remaining species. The same general influences will affect floodplain woods below the main dam on Wolf Creek.

2. Abandoned Railroad Right-of-Way (Community 2)

The abandoned railroad right-of-way represents native bluestem prairie of the region. A moisture gradient will be created along this right-of-way ranging from inundated conditions to normal dry conditions beyond the influence of the proposed lake level. In segments of the abandoned railroad right-of-way nearer the lake edge, marsh vegetation may develop. Intermediate moisture levels may promote the increase of slough grass (*Spartina pectinata*) or perhaps encroachment by woody species.

The abandoned railroad right-of-way sampling plots are elevated about 8 m above the proposed level of the cooling lake. Root systems of prairie species seldom exceed 8 m depths (Weaver 1968); however, capillary action could make available additional soil moisture. Species requiring more moisture than is presently available in Community 2, such as big bluestem, could be locally favored by creation of the cooling lake.

3. Open Pasture (Community 3)

Most of the open pasture ecosystem is located on rolling uplands too dry or hilly for cultivation of crops. Most pasture and range land in the vicinity of the proposed Wolf Creek Generating Station is above the influence of the proposed lake (Kansas Gas and Electric Company 1974). Pasture that lies within the possible influence of the lake may be more susceptible to woody invasion. Grazing will remain a greater influence on the vegetation of the open pastures than changes in the moisture gradient. The monitoring plots for Community 3 are above probable lake influence.

4. Mixed Shrub-grass Pasture (Community 4)

Most of the information presented above for open pastures also applies to mixed shrub-grass pastures. The wooded pastures are often more closely associated with drainageways since woody invasion of pastures is usually promoted by greater available water. Mixed shrub-grass pastures subjected to increases in moisture level, other than complete inundation, should show an

acceleration of woody invasion. As with open pastures, grazing will still be the greatest immediate influence.

The monitoring plots in Community 4 are near the cooling lake level, but are separated from the proposed lake by low hills up to 10 m above the proposed lake level. A small ditch that meanders southwestward to the Neosho River provides some moisture to Community 4; however, construction of dikes along the cooling lake may restrict the flow of this ditch. Thus, it is particularly difficult to predict environmental changes at Community 4 without more specific knowledge of changes that will occur in the moisture regime.

IV. Summary and Conclusions

1. The floodplain woods (Community 1) was dominated by bur oak and hackberry. Oak species were reproducing poorly, whereas typical floodplain species were thriving.

2. The floodplain woods sampled in 1975 represented the third stand of woods near Wolf Creek in which all strata were sampled. Differences among stands relate to past human intervention and topographic variation. Despite differences in moisture regimes, all stands were within the influence of periodic floods. The composition and structure of the floodplain stands were moderately similar.

3. The abandoned railroad right-of-way (Community 2) was composed largely of priarie grasses and forbs. The thick growth of little bluestem reached a height of 7 dm. Tall grasses and sunflowers reached a height of 2 m, and productivity was high.

4. The drought in 1974 and favorable growing conditions in 1975 accounted for the differences between years for data from the abandoned railroad right-of-way. Grasses were better developed in 1975 and canopy height and productivity were nearly twice that recorded in 1974.

5. The open pasture (Community 3) was native prairie altered by grazing. Pasture weeds were prominent in June, whereas prairie species increased considerably by September.

6. The composition and structure recorded in the open pasture for 1974 and 1975 were quite similar. Grazing and climatic conditions effected minor changes.

7. A mixture of noxious weeds and prairie species characterized the mixed shrub-grass pasture (Community 4). Several species of trees and shrubs were invading.

8. The ground layer of the mixed shrub-grass pasture had a very similar composition in September of 1974 and 1975. Changes involved only minor constituents.

9. Primary productivity in 1975 was greater in all communities than in 1974 because of the improved growing conditions in 1975.

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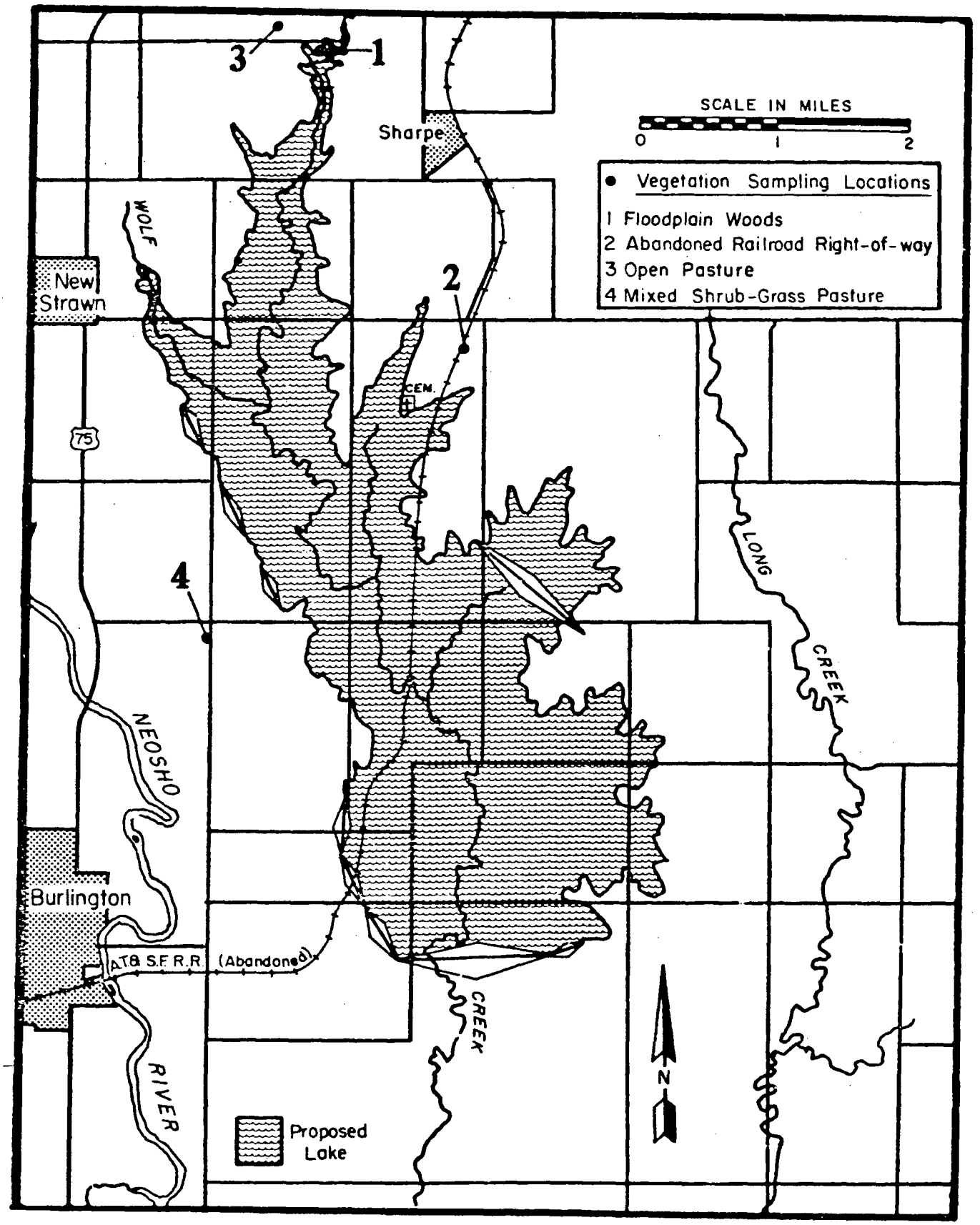

Figure 2.1. Vegetation sampling locations in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1975.

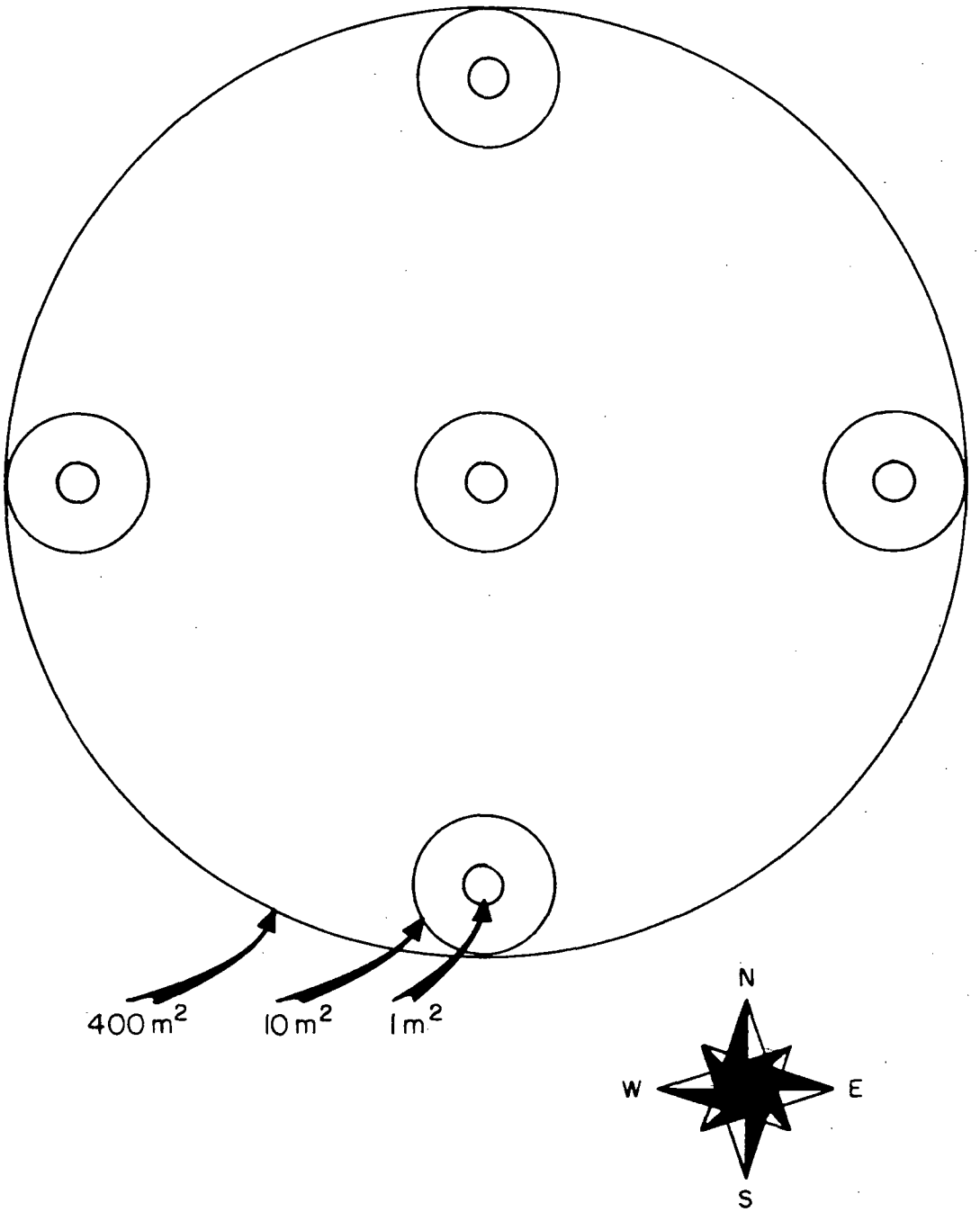

Figure 2.2 Schematic representation of nested quadrat layout for sampling vegetation in a floodplain woods in the vicinity of the proposed Wolf Creek Generating Station, Burlington, Kansas.

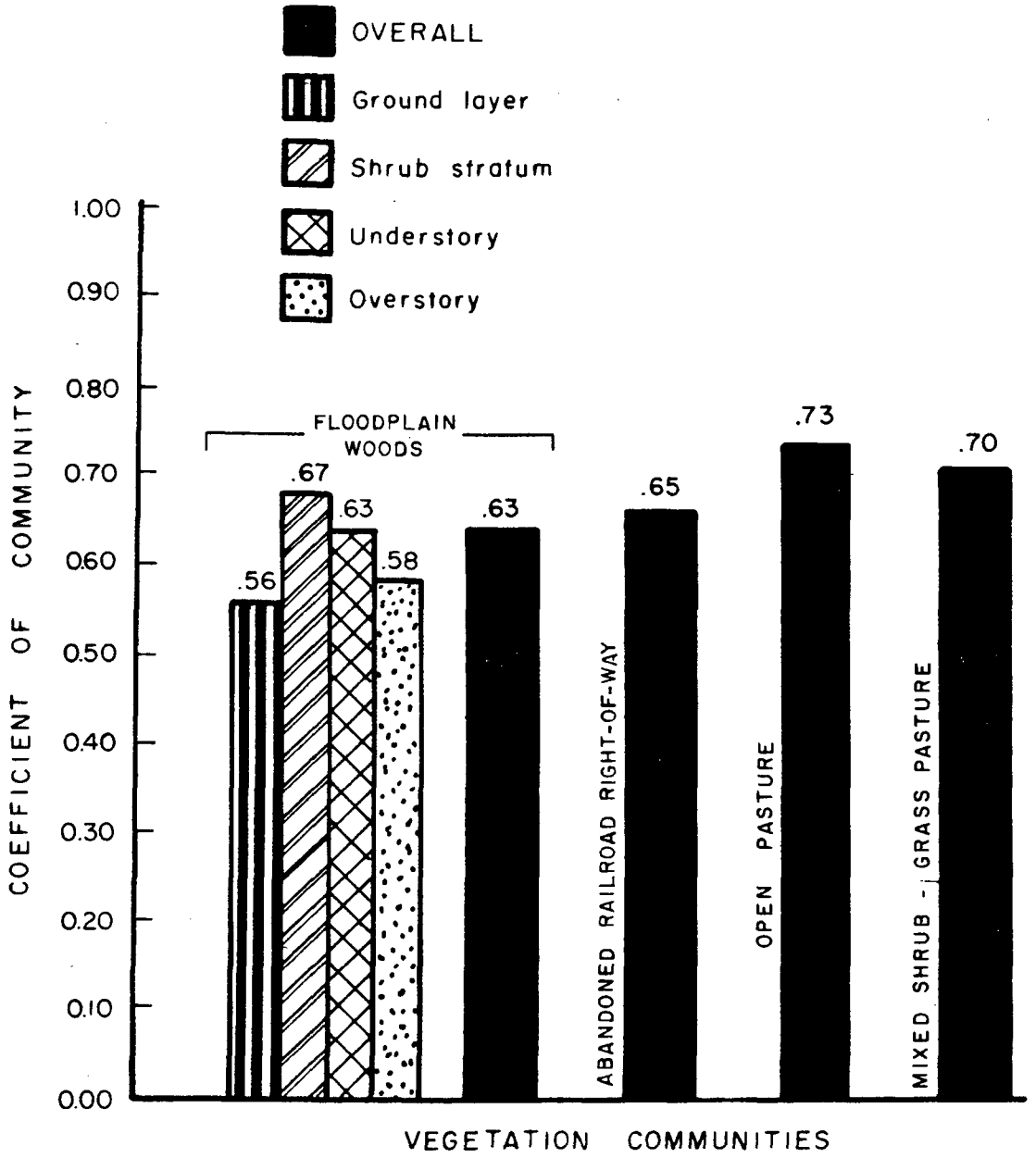

Figure 2.3. Similarity between 1974 and 1975 preoperational monitoring data based on coefficients of community for each plant community sampled in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas.

Table 2.1. **Phytosociological data summary of trees in a floodplain woods, Community 1,** in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June 1975.

Species	Frequency	Relative Frequency	Trees/ Hectare	Relative Density	Basal Area (m^2/ha)	Relative Dominance	Importance Value
Quercus macrocarpa	100.0	18.7	29.2	10.6	11.6	41.1	70.4
Celtis occidentalis	100.0	18.7	83.3	30.3	1.8	6.2	55.3
Juglans nigra	66.7	12.5	50.0	18.2	4.4	15.6	46.3
Carya cordiformis	66.7	12.5	33.3	12.1	1.8	6.4	31.0
Cercis canadensis	66.7	12.5	29.2	10.6	0.6	2.1	25.2
Quercus shumardii	16.7	3.1	8.3	3.0	4.9	17.2	23.3
Fraxinus pennsylvanica	16.7	3.1	12.5	4.5	1.4	4.8	12.5
Gymnocladus dioica	16.7	3.1	8.3	3.0	0.5	1.8	8.0
Ulmus americana	16.7	3.1	4.2	1.5	0.9	3.0	7.7
Ulmus rubra	16.7	3.1	4.2	1.5	0.4	1.4	6.0
Maclura pomifera	16.7	3.1	4.2	1.5	0.0	0.1	4.8
Morus rubra	16.7	3.1	4.2	1.5	0.0	0.1	4.8
Fraxinus americana	16.7	3.1	4.2	1.5	0.0	0.1	4.8
Totals			275.0		28.3		

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Table 2.2. Phytosociological data summary of saplings in a floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1975.

Species	Frequency	Relative Frequency	Saplings/ Hectare	Relative Density	Basal Area (m^2/ha)	Relative Dominance	Importance Value
Celtis occidentalis	100.0	19.4	550.0	65.3	1.5	70.3	155.0
Cercis canadensis	83.3	16.1	137.5	16.3	0.3	14.6	47.1
Fraxinus pennsylvanica	66.7	12.9	58.3	6.9	0.1	4.3	24.1
Carya cordiformis	66.7	12.9	25.0	3.0	0.1	4.0	19.9
Morus rubra	66.7	12.9	20.8	2.5	0.0	2.2	17.6
Ulmus americana	50.0	9.7	25.0	3.0	0.0	1.3	14.0
Maclura pomifera	50.0	9.7	12.5	1.5	0.0	0.4	11.5
Ulmus rubra	16.7	3.2	8.3	1.0	0.0	1.6	5.8
Juglans nigra	16.7	3.2	4.2	0.5	0.0	1.3	5.0
Totals			841.7		2.1		

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Table 2.3. Phytosociological data summary of species in the shrub stratum of a floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1975.

Species	Frequency	Relative Frequency	Stems/ Hectare	Relative Density	% Ground Cover	Relative Dominance	Importance Value
Symphoricarpos orbiculatus	79.2	35.2	5958	65.9	11.5	36.3	137.4
Celtis occidentalis	54.2	24.1	1000	11.1	11.3	35.7	70.8
Fraxinus pennsylvanica	25.0	11.1	708	7.8	5.5	17.5	36.4
Ribes missouriense	12.5	5.6	541	6.0	1.5	4.6	16.1
Ulmus rubra	12.5	5.6	250	2.8	0.6	1.9	10.2
Fraxinus americana	8.3	3.7	208	2.3	0.3	1.0	7.0
Rhus radicans	8.3	3.7	125	1.4	0.1	0.3	5.4
Vitis sp.	8.3	3.7	83	0.9	0.1	0.2	4.8
Ulmus americana	4.2	1.9	41	0.5	0.6	1.8	4.1
Euonymus atropurpureus	4.2	1.9	41	0.5	0.1	0.4	2.7
Gymnocladus dioica	4.2	1.9	41	0.5	0.1	0.4	2.7
Smilax hispida	4.2	1.9	41	0.5	0.0	0.1	2.4
Totals			9041		31.7		

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Table 2.4. Frequency of species in the ground layer and average ground layer cover in a floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June and September 1975.

	June		September	
Species	Frequency	Relative Frequency	Frequency	Relative Frequency
Elymus virginicus	73.3	13.7	56.7	13.6
Sanicula gregaria	66.7	12.4	60.0	14.4
Parthenocissus quinquefolia	46.7	8.7	23.3	5.6
Urtica dioica	40.0	7.5	10.0	2.4
Laportea canadensis	40.0	7.5	63.3	15.2
Verbesina alternifolia	36.7	6.8	33.3	8.0
Carex laxiflora	36.7	6.8	46.7	11.2
Festuca obtusa	33.3	6.2		
Viola sp.	33.3	6.2		
Symphoricarpos orbiculatus	26.7	5.0	20.0	4.8
Polygonum sp.	20.0	3.7		
Geum canadense	16.7	3.1		
Galium aparine	16.7	3.1		
Compositae	13.3	2.5	3.3	0.8
Menispermum canadense	6.7	1.2	3.3	0.8
Rhus radicans	6.7	1.2	10.0	2.4
Pilea pumila	6.7	1.2		
Ambrosia trifida	3.3	0.6		
Celtis occidentalis	3.3	0.6	3.3	0.8
Vitis sp.	3.3	0.6	10.0	2.4
Acer negundo	3.3	0.6		
Ribes missouriense	3.3	0.6	6.7	1.6
Ruellia strepens			13.3	3.2
Polygonum virginianum			13.3	3.2
Leersia virginica			10.0	2.4
Carya cordiformis			6.7	1.6
Polygonum punctatum			6.7	1.6
Cinna arundinacea			3.3	0.8
Gramineae			3.3	0.8
Quercus macrocarpa			3.3	0.8
Smilax hispida			3.3	0.8
Aster sp.			3.3	0.8
	Average Community Ground Layer Cover			
	65%		40%	

Table 2.5. Density (stems per hectare) of saplings and trees by diameter classes in a floodplain woods, Community 1, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June 1975.

	Diameter Classes dbh (cm)											
	Sapling Class			Tree Class								
Species	2.5-6.2	6.3-10.0	Sub-Total	10.1-17.5	17.6-25.0	25.1-32.5	32.6-40.0	40.1-47.5	47.6-55.0	> 55.1	Sub-Total	Totals
Celtis occidentalis	370.8	179.2	550.0	62.5	12.5	4.2	4.2				83.3	633.3
Cercis canadensis	95.8	41.7	137.5	20.8	8.3						29.2	166.7
Fraxinus pennsylvanica	50.0	8.3	58.3		4.2	4.2			4.2		12.5	70.8
Carya cordiformis	12.5	12.5	25.0	12.5	4.2	12.5		4.2			33.3	58.3
Juglans nigra		4.2	4.2	8.3	8.3	4.2	20.8	4.2	4.2		50.0	54.2
Ulmus americana	25.0		25.0						4.2		4.2	29.2
Quercus macrocarpa			0.0		4.2		4.2			20.3	29.2	29.2
Morus rubra	16.7	4.2	20.8	4.2							4.2	25.0
Maclura pomifera	12.5		12.5	4.2							4.2	16.7
Ulmus rubra		8.3	8.3				4.2				4.2	12.5
Gymnocladus dioica			0.0	4.2			4.2				8.3	8.3
Quercus shumardii			0.0							8.3	8.3	8.3
Fraxinus americana			0.0	4.2							4.2	4.2
Totals	583.3	258.3	841.7	120.8	41.7	25.0	37.5	8.3	12.5	29.2	275.0	1116.7

Table 2.6. Primary productivity and biomass of representative plant communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June and November 1975.

Plant Community	Primary Productivity (kg/ha per yr)	Biomass (kg/ha)	Litter Turnover (%/yr)
Floodplain woods (Community 1)	8763	189,116	53.1
Abandoned railroad right-of-way (Community 2)	7446	-	-
Open pasture (Community 3)	4162	-	-
Mixed shrub-grass pasture (Community 4)	2055	-	-

Table 2.7. Comparisons of vegetation data from four representative plant communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973[a], 1974[b], and 1975.

Location	Year	No. Species	Density (stems/ha) Overstory	Density (stems/ha) Understory	Density (stems/ha) Shrub Stratum	Basal Area (m^2/ha) Overstory	Basal Area (m^2/ha) Understory	% Cover Shrub Stratum	% Cover Ground Layer[c]	Primary Productivity (kg/ha/yr)	Biomass (kg/ha)	Litter Turnover (%/yr)
Floodplain Woods	1973[d]	57	320	411		19.0		59.0				
	1974[d]	45	593	700	1836	18.6	2.1	14.1	33	8995	168,455	49.9
	1975	42	275	842	9041	28.3	2.1	31.7	40	8763	189,116	53.1
Abandoned Railroad Right-of-Way	1973[d]	50										
	1974	30							100	3811		
	1975	40							100	7446		
Open Pasture	1973[d]	52										
	1974	46							87	2323		
	1975	48							97	4162		
Mixed Shrub Grass Pasture	1973[d]	37						30.1				
	1974	31							57	1810		
	1975	53			9500			19.0	65	2055		

a Kansas Gas and Electric Company (1974)
b Buchanan (1975b)
c Ground cover values for September only.
d Community locations different from present monitoring location.

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Table 2.8. Frequency of species in the ground layer and average ground layer cover in an abandoned railroad right-of-way, Community 2, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June and September 1975.

Species	June		September	
	Frequency	Relative Frequency	Frequency	Relative Frequency
Gramineae	96.0	16.3	4.0	0.8
Panicum scribnerianum	88.0	15.0		
Compositae	44.0	7.5		
Panicum lanuginosum	40.0	6.8		
Oxalis sp.	40.0	6.8	4.0	0.8
Elymus virginicus	36.0	6.1	44.0	9.3
Achillea millefolium	32.0	5.4	16.0	3.4
Agrostis hyemalis	28.0	4.8		
Erigeron strigosus	24.0	4.1		
Poa pratensis	20.0	3.4		
Bromus japonicus	20.0	3.4		
Euphorbia corollata	20.0	3.4	8.0	1.7
Viola pedatifida	12.0	2.0	4.0	0.8
Koeleria cristata	12.0	2.0	4.0	0.8
Physalis sp.	8.0	1.4		
Juncus sp.	8.0	1.4		
Triodanis perfoliata	8.0	1.4		
Plantago virginica	8.0	1.4		
Petalostemum sp.	8.0	1.4	8.0	1.7
Lactuca serriola	4.0	0.7		
Scutellaria sp.	4.0	0.7		
Galium aparine	4.0	0.7		
Phalaris caroliniana	4.0	0.7		
Lobelia spicata	4.0	0.7		
Geranium carolinianum	4.0	0.7		
Myosotis verna	4.0	0.7		
Carex sp.	4.0	0.7		
Vitis sp.	4.0	0.7	4.0	0.8
Panicum sp.			88.0	18.6
Andropogon scoparius			80.0	16.9
Panicum virgatum			72.0	15.3
Sorghastrum nutans			40.0	8.5
Acalypha gracilens			36.0	7.6
Eragrostis spectabilis			24.0	5.1
Aster ericoides			8.0	1.7
Croton capitatus			4.0	0.8
Vernonia baldwini			4.0	0.8
Sporobolus asper			4.0	0.8
Elymus canadensis			4.0	0.8
Helianthus maximiliani			4.0	0.8
Helianthus laetiflorus			4.0	0.8
Andropogon gerardi			4.0	0.8
	Average Community Ground Layer Cover			
	96%		100%	

Table 2.9. Frequency of species in the ground layer and average ground layer cover in an open pasture, Community 3, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June and September 1975.

Species	June		September	
	Frequency	Relative Frequency	Frequency	Relative Frequency
Cerastium vulgatum	76.7	10.0		
Poa compressa	63.3	8.3	6.7	1.1
Gramineae	60.0	7.8	36.7	5.9
Ambrosia psilostachya	60.0	7.8	56.7	9.1
Bromus japonicus	60.0	7.8		
Pycnanthemum sp.	53.3	7.0		
Ambrosia artemisiifolia	46.7	6.1	36.7	5.9
Hordeum pusillum	33.3	4.3		
Solidago graminifolia	33.3	4.3	46.7	7.5
Panicum scribnerianum	30.0	3.9		
Eupatorium serotinum	30.0	3.9	26.7	4.3
Symphoricarpos orbiculatus	26.7	3.5	20.0	3.2
Plantago virginica	26.7	3.5		
Compositae	23.3	3.0		
Panicum lanuginosum	16.7	2.2		
Poa pratensis	13.3	1.7		
Carex sp.	13.3	1.7		
Lespedeza stipulacea	13.3	1.7	30.0	4.8
Juncus interior	13.3	1.7		
Agrostis hyemalis	10.0	1.3		
Myosotis verna	6.7	0.9		
Eleocharis sp.	6.7	0.9		
Solanum carolinense	6.7	0.9	13.3	2.2
Cirsium sp.	6.7	0.9		
Gleditsia triacanthos	6.7	0.9	3.3	0.5
Fragaria virginiana	6.7	0.9	3.3	0.5
Oxalis sp.	6.7	0.9		
Achillea millefolium	3.3	0.4		
Ambrosia bidentata	3.3	0.4	6.7	1.1
Agrimonia sp.	3.3	0.4		
Carex festucacea	3.3	0.4		
Rumex crispus	3.3	0.4		
Andropogon scoparius			60.0	9.7
Setaria geniculata			43.3	7.0
Panicum sp.			36.7	5.9
Acalypha gracilens			30.0	4.8
Andropogon gerardi			26.7	4.3
Sorghastrum nutans			26.7	4.3
Pycnanthemum flexuosum			23.3	3.8
Panicum virgatum			23.3	3.8
Paspalum ciliatifolium			23.3	3.8
Triodia flava			10.0	1.6
Sporobolus asper			6.7	1.1

Table 2.9. (continued)

Species	June Frequency	June Relative Frequency	September Frequency	September Relative Frequency
Vernonia baldwini			3.3	0.5
Erigeron strigosus			3.3	0.5
Muhlenbergia sp.			3.3	0.5
Aster ericoides			3.3	0.5
Baptisia leucophaea			3.3	0.5
Solidago sp.			3.3	0.5
Geum canadense			3.3	0.5
	Average Community Ground Layer Cover			
	89%		97%	

Table 2.10. Phytosociological data summary of species in the shrub stratum of a mixed shrub-grass pasture, Community 4, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June 1975.

Species	Frequency	Relative Frequency	Stems/ Hectare	Relative Density	% Ground Cover	Relative Dominance	Importance Value
Symphoricarpos orbiculatus	80.0	33.3	5700	60.0	3.6	18.7	112.1
Ulmus sp.	70.0	29.2	1400	14.7	7.4	38.9	82.8
Rhus glabra	20.0	8.3	1500	15.8	5.3	28.0	52.1
Rosa sp.	30.0	12.5	300	3.2	1.9	10.0	25.7
Juniperus virginiana	20.0	8.3	200	2.1	0.3	1.7	12.1
Fraxinus pennsylvanica	10.0	4.2	100	1.1	0.5	2.4	7.6
Gleditsia triacanthos	10.0	4.2	300	3.2	0.0	0.3	7.6
Totals			9500		19.0		

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Table 2.11. Frequency of species in the ground layer and average ground layer cover in a mixed shrub-grass pasture. Community 4, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June and September 1975.

Species	June		September	
	Frequency	Relative Frequency	Frequency	Relative Frequency
Lespedeza stipulacea	93.3	12.3	90.0	14.8
Fragaria virginiana	86.7	11.4	63.3	10.4
Gramineae	83.3	11.0	73.3	12.1
Bromus japonicus	76.7	10.1		
Ambrosia artemisiifolia	66.7	8.8	50.0	8.2
Plantago virginica	46.7	6.1		
Compositae	40.0	5.3		
Ambrosia bidentata	36.7	4.8	46.7	7.7
Solidago graminifolia	36.7	4.8	26.7	4.4
Panicum lanuginosum	23.3	3.1		
Cerastium vulgatum	20.0	2.6		
Trifolium repens	16.7	2.2		
Achillea millefolium	13.3	1.8	6.7	1.1
Symphoricarpos orbiculatus	13.3	1.8	3.3	0.5
Poa compressa	13.3	1.8		
Juncus interior	13.3	1.8		
Desmodium sp.	13.3	1.8		
Erigeron strigosus	10.0	1.3		
Antennaria neglecta	10.0	1.3	3.3	0.5
Artemisia ludoviciana	3.3	0.4	3.3	0.5
Rhus glabra	3.3	0.4		
Taraxacum officinale	3.3	0.4	3.3	1.5
Panicum sp.	3.3	0.4	46.7	7.7
Apocynum sp.	3.3	0.4		
Panicum scribnerianum	3.3	0.4		
Eupatorium sp.	3.3	0.4		
Ruellia humilis	3.3	0.4	3.3	0.5
Baptisia leucophaea	3.3	0.4		
Cornus racemosa	3.3	0.4		
Ulmus sp.	3.3	0.4		
Gleditsia triacanthos	3.3	0.4	10.0	1.6
Plantago rugelii	3.3	0.4		
Poa pratensis	3.3	0.4		
Gutierrezia dracunculoides			23.3	3.8
Vernonia baldwini			16.7	2.7
Paspalum ciliatifolium			16.7	2.7
Aster sp.			16.7	2.7
Setaria glauca			13.3	2.2
Acalypha gracilens			13.3	2.2
Trifolium sp.			10.0	1.6
Oxalis sp.			10.0	1.6
Andropogon scoparius			10.0	1.6
Croton capitatus			6.7	1.1

Table 2.11. (continued)

Species	June Frequency	June Relative Frequency	September Frequency	September Relative Frequency
Solanum carolinense			6.7	1.1
Ranunculus sp.			3.3	0.5
Carex sp.			3.3	0.5
Muhlenbergia schreberi			3.3	0.5
Eupatorium rugosum			3.3	0.5
Triodia flava			3.3	0.5
Andropogon gerardi			3.3	0.5
Digitaria sanguinalis			3.3	0.5
Bouteloua curtipendula			3.3	0.5
Labiatae			3.3	0.5
Juniperus virginiana			3.3	0.5
Average Community Ground Layer Cover	78%		65%	

Chapter 3

WILDLIFE MONITORING

By

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and
Mel L. Schamberger

I. Introduction

Preconstruction monitoring of terrestrial wildlife occurred in the vicinity of the proposed Wolf Creek Generating Station on 7-9 May, 7-12 June, 15-19 July, 8-10 September, and 24-26 November 1975, and 20-22 January 1976. Avifauna, medium and large-sized mammals, and herpetofauna were observed along a 20-mile survey route and within four communities (floodplain woods, abandoned railroad right-of-way, open pasture, and mixed shrub-grass pasture, Figure 3.1). Small mammals were censused in four communities.

Studies were designed to provide:

1. Baseline data for communities studied for the first time;

2. Continuity between baseline studies (Kansas Gas and Electric Company 1974), preconstruction monitoring studies (Schamberger et al. 1975) and projected monitoring studies that will occur during the construction phase of the project;

3. Data for comparisons with baseline and preconstruction monitoring studies; and

4. Information pertinent to the assessment of potential impacts resulting from the construction and/or operation of Wolf Creek Generating Station.

II. Field and Analytical Procedures

A. Study Areas

Wildlife populations were censused in four communities, a 20-mile survey route, and four wooded areas during the 1975-76 monitoring study (Figure 3.1). The 20-mile survey route was identical to the one censused in the 1973 baseline study and 1974 monitoring study. Time-area counts for squirrels were also conducted in the areas censused during the baseline and 1974 monitoring studies (Figure 3.1). However, community locations have changed several times since the initiation of the baseline study. All communities censused during 1975-76 were identical to those used subsequent to September 1974. The four communities censused were representative of natural habitats in the project area.

The floodplain woods (Community 1) was initially sampled during the baseline study but was not used for monitoring until the November 1974 sampling period. This wooded community was located along Wolf Creek and had not been recently logged.

The abandoned railroad right-of-way (Community 2) was selected in May 1974 and has been used during the 1974 and 1975 monitoring studies. It is typical of railroad rights-of-way in that relatively low areas parallel each side of the former track bed. Since abandonment, the tracks have been removed and railroad ties and debris have accumulated in the low areas providing good cover for small mammals. Beyond the low areas, the right-of-way was generally flat and supported a sod of prairie grasses. The tenant of the adjacent farm fenced the community in 1974 and pastured cattle to the perimeter; thus, the

extent of undisturbed area was reduced and limited to the immediate study area.

The open pasture (Community 3) was originally selected in May 1974 but was classified as a shrub-pasture community at that time. Subsequent sampling revealed that this area was more representative of open pastures near the project area; hence, the community was reclassified and sampled as open pasture in July 1974. This community was bordered by hedgerows and contained a few small scattered shrubs.

The shrub-grass pasture (Community 4) sampled during the 1975 monitoring program was established in July 1974 and has been used since that time. This community contained an intermittent stream bordered by sparse woods. It was pastured, but considerable shrub and woody growth was present.

B. Mammals

1. Small Mammal Trapping

A grid of 50 Sherman live-traps was established in each of four terrestrial communities (Figure 3.1) to determine species composition and abundance of small mammal populations during June and September 1975. Each trapping grid consisted of five parallel lines of traps, designated A, B, C, D and E, spaced at 10 m intervals. One Sherman live-trap was placed at each of 10 stations located at 10 m intervals along each line. Traps were baited with a mixture of peanut butter and rolled oats, operated for three consecutive nights in June and four consecutive nights in September, and checked daily during the early morning hours. Captured animals were toeclipped for identification. The sex, reproductive condition, weight, and standard body measurements of each individual were recorded. Capture data were converted to captures per 100 trapnights (TN) to facilitate comparisons. In communities where sufficient recapture data were available, the Lincoln Index (Lincoln 1930) was used to estimate population densities. An area equal to one-half the home range of the animal was added to the periphery of the trapping grid to determine the area of influence of the traps (Fitch 1958).

2. Squirrel and Rabbit Censuses

Rabbits were censused in June and July 1975 by standard roadside counts along the 20-mile survey route (Figure 3.1). Estimates of squirrel abundance were derived from 20-minute time-area counts (Preno and Labisky 1971) in four wooded areas (Figure 3.1) in January 1976. Squirrel counts were made on two consecutive days between mid-morning and mid-afternoon during periods of moderate weather.

3. Supplemental Data

In addition to the described surveys, records were kept of all observations of mammals and/or their signs during each field trip. These observations provided information on species composition and relative abundance of larger mammals in the site area.

4. Nomenclature

Identification and/or nomenclature followed Cockrum (1952), Murie (1954), and Blair et al. (1957).

C. Avifauna

Avifauna censuses were conducted seasonally to derive species lists and estimates of relative densities of game and nongame species that occur near Wolf Creek. Seasons, for the purpose of this study, were defined as follows: spring-March, April and May; summer-June, July and August; fall-September, October and November; and winter-December, January and February.

1. Transect Counts

Relative population densities of birds in four communities (Figure 3.1) were derived from transect counts (Kendeigh 1944); three censuses were conducted in each community during each survey period. Both sight observations and songs were used for species identification. The species, numbers observed, and duration of each census period were recorded. Raw data were converted to number of birds per hour to provide a basis for direct comparisons. Relative frequencies were calculated for each species.

2. 20-mile Wildlife Survey Route

A 20-mile wildlife survey route, established along roads near the site area (Figure 3.1), was driven twice during each survey period. All species of wildlife were recorded with observations listed by mile segment along the route.

Bobwhite quail (*Colinus Virginianus*) were censused on two successive days in June and July at one-mile intervals along the 20-mile wildlife survey route. During each survey, quail calls were counted for 2-minute intervals at each stop during the early morning hours (Preno and Labisky 1971).

3. Bird Species Diversity

The bird species diversity index (BSD), a derivation of the information theory (Shannon and Weaver 1949) and a measure of biotic diversity (MacArthur 1965), was calculated for avian species recorded within each community. The equation:

$$BSD = 1/N \left(N \log_e N - \sum_{i=1}^{s} n_i \log_e n_i\right)$$

(Lloyd et al. 1968), where N = total population, n_i = number of species observations, and s = total number of species in the aggregation, was used to calculate diversity. Bird species diversity was programmed on a WANG calculator and determined for each census period.

4. Supplemental Data

Observational data were provided by personnel from the Flint

Hills National Wildlife Refuge and the U. S. Fish and Wildlife Service concerning avifauna observations near John Redmond Reservoir.

5. Nomenclature

Nomenclature followed the American Ornithologists' Union checklist (1957, 1973). Identification was confirmed by reference to Robbins et al. (1966).

D. Reptiles and Amphibians

1. General Observations

Surveys to determine species composition, relative abundance, and distribution of reptiles and amphibians were conducted in a variety of habitats during May, June, July, and September. A species list of reptiles and amphibians observed during the study was compiled.

2. Supplemental Data

Additional herptile observations were obtained during aquatic sampling along Wolf Creek and the Neosho River and are included in this report.

3. Nomenclature

Nomenclature followed Conant (1958).

E. Rare and Endangered Species

All species lists were checked against published lists of rare and endangered species of the United States (U. S. Dep. Interior 1973).

III. Results and Discussion

A. Mammals

1. Small Mammals

Two species of small mammals were captured during the 1975 preconstruction monitoring study in a 1400 trapnight (TN) effort in four communities. Trap success averaged 4.6 captures per 100 TN and included 38 original captures and 26 recaptures of marked individuals (Table 3.1). The number of captures was greatest in the floodplain woods (16.6/100 TN) and represented 90.7% of all small mammal captures. The white-footed mouse (*Peromyscus leucopus*) was captured in the floodplain woods and mixed shrub-grass pasture and represented 94.7% of all small mammal captures (Table 3.2). The cotton rat (*Sigmodon hispidus*) was captured only in the abandoned railroad right-of-way. No species were captured in the open pasture community.

a. Species Accounts

White-footed Mouse: The white-footed mouse is primarily a woodland species (Burt and Grossenheider 1964; Cockrum 1952) and in Kansas is

usually restricted to bottomlands along rivers and streams (Cockrum 1952). This species was captured in the mixed shrub-grass pasture community, although the majority of individuals were recorded in the floodplain woods community (Table 3.2).

Cotton Rat: Two cotton rats were captured during the 1975 monitoring study in the abandoned railroad right-of-way; *S. hispidus* was the only species captured in this community. This species accounted for 5.3% of all original captures in 1975. Habitat preference for the cotton rat is more dependent upon cover density than plant species composition (Fleharty and Mares 1973). Continued cattle grazing at the perimeter of the trapping grid has reduced available cover, and trapping data from 1975 indicated that a continued decline in the numbers of cotton rats occurred in this community over the three-year study period.

b. Community Analyses

Floodplain Woods (Community 1): The number of small mammal captures was greatest in this community, representing 90.6% of all captures. The white-footed mouse was the only species recorded; the 58 captures included 33 original captures and 25 recaptures for a trap success of 16.6/100 TN (Table 3.1).

Five species of larger mammals were observed in the floodplain woods. The eastern cottontail (*Sylvilagus floridanus*) and eastern fox squirrel (*Sciurus niger*) were observed during May and July, and the raccoon (*Procyon lotor*) and white-tailed deer (*Odocoileus virgineanus*) were recorded in June and July (Table 3.3). Coyotes (*Canis latrans*) were heard calling in May. The floodplain woods provided favorable habitat for game and nongame animals. More mammalian species and individuals were recorded in this community than in any other community studied near the proposed Wolf Creek Generating Station in 1975.

Abandoned Railroad Right-of-Way (Community 2): Two captures were recorded within this community for a trap success of 0.6/100 TN (Table 3.1); the cotton rat was the only species captured. Small mammal captures in this community accounted for 3.1% of all captures in the 1975 study. The eastern cottontail was observed in this community in November and January (Table 3.3).

Open Pasture (Community 3): No small mammal species were captured in this community during the 1975 monitoring study. No larger mammals were noted.

Mixed Shrub-Grass Pasture (Community 4): Four white-footed mice were captured in this community for a trap success of 1.1/100 TN (Table 3.1). Captures in the mixed shrub-grass pasture accounted for 6.3% of all small mammals captured during the study (Table 3.2). The eastern cottontail was recorded on numerous occasions and the eastern fox squirrel was observed during May (Table 3.3).

c. Seasonal Abundance

White-footed mice were much more abundant during June in the floodplain woods than during September. However, in the mixed shrub-grass

pasture more captures were recorded in September. Cotton rats were only captured in the abandoned railroad right-of-way during September (Table 3.4).

d. Density Estimates

The white-footed mouse was the only species recaptured in sufficient numbers to permit density estimates (Table 3.5). Density estimates for the floodplain woods were 31/ha in June and 12/ha in September with an average of 21.5/ha.

e. Comparisons with Baseline and 1974 Monitoring Studies

Direct comparisons between the baseline study and the 1975 monitoring study were not feasible. Community locations were changed from the baseline study, and during the 1974 monitoring program additional changes occurred. Further, the baseline snap-trapping study was designed to determine relative abundance and species composition, whereas live-trapping in the 1975-76 monitoring study was designed to provide density estimates. Although species composition can be determined by live-trapping, many small mammal species respond differently to trap types, and results from different methods are not directly comparable.

Because of changes in sampling communities, absence of a November sampling period, and a difference in the number of trapnights, direct comparisons between portions of the 1974 and 1975 monitoring studies are not valid. However, several items can be noted. A comparison of the number of captures in each community type shows that fewer species and individuals were captured during the 1975 study than in 1974 (Table 3.6). Five species were captured in 1974 that were not recorded in 1975. Two of these species, Cryptotis parva and Pitmys pinetorum, were recorded only once during the 1974 study and the absence of these species in 1975 is likely due to the small sample size. Three species, Blarina brevicauda, Peromyscus maniculatus, and Microtus ochrogaster, were captured in larger numbers during 1974, and the reason for their absence is unclear. The following items may partially explain the reduced number of species captured in 1975: (1) populations may have been reduced as a result of dry weather conditions and winter mortality in 1974, (2) increased food availability in 1975 may have resulted in decreased attractability of the bait in 1975, (3) variation in weather conditions at the time of trapping may have affected capture success, and (4) this may be a normal low of a natural population cycle. The two species captured in 1975, P. leucopus and S. hispidus, were far less abundant than in previous years; P. leucopus declined from 97 captures in 1974 to 62 captures in 1975. However, the floodplain woods community was relocated during 1974, and these data may reflect differences in habitat rather than in populations. Since no disturbance attributable to construction of the station or associated facilities has taken place, the above differences must be due to natural population changes, sampling errors caused by variations in community type, or local changes in land use practices by residents (i.e., abandoned railroad right-of-way).

2. Game Censuses

a. Squirrel Census

Time area counts for fox squirrels conducted at four locations

in January produced a mean of 1.0 observations per site per day (Table 3.7). These results were the same as those reported in the baseline study (Kansas Gas and Electric Company 1974) and 50% lower than those reported in the 1974 monitoring study (Schamberger et al. 1975). The numbers recorded during the baseline and monitoring studies were higher than those reported by Preno and Labisky (1971) for wooded regions in east-central Illinois (0.83/count).

b. Eastern Cottontail Census

Results of the eastern cottontail censuses conducted in June and July 1975 showed only 0.05 rabbits per mile during each month (Table 3.3). These results are lower than those recorded in the baseline study (0.35 and 0.40/mile) and the 1974 monitoring study (0.20 and 0.13/mile). Preno and Labisky (1971) recorded a mean of 0.46/mile in Illinois. The decline in the 1975 rabbit census results paralleled the decline in squirrel and small mammal populations noted above.

3. Rare and Endangered Species

No rare or endangered species of mammals were observed during this study.

B. Avifauna

In Kansas, 383 species have been recorded, but only 184 species are known to breed in the state (Johnston 1965). A list of 183 avian species has been compiled within the Flint Hills National Wildlife Refuge (U. S. Dep. Interior 1970) which is located about 7 miles west of the study area. Bird species and numbers utilizing habitat in the Flint Hills National Wildlife Refuge between July 1974 and June 1975 have been documented by the U. S. Fish and Wildlife Service (Appendix B). Wetland habitats are abundant in the refuge and support approximately 63 aquatic or semi-aquatic avian species; these habitat types are not presently found near the Wolf Creek Generating Station site. Future development of the cooling lake will result in an increase in aquatic habitat with a corresponding increase of aquatic habitat with a corresponding increase of aquatic and semi-aquatic avian species. Ninety avian species were recorded near the Wolf Creek Generating Station site in 1975, including 29 permanent resident, 35 summer resident, 10 winter resident, and 16 migrant species (Table 3.8).

1. Transects

a. Community Analyses

Floodplain Woods (Community 1): Thirty-nine species of birds were recorded in the floodplain woods during the 1975 monitoring study. Of the permanent residents, the black-capped chickadee (*Parus atricapillus*), red-headed woodpecker (*Melanerpes erythrocephalus*), and cardinal (*Cardinalis cardinalis*) were most abundant. Many woodland species such as the brown creeper (*Certhia familiaris*) and ovenbird (*Siurus aurocapillus*) were recorded only in this community (Table 3.8). The number of observations was greatest in the winter (97.9/hr) and spring (72.6/hr) and lowest during June (8.0/hr; Table 3.9).

Abandoned Railroad Right-of-Way (Community 2): Thirty avian species were recorded in this community (Table 3.8). Meadowlarks (*Sturnella* spp.), mourning doves (*Zenaida macroura*), and mockingbirds (*Mimus polyglottos*) were the most common residents (Table 3.9). The large numbers of winter sparrows and meadowlarks accounted for the high number of birds (157.8/hr) recorded in January. The fewest birds were recorded in September (11.4/hr; Table 3.9).

Open Pasture (Community 3): The fewest number of species were recorded in this community (20 species; Table 3.8). Meadowlarks, mourning doves, and bobwhite (*Colinus virginianus*) were the most abundant permanent resident species. The greatest number of birds were present in summer when the dickcissel (*Spiza americana*), grasshopper sparrow (*Ammodramus savannarum*), and barn swallow (*Hirundo rustica*) were using the area (83.4/hr; Table 3.9). Numbers of observations were lowest in the fall and winter.

Mixed Shrub-grass Pasture (Community 4): The greatest number of species (42) was recorded in the mixed shrub-grass pasture. Bobwhite, cardinals and goldfinches (*Spinus tristis*) were the most common permanent residents (Table 3.8). The greatest number of birds (404.1/hr) was recorded in January when the dark-eyed junco (*Junco hyemalis*), tree sparrow (*Spizella arborea*), and Harris' sparrow (*Zonotrichia querula*) were abundant; relatively few birds were recorded in September (Table 3.9).

The total number of species observed in all communities was highest in May (55) and remained fairly stable at other times of the year (Table 3.8). Since pronounced spring and fall peaks were absent in the current study, it is likely that sampling periods did not correspond with peak migratory periods. In all communities sampled, greater numbers of birds were observed in the spring, fall, and winter sampling periods than during the summer censuses (Table 3.10).

b. Birds Species Diversity

Bird species diversity (BSD) was calculated for each community and sampling period. BSD values ranged from 0.69 to 2.96 (Figure 3.2). Seasonal patterns were similar for the open pasture, abandoned railroad right-of-way, and mixed shrub-grass pasture. BSD values in these communities were high in spring and generally decreased through fall, but increased dramatically in winter (Figure 3.2). The floodplain woods BSD was also high in spring, but fluctuated through the summer and then increased in September (Figure 3.2). Seasonal BSD values should peak in the fall and spring because of the influx of migrants, and should be lower in summer and winter. BSD values calculated for communities near the Wolf Creek Generating Station did not conform to this pattern. This discrepancy may have been caused by (1) sampling at times that did not correspond to peak migratory periods, and (2) a large influx of wintering sparrows in January.

BSD was generally higher in the floodplain woods and mixed shrub-grass pasture than in the open pasture or abandoned railroad right-of-way (Table 3.10). More complex physiognomic communities have greater BSD values (Karr 1968), and grasslands are known for low BSD values (Shugart and James 1973).

BSD values calculated for the communities in this study showed similar trends (Figure 3.2). The wooded communities had a greater structural and vegetational complexity than did the two grassland communities and calculated BSD values followed this complexity gradient.

c. Comparison with Baseline and 1974 Monitoring Studies

Data collected during the 1973 baseline study were not comparable to those collected during the 1975 monitoring study due to community location and sampling differences. Similarly, except for the abandoned railroad right-of-way, direct comparisons between the 1974 and 1975 monitoring data were not possible due to community changes in 1974. However, some general observations concerning the avifauna data are appropriate if one considers that the communities sampled are representative of habitat types, rather than specific sampling areas. The number of species observed in the open pasture and abandoned railroad right-of-way was lower in 1975 than 1974, whereas the floodplain woods and mixed shrub-grass pasture showed an increase in the number of species in 1975 over 1974 (Tables 3.11-3.14). In a like manner, the total individuals per hour was lower in the grassland communities and higher in the woodland communities in 1975 than in previous studies. It appears that avian populations have declined in the less stable grassland communities but increased in the wooded communities during 1975. A decline in the abundance of small mammals was also noted in the grassland communities. Woodland communities are generally more complex and less dependent on surface water than grasslands and respond less quickly to moisture stress. It is possible that declines in animal populations in grassland communities were related to summer drought in 1974 that may have reduced food supplies in the grasslands. Increased grazing pressure, weather conditions, and/or naturally occurring population cycles may also be partially responsible for the lower numbers in 1975.

2. 20-Mile Wildlife Survey Route

a. Seasonal Analysis

Eighty-one species were observed along the 20-mile survey route during the 1975 monitoring study (Table 3.8). The number of observed species remained fairly constant throughout the year, but was lower in November and January (Table 3.15). The numbers of birds recorded along the route were lower in the summer months and higher in November and January.

Species observed along the route reflected the diversity of habitats and seasonal changes in avifaunal composition. Many aquatic species such as the Canada goose (*Branta canadensis*), great blue heron (*Ardea herodias*), and mallard (*Anas platyrhynchos*) were recorded on ponds or feeding in grain fields near the route.

b. Comparison with Baseline and 1974 Monitoring Studies

The 81 species recorded along the 20-mile survey route during the 1975 monitoring study was higher than the 64 species observed during the 1973 baseline and the 1974 monitoring studies. The number of species noted per

month was approximately the same in 1974 and 1975 (Table 3.15). The number of observations was greater during 1974, largely due to a high count in January (Table 3.15). Yearly variations can be attributed to natural variability, weather conditions, and/or sampling bias.

3. Selected Game Species

a. Bobwhite

During the 1975 monitoring study, bobwhite were commonly observed in the railroad right-of-way, open pasture, and mixed shrub-grass pasture (Table 3.9). These communities are representative of the mixture of wooded, edge, and open field habitats that provide favorable habitat for bobwhite (Edminister 1954).

Bobwhite normally begin whistling in early April and reach peak activity between mid-June and mid-July in Kansas (Robel et al. 1969). Call counts made in June and July to estimate bobwhite populations resulted in an average of 20 and 16 calls/census route, respectively (Table 3.16). These results were lower than those reported by Preno and Labisky (1971) in Illinois counties where bobwhite maintain relatively high populations.

The average number of call counts recorded in 1975 (18) was lower than those of the 1974 monitoring study (39 calls/census route; Schamberger et al. 1975) and those of the 1973 baseline study (57 calls/census route; Kansas Gas and Electric Company 1974). Bobwhite have continued to decline in the area since 1973, and this may be correlated with environmental factors such as drought or severe winter weather.

b. Mourning Doves

Mean numbers of mourning doves along the 20-mile route were 33.0, 37.5, and 22.0 for May, June, and July 1975, respectively (Table 3.16). These values were within the mean of dove counts reported for the years 1962-1972 in Illinois (Preno and Labisky 1971). Comparable June and July counts made during the 1974 monitoring study were 29.5 and 36.0, respectively, indicating similar population levels between years.

4. Rare and Endangered Species

No rare or endangered avian species were observed during the 1975 monitoring study.

C. Reptiles and Amphibians

Seven species of herpetofauna were observed during the 1975 monitoring study (Table 3.17). The ornate box turtle (*Terrapene ornata*) was observed in several locations. Other reptiles and amphibians observed were the bullfrog (*Rana catesbeiana*), leopard frog (*R. pipiens*), western chorus frog (*Pseudacris triseriata*), map turtle (*Graetemys geographica*), false map turtle (*Graetemys pseudogeographica*), and western spiny softshell turtle (*Trionyx spinifer*). Discussion of Wolf Creek herpetofauna is not justified due to insufficient data.

D. Relationships Between Wildlife and the Environment

1. Mammals

Mammalian distribution near the proposed Wolf Creek Generating Station site was generally governed by vegetative cover and food availability, which in turn were governed by precipitation and land use practices. Larger species such as the white-tailed deer and raccoon were generally distributed throughout the area, but were only observed in wooded areas along Wolf Creek. Smaller species such as mice were more restricted to specific habitat types within the site.

Small mammal captures declined in 1975 from the 1974 levels, particularly in grassland habitats. Although captures were lower in woodlands as well, the decline was less in woodland than grassland communiities. This may be related to a greater susceptability of grasslands to drought conditions. Dry conditions in the summer of 1974 may have reduced food availability during the fall and winter of 1974-75, increasing winter mortality and decreasing the 1975 population. Other factors that may have influenced the lower 1975 capture rate could include weather conditions at the time of trapping, increased grazing in the pastures, increased predation, and naturally occurring population cycles.

Changing land use practices also affected mammalian populations as evidenced in data from the abandoned railroad right-of-way where the recorded numbers of species and individuals declined from 1974. Increased grazing near the community decreased adjacent cover and food; consequently, population declines were noted.

Mammal populations near the proposed Wolf Creek Generating Station site have therefore been influenced by the two variables described above; construction activities will soon become a third factor influencing local populations.

2. Avifauna

Avifaunal relationships with the environment were similar to those described for mammals; cover and food usually determined avain distribution and abundance. Data from 1975 also showed a decrease in avian species in grassland communities and an increase in species in woodland habitats. It is possible that the decrease in grasslands species was related to precipitation, and the increase in woodland species further reflected the greater stability of woodland communities to short-term stress.

3. Anticipated Construction Impacts

a. Sampling Communities

The sampling communities are not located within anticipated construction areas; therefore, little or no impact is expected on smaller species existing within these areas. Larger, more mobile species are expected to alter their home ranges to avoid construction areas.

b. Site

Small species residing within construction areas will probably be destroyed. Larger species will move out of the construction areas to avoid noise and vehicular traffic. Sensitive species will decline in numbers, and the more adaptable species will continue to use nearby areas. In areas where habitat quality is improved, carrying capacity will be increased and total populations will increase in such areas. Species that require a constant water source will increase; these will include aquatic, semi-aquatic, and riparian species. Amphibians and aquatic reptiles will increase, as will shorebirds, waterfowl, and marsh birds. In all probability, areas adjacent to the lake will have an elevated water table, and better vegetational growth will occur in areas where the roots can reach the water table; this increased vegetational growth will provide better habitat for wildlife populations, particularly small mammals. In other areas removed from the lake, land use will be the most significant factor influencing wildlife.

IV. Summary and Conclusions

1. The white-footed mouse and cotton rat were captured during live-trapping studies; the white-footed mouse represented 94% of all captures.

2. The greatest number of animals was captured in the floodplain woods where 90.6% of the animals were recorded. Captures in other communities, listed in order of decreasing abundance were: mixed shrub-grass pasture, abandoned railroad right-of-way, and open pasture.

3. Density estimates for the white-footed mouse in the floodplain woods averaged 21.5/ha.

4. Comparison of small mammal capture data with that of the 1974 monitoring study showed that fewer species and individuals were captured in 1975. Reduced captures could be related to: (1) residual impacts of the dry weather conditions of 1974, (2) weather conditions at the time of trapping, (3) decreased bait attractability in 1975 resulting from increased food availability, or (4) a low point in natural population cycles.

5. Squirrel populations, as indicated by time area counts, were 50% lower than similar counts conducted during the 1974 monitoring study and identical to those reported in the baseline study.

6. Results of the eastern cottontail censuses along the 20-mile route indicated a continued decline in rabbit populations in the area.

7. Ninety avian species were recorded during the 1975 monitoring study compared to 83 during the 1974 monitoring study and 78 during the baseline study.

8. The greatest number of avian species was recorded in the mixed shrub-grass pasture, followed by the floodplain woods, abandoned railroad right-of-way, and open pasture.

9. Bird species diversity values were generally higher in wooded communities than in grassland communities because of greater vegetational stratification and complexity in woodlands.

10. Eighty-one avian species were recorded along the 20-mile wildlife survey route.

11. An average of 18 bobwhite calls per census was recorded during the 1975 monitoring study. This was much lower than either the 1974 monitoring or baseline studies. Lower bobwhite numbers may be related to high winter mortality, poor nesting success, or increased predation.

12. Dove population data along the 20-mile wildlife survey route in 1975 were similar to the 1974 data.

13. Seven species of reptiles and amphibians were recorded.

14. No rare or endangered species were observed during this survey.

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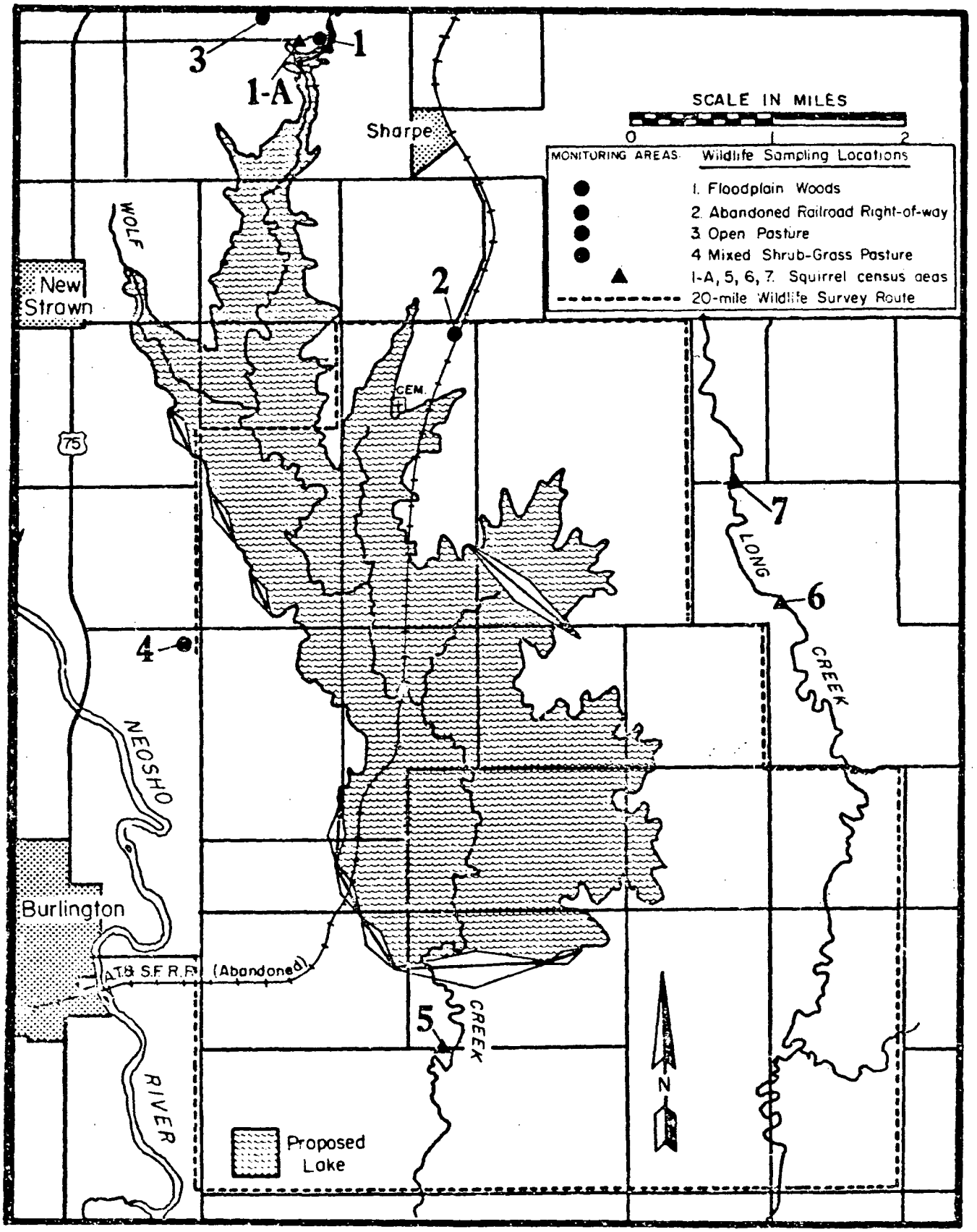

Figure 3.1. Wildlife sampling locations in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1975.

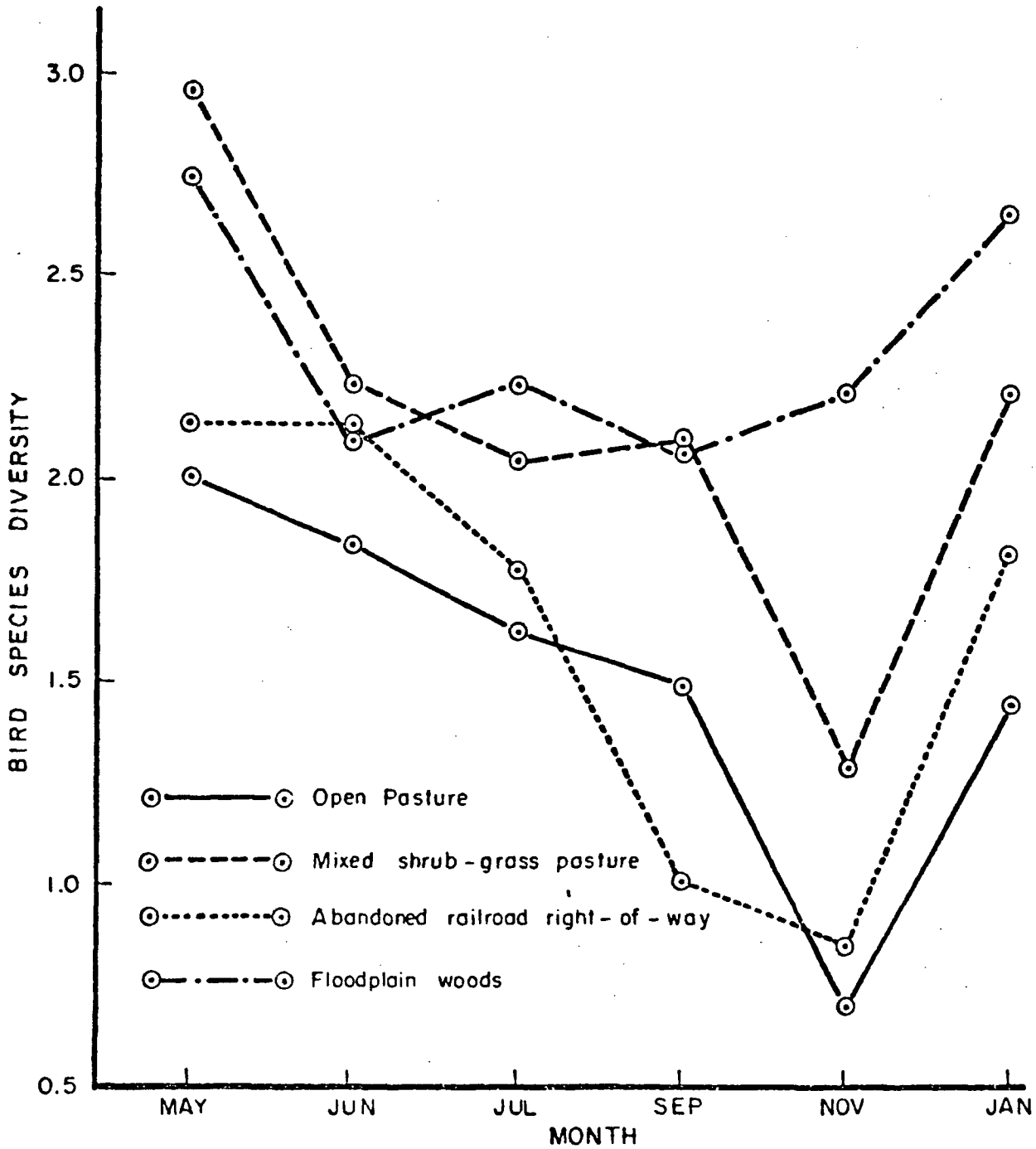

Figure 3.2. Bird species diversity in four communities in the vicinity of the Wolf Creek Generating Station Site, Burlington, Kansas, May 1975-January 1976.

Table 3.1 Number of trapnights, captures, species and small mammal individuals in four communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Site	Number of Trapnights	Captures: Original Captures	Captures: Total Captures	Number of Species	Number Per 100 TN[a]
Floodplain woods	350	33	58	1	16.6
Abandoned railroad right-of-way	350	2	2	1	0.6
Open pasture	350	--	--	--	--
Mixed shrub-grass pasture	350	3	4	1	1.1
Totals	1400	38	64	--	4.6

[a]Includes recaptures.

Table 3.2 Species list and number of small mammal captures in four communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, June, September, 1975.

Scientific Name	Common Name	Community: Floodplain Woods	Abandoned Railroad Right-of-way	Open Pasture	Mixed Shrub-grass Pasture	Species Totals	Species %[a]
Peromyscus leucopus	White-footed mouse	33(25)[b]	--	--	3(1)	36(26)	94.7
Sigmodon hispidus	Cotton rat	--	2	--	--	2	5.3
Community totals		33(25)	2	--	3(1)	38(26)	100.0
% Habitat utilization		90.6	3.1	0.0	6.3	100	

[a]Based upon original captures only.
[b]Numbers in parentheses represent recaptures.

NALCO ENVIRONMENTAL SCIENCES

Table 3.3 Incidental mammal observations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Location/Species	Date	Type of Observation	Number
Floodplain woods			
Eastern cottontail (*Sylvilagus floridanus*)	8 May	Sight	1
	16 July	Sight	1
Eastern fox squirrel (*Sciurus niger*)	8 May	Sight	2
	9 May	Sight	1
	18 July	Sight	1
Raccoon (*Procyon lotor*)	12 June	Tracks	2
Coyote (*Canis latrans*)	7 May	Calls	2
White-tailed deer (*Odocoileus virginianus*)	10 June	Tracks	1
	11 June	Sight	2
	17 July	Tracks	1-2
Abandoned railroad right-of-way			
Eastern cottontail (*Sylvilagus floridanus*)	25 Nov.	Sight	2
	20 Jan.	Sight	1
	22 Jan.	Sight	1
Mixed shrub-grass pasture			
Eastern cottontail (*Sylvilagus floridanus*)	9 May	Sight	1
	17 July	Sight	1
	11 Sept.	Sight	1
	22 Jan.	Sight	1
Eastern fox squirrel (*Sciurus niger*)	9 May	Sight	1
20-mile route			
Eastern cottontail (*Sylvilagus floridanus*)	8 May	Sight	1
	11 June	Sight	1
	16 July	Sight	1
Eastern fox squirrel (*Sciurus niger*)	7 May	Sight	1
	17 July	Sight	1
	10 Sept.	Sight	1
	25 Nov.	Sight	1
	22 Jan.	Sight	4
Striped skunk (*Mephitis mephitis*)	8 May	Odor	1
Coyote (*Canis latrans*)	10 June	Sight	1
	25 Nov.	Sight	1
	26 Nov.	Sight	1
Mouth of Wolf Creek			
Beaver (*Castor canadensis*)	8 Sept.	Cuttings	Several

Table 3.4 Monthly summary of number of original captures for small mammal species and each community in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Species/Community	Month		Totals
	June	September	
Species			
Peromyscus leucopus	27	9	36
Sigmodon hispidus	--	2	2
Monthly totals	27	11	38
Community			
Floodplain woods	26	7	33
Abandoned railroad right-of-way	--	2	2
Open pasture	--	--	--
Mixed shrub-grass pasture	1	2	3

Table 3.5 Density calculations for *Peromyscus leucopus* using mark-recapture data from a floodplain woods in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Month	Day 1		Day 2		Day 3		Day 4		Density
	Cap.	Recap.	Cap.	Recap.	Cap.	Recap.	Cap.	Recap.	(No./ha)
June	11	--	8	7	5	12	--	--	31
September	3	--	1	2	2	1	1	1	12
Mean									21.5

Table 3.6 Comparison of small mammal capture data from four communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1974-1975.

	Community							
	Floodplain Woods		Abandoned Railroad Right-of-way		Open Pasture		Mixed Shrub-Grass Pasture	
Species	1974	1975	1974	1975	1974	1975	1974	1975
Blarina brevicauda	8	--	2	--	1	--	--	--
Cryptotis parva	--	--	--	--	1	--	--	--
Peromyscus leucopus	94	58	--	--	--	--	3	4
P. maniculatus	--	--	3	--	12	--	2	--
Sigmodon hispidus	--	--	28	2	1	--	--	--
Microtus ochrogaster	--	--	--	--	6	--	--	--
Pitymys pinetorum	1	--	--	--	--	--	--	--
Total	103	58	33	2	21	--	5	4

Table 3.7. Number of squirrels sighted during 20-minute observation periods at four sites in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 20-21 January 1976.

Date	Site 1A	Site 5	Site 6	Site 7	Daily Mean/Site
20 January	1	1	0	0	0.5
21 January	1	0	1	4	1.5
Site mean	1.0	0.5	0.5	2.0	
Mean/site/day		1.0			

Table 3.8 Species list, residency status, and community and monthly occurrence of avifauna in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975-1976.

Scientific Name	Common Name	Residency[a] Status	Community 1	Community 2	Community 3	Community 4	20-Mile Survey	Month May	Month Jun	Month Jul	Month Sep	Month Nov	Month Jan
Phalacrocorax auritus	Double-crested cormorant	M					X				X		
Ardea herodias	Great blue heron	S					X	X	X		X		X
Butorides virescens	Green heron	S					X	X	X				
Branta canadensis	Canada goose	W					X						X
Chen caerulescens	Snow goose	M					X					X	
Anas platyrhynchos	Mallard	P					X	X				X	X
Carthartes aura	Turkey vulture	S					X	X					
Buteo jamaicensis	Red-tailed hawk	P	X		X	X	X	X	X	X	X	X	X
Buteo swainsoni	Swainson's hawk	S					X	X					
Circus cyaneus	Marsh hawk	W		X	X		X				X	X	X
Falco sparverius	American kestrel	P			X	X	X	X			X	X	X
Colinus virginianus	Bobwhite	P		X	X	X	X	X	X	X	X	X	X
Charadrius vociferus	Killdeer	S		X			X	X	X	X	X		
Tringa flavipes	Lesser yellowlegs	M					X	X					
Columba livia	Rock dove	P					X	X	X	X	X	X	X
Zenaida macroura	Mourning dove	P	X	X	X	X	X	X	X	X	X	X	
Coccyzus americanus	Yellow-billed cuckoo	S					X				X		
Bubo virginianus	Great horned owl	P	X			X						X	X
Chaetura pelagica	Chimney swift	S				X	X	X	X		X		
Archilochus colubris	Ruby-throated hummingbird	S					X				X		
Colaptes auratus	Common flicker	P	X	X	X	X	X	X	X	X	X	X	X
Centurus carolinus	Red-bellied woodpecker	P	X			X	X	X			X		X
Melanerpes erythrocephalus	Red-headed woodpecker	P	X			X	X	X	X	X	X	X	X

NALCO ENVIRONMENTAL SCIENCES

Table 3.8 (continued)

Scientific Name	Common Name	Residency[a] Status	Community 1	Community 2	Community 3	Community 4	20-Mile Survey	Month May	Month Jun	Month Jul	Month Sep	Month Nov	Month Jan
Dendrocopos villosus	Hairy woodpecker	P	X			X	X	X				X	X
Dendrocopos pubescens	Downy woodpecker	P	X	X		X	X			X	X	X	X
Tyrannus tyrannus	Eastern kingbird	S	X	X	X	X	X	X	X	X	X		
Tyrannus verticalis	Western kingbird	S					X		X				
Musivora forticata	Scissor-tailed flycatcher	S					X		X	X			
Myiarchus crinitus	Great-crested flycatcher	S	X					X					
Sayornis phoebe	Eastern phoebe	S					X	X			X		
Empidonax sp.	Flycatcher		X			X	X	X	X				
Contopus virens	Eastern wood pewee	S	X			X	X		X	X	X		
Eremophila alpestris	Horned lark	P		X	X		X	X	X	X		X	X
Stelgidopteryx ruficollis	Rough-winged swallow	S					X			X			
Hirundo rustica	Barn swallow	S		X	X	X	X	X	X	X	X		
Petrochelidon pyrrhonota	Cliff swallow	S					X			X			
Progne subis	Purple martin	S					X		X	X			
Cyanocitta cristata	Blue jay	P	X	X		X	X	X	X	X	X	X	X
Corvus brachyrhynchos	Common crow	P	X	X		X	X	X	X	X	X	X	X
Parus atricapillus	Black-capped chickadee	P	X	X		X	X	X	X	X	X	X	X
Parus bicolor	Tufted titmouse	P	X		X		X				X	X	X
Sitta carolinensis	White-breasted nuthatch	P	X				X	X			X	X	X
Certhia familiaris	Brown creeper	W	X										X
Troglodytes aedon	House wren	S	X			X	X	X	X	X	X		
Troglodytes troglodytes	Winter wren	W	X										X
Thryothorus ludovicianus	Carolina wren	P	X										X

NALCO ENVIRONMENTAL SCIENCES

Table 3.8 (continued)

Scientific Name	Common Name	Residency[a] Status	Community 1	2	3	4	20-Mile Survey	Month May	Jun	Jul	Sep	Nov	Jan
Mimus polyglottos	Mockingbird	P	X	X		X	X	X	X	X	X		X
Dumetella carolinensis	Gray catbird	S	X			X	X	X					
Toxostoma rufum	Brown thrasher	S	X	X	X	X	X	X	X	X	X	X	
Turdus migratorius	American robin	S		X		X	X	X	X	X	X		X
Catharus fuscescens	Veery	M	X			X	X	X					
Sialia sialis	Eastern bluebird	S	X				X		X	X	X		X
Regulus satrapa	Golden-crowned kinglet	M	X									X	
Lanius ludovicianus	Loggerhead shrike	P		X		X	X	X	X	X	X	X	X
Sturnus vulgaris	Starling	P	X			X	X	X	X	X	X	X	X
Vireo bellii	Bell's vireo	S					X	X					
Vireo olivaceus	Red-eyed vireo	S	X						X	X			
Vermivora ruficapilla	Nashville warbler	M					X				X		
Dendroica petechia	Yellow warbler	M	X				X	X		X			
Dendroica coronata	Yellow-rumped warbler	M	X					X					
Dendroica fusca	Blackburnian warbler	M					X				X		
Seiurus aurocapillus	Ovenbird	M	X								X		
Geothlypis trichas	Common yellowthroat	S					X		X				
Wilsonia pusilla	Wilson's warbler	M					X				X		
Passer domesticus	House sparrow	P		X			X	X	X	X	X	X	X
Sturnella sp.	Meadowlark			X	X	X	X	X				X	y
Sturnella magna	Eastern meadowlark	P		X	X	X	X		X	X	X		
Sturnella neglecta	Western meadowlark	S		X	X	X	X			X			
Agelaius phoeniceus	Red-winged blackbird	P		X			X	X	X	X	X	X	X

NALCO ENVIRONMENTAL SCIENCES

Table 3.8 (continued)

Scienctific Name	Common Name	Residency[a] Status	Community 1	Community 2	Community 3	Community 4	20-Mile Survey	Month May	Month Jun	Month Jul	Month Sep	Month Nov	Month Jan
Icterus spurius	Orchard oriole	S				X	X	X					
Icterus galbula	Northern oriole	S		X			X	X	X	X	X		
Quiscalus quiscula	Common grackle	S		X		X	X	X	X	X		X	
Molothrus ater	Brown-headed cowbird	P		X	X	X	X	X	X	X	X		X
Piranga rubra	Summer tanager	S	X					X	X				
Cardinalis cardinalis	Cardinal	P	X	X		X	X	X	X	X	X	X	X
Passerina cyanea	Indigo bunting	S	X				X	X	X	X			
Spiza americana	Dickcissel	S		X	X		X	X	X	X	X		
Spinus pinus	Pine siskin	W	X	X		X							X
Spinus tristis	American goldfinch	P	X	X	X	X	X		X	X	X	X	X
Passerculus sandwichensis	Savannah sparrow	M			X		X					X	X
Ammodramus savannarum	Grasshopper sparrow	S			X	X	X	X	X				
Pooecetes gramineus	Vesper sparrow	M					X			X			
Chondestes grammacus	Lark sparrow	S					X	X	X	X	X	X	
Junco hyemalis	Dark-eyed junco	M	X			X	X					X	X
Spizella arborea	Tree sparrow	W		X		X	X					X	X
Spizella pusilla	Field sparrow	P			X	X	X	X	X	X	X		X
Zonotrichia querula	Harris' sparrow	W		X		X	X	X				X	X
Zonotrichia leucophrys	White-crowned sparrow	W					X					X	X
Zonotrichia albicollis	White-throated sparrow	W					X						X
Passerella iliaca	Fox sparrow	M					X	X					
Melospiza lincolnii	Lincoln's sparrow	M					X					X	
Melospiza melodia	Song sparrow	W	X			X	X	X				X	
Total		90	39	30	20	42	81	55	44	42	46	36	42

[a] S = summer resident; W = winter resident; P = permanent resident; and M = migrant.

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Table 3.9 Number per hour and relative abundance of avifauna observed in four communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975-1976.

Species	May	Jun	Jul	Sep	Nov	Jan	Relative Abundance
			Floodplain Woods (Community 1)				
Red-tailed hawk	-	-	-	-	-	0.7	0.3
Mourning dove	4.0	-	-	-	-	-	1.4
Great horned owl	-	-	-	-	0.7	1.4	0.8
Common flicker	1.3	0.9	0.8	0.5	6.3	0.7	4.4
Red-bellied woodpecker	2.0	-	-	0.9	-	11.3	5.8
Red-headed woodpecker	3.3	-	-	2.3	5.6	13.4	10.2
Hairy woodpecker	0.7	-	-	-	-	0.7	0.5
Downy woodpecker	-	-	0.8	1.8	-	4.9	3.3
Eastern kingbird	6.0	-	-	-	-	-	2.5
Great-crested flycatcher	3.3	-	-	-	-	-	1.4
Flycatcher	7.3	-	-	-	-	-	3.0
Eastern wood pewee	-	0.4	1.6	0.5	-	-	1.1
Blue jay	1.3	0.4	2.4	2.8	-	10.6	6.6
Common crow	11.3	1.3	1.6	-	4.2	-	7.7
Black-capped chickadee	1.3	-	1.6	4.2	6.3	13.4	11.3
Tufted titmouse	-	-	-	1.4	1.4	7.0	1.7
Nuthatch	0.7	-	-	-	-	-	0.3
White-breasted nuthatch	-	-	-	0.5	0.7	4.2	2.2
Brown creeper	-	-	-	-	-	2.8	1.1
House wren	6.0	1.3	3.2	0.5	-	-	4.7
Winter wren	-	-	-	-	-	1.4	0.5
Carolina wren	-	-	-	-	-	1.4	0.5
Mockingbird	0.7	-	-	-	-	-	0.3
Gray catbird	0.7	-	-	-	-	-	0.3
Brown thrasher	-	-	3.2	-	-	-	1.1
Veery	0.7	-	-	-	-	-	0.3
Eastern bluebird	-	-	0.8	-	-	2.1	1.1
Golden-crowned kinglet	-	-	-	-	2.8	-	1.1
Starling	2.7	-	-	-	5.6	2.8	4.4
Red-eyed vireo	-	1.3	0.8	-	-	-	1.1
Yellow warbler	2.0	-	-	-	-	-	0.8
Yellow-rumped warbler	2.0	-	-	-	-	-	0.8
Ovenbird	-	-	-	0.5	-	-	0.3
Summer tanager	0.7	0.9	-	-	-	-	0.8
Cardinal	7.3	0.9	0.8	-	3.5	4.9	7.2
Indigo bunting	3.3	0.4	-	-	-	-	1.7
Pine siskin	-	-	-	-	-	5.6	2.2
American goldfinch	-	-	-	-	2.1	2.8	1.9
Dark-eyed junco	-	-	-	-	-	5.6	2.2
Song sparrow	2.7	-	-	-	-	-	1.1
Total	73.3	8.0	18.4	15.7	39.2	97.9	100.0
			Abandoned Railroad Right-of-Way (Community 2)				
Marsh hawk	-	-	-	-	-	3.8	0.7
Bobwhite	2.7	-	-	-	-	-	0.9
Killdeer	7.3	0.8	3.7	-	-	-	3.8
Mourning dove	10.0	5.6	2.8	5.7	2.1	-	8.8
Common flicker	-	-	0.9	-	-	2.6	0.7
Downy woodpecker	-	-	-	-	-	1.3	0.5
Eastern kingbird	1.3	0.8	0.9	-	-	-	0.7
Horned lark	-	-	-	-	4.9	2.6	2.1
Barn swallow	10.0	4.0	1.8	3.8	-	-	6.7
Blue jay	-	-	-	-	-	3.8	0.7
Common crow	-	-	-	-	-	6.4	1.2
Black-capped chickadee	-	-	-	-	-	1.3	0.2
Mockingbird	3.7	4.8	4.6	-	-	1.3	3.1
Brown thrasher	1.3	1.6	-	-	-	-	0.9
American robin	0.7	0.8	-	-	-	-	0.5
Loggerhead shrike	0.7	-	-	-	0.7	1.3	0.7
House sparrow	2.0	-	-	-	-	-	0.7
Meadowlark	8.0	-	-	-	-	55.1	13.1
Eastern meadowlark	-	3.2	-	1.9	-	-	1.7
Western meadowlark	-	-	4.6	-	-	-	1.2
Red-winged blackbird	-	1.6	-	-	-	15.4	3.3
Northern oriole	-	0.8	-	-	-	-	0.2
Common grackle	20.0	5.6	-	-	-	-	8.8
Brown-headed cowbird	2.7	-	-	-	-	-	0.9
Cardinal	-	-	-	-	-	1.3	0.2

Table 3.9 (continued)

Species	May	Jun	Jul	Sep	Nov	Jan	Relative Abundance
Abandoned Railroad Right-of-Way (Community 2)(continued)							
Dickcissel	1.3	-	-	-	-	-	0.5
Pine siskin	-	-	-	-	-	2.6	0.5
American goldfinch	-	-	-	-	-	7.7	1.4
Tree sparrow	-	-	-	-	59.2	51.3	29.6
Harris' sparrow	-	-	-	-	15.5	-	5.3
Total	68.7	29.6	19.3	11.4	82.4	157.8	100.0
Open Pasture (Community 3)							
Red-tailed hawk	0.7	-	-	-	-	1.9	1.4
Marsh hawk	-	-	-	0.7	-	-	0.5
American kestrel	-	-	-	0.7	-	-	0.5
Bobwhite	6.7	1.1	0.8	-	-	-	6.0
Mourning dove	1.3	0.6	3.2	2.1	-	-	4.6
Chimney swift	4.0	-	-	-	-	-	2.8
Common flicker	-	-	-	-	0.8	3.9	2.3
Eastern kingbird	1.3	0.6	0.8	-	-	-	1.9
Horned lark	-	2.2	-	-	-	-	1.9
Barn swallow	10.0	3.3	12.0	4.9	-	-	20.0
Brown thrasher	1.3	-	-	-	-	-	0.9
Meadowlark	14.0	-	-	-	0.8	3.9	12.0
Eastern meadowlark	-	3.8	4.0	1.4	-	-	6.5
Western meadowlark	-	-	0.8	-	-	-	0.5
Brown-headed cowbird	4.7	-	-	-	-	-	3.2
Dickcissel	22.0	2.2	6.4	0.7	-	-	21.3
American goldfinch	-	-	-	-	-	1.0	0.5
Savannah sparrow	-	-	-	-	-	1.0	0.5
Grasshopper sparrow	16.7	0.6	-	-	-	-	12.0
Field sparrow	0.7	-	0.8	-	-	-	0.9
Total	83.4	14.2	28.8	10.6	1.6	11.7	100.0
Mixed Shrub-Grass Pasture (Community 4)							
Red-tailed hawk	-	-	-	-	0.7	1.8	0.4
American kestrel	0.7	-	-	-	-	-	0.1
Bobwhite	4.7	6.8	3.8	-	-	51.8	10.8
Mourning dove	9.3	5.3	3.0	1.2	-	-	3.9
Great horned owl	-	-	-	-	-	4.5	0.7
Chimney swift	-	0.8	-	-	-	-	0.1
Common flicker	-	-	0.8	0.4	1.4	3.6	1.1
Red-bellied woodpecker	0.7	-	-	0.8	-	1.8	0.7
Red-headed woodpecker	6.7	0.8	-	-	-	0.9	1.6
Hairy woodpecker	-	-	-	-	-	0.9	0.1
Downy woodpecker	-	-	-	-	-	0.9	0.1
Eastern kingbird	2.7	-	-	-	-	-	0.5
Flycatcher	2.7	-	-	-	-	-	0.5
Eastern wood pewee	-	-	-	0.8	-	-	0.3
Barn swallow	0.7	0.8	0.8	-	-	-	0.4
Blue jay	3.3	0.8	0.8	0.4	1.4	2.7	1.8
Common crow	-	-	-	-	4.2	2.7	1.2
Black-capped chickadee	-	0.8	-	0.4	0.7	4.5	1.1
Tufted titmouse	-	-	-	-	-	1.8	0.3
House wren	2.7	-	-	-	-	-	0.5
Mockingbird	2.7	0.8	0.8	-	-	0.9	0.9
Gray catbird	1.3	-	-	-	-	-	0.3
Brown thrasher	8.7	0.8	-	0.8	-	-	2.2
American robin	1.3	1.5	-	-	-	20.9	3.7
Veery	2.7	-	-	-	-	-	0.5
Loggerhead shrike	0.7	-	-	-	-	-	0.1
Starling	1.3	-	-	-	-	-	0.3
Meadowlark	4.0	-	-	-	-	7.2	1.9
Eastern meadowlark	-	3.0	-	-	-	-	0.5
Western meadowlark	-	-	1.5	-	-	-	0.3
Orchard oriole	0.7	-	-	-	-	-	0.1
Common grackle	3.3	-	-	-	-	-	0.7
Brown-headed cowbird	5.3	-	-	-	-	-	1.1
Cardinal	7.3	0.8	3.8	-	1.4	9.1	4.0
Pine siskin	-	-	-	-	-	21.8	3.3

Table 3.9 (continued)

Species	May	Jun	Jul	Sep	Nov	Jan	Relative Abundance
			Mixed Shrub-Grass Pasture (Community 4)(continued)				
American goldfinch	-	0.8	4.5	1.2	-	43.6	8.0
Grasshopper sparrow	1.3	-	-	-	-	-	0.3
Dark-eyed junco	-	-	-	-	-	100.0	15.2
Tree sparrow	-	-	-	-	28.9	43.6	12.3
Field sparrow	1.3	3.0	1.5	0.4	-	-	1.2
Harris' sparrow	4.7	-	-	-	16.9	79.1	16.3
Song sparrow	0.7	-	-	-	-	-	0.1
Total	81.5	26.3	21.3	6.6	55.6	404.1	100.0

Table 3.10 Number of species, birds per hour, and species diversity of avifauna recorded by month in four communities in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975-1976.

Location/Type of Data	May	Jun	Jul	Sep	Nov	Jan
Floodplain woods						
Number of species	23	9	11	11	11	20
Birds per hour	72.6	8.0	18.4	15.7	39.2	97.9
Species diversity	2.74	2.11	2.25	2.09	2.21	2.67
Abandoned railroad right-of-way						
Number of species	14	11	7	3	5	15
Birds per hour	68.7	29.6	19.3	11.4	82.4	157.8
Species diversity	2.13	2.14	1.79	1.01	0.85	1.81
Open pasture						
Number of species	12	8	8	6	2	5
Birds per hour	83.4	14.2	28.8	10.6	1.6	11.7
Species diversity	2.01	1.84	1.62	1.49	0.69	1.44
Mixed shrub-grass pasture						
Number of species	26	14	10	9	8	21
Birds per hour	81.3	26.3	21.3	6.6	55.6	404.1
Species diversity	2.96	2.24	2.07	2.10	1.29	2.21

Table 3.11 Comparison of the numbers of species, birds per hour, and species diversity of the avifauna recorded on a floodplain woods community in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1974-1975.

Month	Number of Species		Birds Per Hour		Species Diversity	
	1974	1975	1974	1975	1974	1975
May[a]	18	23	37.3	72.6	2.63	2.74
June[a]	12	9	22.7	8.0	2.35	2.11
July[a]	12	11	22.0	18.4	2.24	2.25
September[a]	12	11	26.0	15.7	2.30	2.09
November	9	11	18.7	39.2	1.89	2.21
January[b]	10	20	17.3	97.9	1.96	2.67
Total	35	39	144.0	251.8	--	--

[a]Represent different communities.
[b]1975-1976.

Table 3.12 Comparison of the number of species, birds per hour, and species diversity of the avifauna recorded on the abandoned railroad right-of-way community in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1974-1975.

Month	Number of Species		Birds Per Hour		Species Diversity	
	1974	1975	1974	1975	1974	1975
May	21	14	69.6	68.7	2.66	2.13
June	17	11	63.3	29.6	2.62	2.14
July	18	7	79.3	19.3	2.42	1.79
September	13	3	239.0	11.4	1.53	1.01
November	15	5	176.0	82.4	1.98	0.85
January[a]	12	15	274.0	157.8	1.47	1.81
Total	37	30	901.2	369.2	--	--

[a]1975-1976.

Table 3.13 Comparison of the number of species, birds per hour, and species diversity of the avifauna recorded on an open pasture community in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1974-1975.

Month	Number of Species		Birds Per Hour		Species Diversity	
	1974	1975	1974	1975	1974	1975
May[a]	17	12	79.4	83.4	2.36	2.01
June[a]	15	8	51.3	14.2	2.26	1.84
July	8	8	50.7	28.8	1.69	1.62
September	7	6	54.0	10.6	1.44	1.49
November	9	2	64.0	1.6	1.37	0.69
January[b]	3	5	4.1	11.7	0.87	1.44
Total	25	20	303.5	150.3	--	--

[a]Represent different communities.
[b]1975-1976.

Table 3.14 Comparison of the number of species, birds per hour, and species diversity of the avifauna recorded on the mixed shrub-grass pasture community in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1974-1975.

Month	Number of Species		Birds Per Hour		Species Diversity	
	1974	1975	1974	1975	1974	1975
May	--[b]	26	--	81.3[c]	--	2.96
June	--	14	--	26.3[c]	--	2.24
July	21	10	54.7	21.3	2.77	2.07
September	13	9	25.0	6.6	2.43	2.10
November	13	8	82.7	55.6	1.93	1.29
January[a]	8	21	54.0	404.1	1.72	2.21
Total	41	42	216.4	487.6	--	--

[a]1975-1976.
[b]Not sampled.
[c]Not included in total.

Table 3.15 Comparison of the number of species and individuals observed along a 20-mile survey route in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973, 1974, 1975.

	Number of Species			Number of Individuals		
Month	1973	1974	1975	1973	1974	1975
May	37	42	45	471	837	1452
June	--[a]	45	41	--	955	1065
July	--	40	41	--	1630	791
September	27	43	42	530	1288	678
November	37	35	34	1806	2104	2568
January	--	31	33	--	5218	2242
Total	64	64	81	2807	12032	8796

[a] Not censused.

Table 3.16 Quail call counts and dove observations along a 20-mile census route in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

	No. Quail Call/2Min.						Dove Observations					
	May		Jun		Jul		May		Jun		Jul	
Mile	8	9	10	11	16	17	8	9	10	11	16	17
1	1	-	-	-	-	4	-	-	1	-	-	3
2	1	-	-	-	-	-	3	1	-	1	-	-
3	-	-	2	-	-	-	1	-	1	1	2	-
4	-	-	1	-	-	-	-	-	1	1	-	2
5	1	-	1	3	2	-	6	1	4	2	-	3
6	-	-	2	-	2	1	5	3	2	-	3	2
7	1	-	1	-	-	-	1	3	2	2	-	-
8	-	-	1	-	-	2	2	1	-	2	-	2
9	-	-	-	-	-	2	2	2	3	2	-	-
10	2	1	-	-	-	1	2	2	3	5	3	3
11	-	1	-	2	-	-	2	2	2	-	2	1
12	-	-	1	1	-	1	1	1	2	2	2	4
13	-	1	-	1	-	-	1	1	1	5	1	1
14	-	-	3	3	-	2	1	2	-	-	-	1
15	1	-	1	2	5	-	-	3	1	1	-	-
16	1	2	4	3	1	-	3	3	2	2	3	-
17	-	-	-	-	-	-	1	-	-	-	-	-
18	-	-	1	-	-	2	-	1	5	3	-	-
19	1	-	2	1	-	1	2	2	6	8	-	-
20	1	1	2	3	2	2	3	2	2	-	3	3
Total	10	6	22	19	12	18	36	30	38	37	19	25
Mean	0.50	0.30	1.10	0.95	0.60	0.90	33.0		37.5		22.0	

Table 3.17 Reptile and amphibian observations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Location/Species	Date	Type of Observation	Number
Floodplain woods			
Bullfrog (*Rana catesbeiana*)	12 Jun	Sight	2
Abandoned railroad right-of-way			
Ornate box turtle (*Terrapene ornata*)	9 May	Sight	1
Mixed shrub-grass pasture			
Ornate box turtle (*Terrapene ornata*)	10 Jun	Trap	1
	12 Jun	Trap	1
Twenty-mile route			
Ornate box turtle (*Terrapene ornata*)	8 May	Sight	1
	9 Sep	Sight	1
Wolf Creek, 1/2 mile S of proposed dam			
Western chorus frog (*Pseudacris triseriata*)	16 Apr	Sight	1
	8 Sep	Sight	1
Leopard frog (*Rana pipiens*)	8 Sep	Sight	2
Neosha River, 1/2 mile SE of mouth of Wolf Creek			
Map turtle (*Gratemys geographica*)	17 Apr	Hoop net	4
False map turtle (*G. pseudogeographica*)	17 Apr	Hoop net	8
Western spiny softshell turtle (*Trionyx spinifer*)	17 Apr	Hoop net	1
Neosha River, 1 mile NW of mouth of Wolf Creek			
Leopard frog (*Rana pipiens*)	8 Sep	Sight	1
Neosha River, 1 mile E of mouth of Wolf Creek			
False map turtle (*Graptemys pseudogeographica*)	8 Sep	Sight	1

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Chapter 4

WATER QUALITY STUDY

By

David J. Byrnes

I. Introduction

Water quality monitoring of surface and groundwater in the vicinity of the proposed Wolf Creek Generating Station has been conducted since 1973 (Kansas Gas and Electric Company 1974; Bowling and Ellis 1975) to establish baseline data on the concentrations of selected water quality parameters.

The objectives of the 1975 study were:

1. To provide additional baseline data on the water quality of the aquatic environments in the vicinity of the proposed nuclear facility;

2. To document the concentrations of aquatic nutrients, organically-derived materials and certain trace metals; and

3. To document any naturally occurring spatial or temporal variability in water quality.

II. Field and Analytical Procedures

A. Sampling Frequency, Locations and Parameters

1. Surface Water

Water samples for chemical and bacteriological analyses were collected quarterly, once during each season of 1975, in conjunction with aquatic biology sampling. They were collected at the seven locations identified in Figure 4.1 in the vicinity of the proposed nuclear facility:

a. Location 1: in John Redmond Reservoir, immediately above the reservoir outlet;

b. Location 2: in Wolf Creek, near the northernmost extent of the proposed cooling lake;

c. Location 3: in Wolf Creek, immediately downstream of the cooling lake dam site;

d. Location 4: in the Neosho River, approximately one mile downstream from its confluence with Wolf Creek;

e. Location 5: in Wolf Creek approximately one mile upstream from its confluence with the Neosho River;

f. Location 7: in Wolf Creek, upstream from the area to be inundated by the proposed cooling lake; and

g. Location 10: in the Neosho River, upstream from the confluence with Wolf Creek.

The meteorological and hydrological measurements made at each location are presented in Table 4.1 and the water quality parameters measured are listed in Table 4.2.

2. Groundwater

Groundwater samples were also collected quarterly from eight wells designated as B-12, C-6, C-20, C-50, D-28, D-42, D-55, and D-65, respectively. The location of these wells is also identified in Figure 4.1, and the water quality parameters measured are listed in Table 4.3.

B. Sampling Procedures

1. Surface Water

Duplicate water samples were collected at a depth of one meter, whenever possible, using a 6-liter, polyvinyl chloride sampler of the Van Dorn design. Immediately after collection, samples were preserved, placed in insulated containers, packed in ice, and shipped to the laboratory for analysis. The instrumentation, methodology, and precision of measurement for meteorological parameters and current velocity are presented in Table 4.1.

2. Groundwater

Single groundwater samples were obtained from 5 to 10 ft below the water level whenever possible, using a weighted sample bottle. When the well opening was too small to allow entry of the sample bottle, samples were obtained from a hand pump or tap source serving the well. The water level in each well was measured using a Soil-Test M-Probe and an engineer's rule.

Groundwater samples were preserved at the time of collection, placed in insulated containers, packed in ice, and shipped to the laboratory for analysis.

C. Analytical Procedures

The instrumentation, methodology and precision of measurement for meteorological parameters and current velocity are presented in Table 4.1. Water analyses were performed according to Standard Methods for the Examination of Water and Wastewater (APHA et al. 1975) and procedures accepted or developed by the Environmental Protection Agency. Water temperature, dissolved oxygen, pH, total alkalinity, and turbidity were measured in the field. References, preservation techniques, and analytical detection limits for the various water quality parameters are presented in Table 4.4.

Strict quality assurance procedures were followed in accordance with recommendations of the U. S. Environmental Protection Agency (1972). These procedures applied to field sampling, accuracy and precision of analytical methods, the calibration of laboratory instruments, and data reduction and analysis; they have been previously summarized by Bowling and Ellis (1975).

III. Results and Discussion

Water quality data will be discussed with respect to hydrology, seasonal fluctuations, variations among sampling locations, and previously reported data. Concentrations of the various water quality parameters will also be compared to

the Kansas State Board of Health Water Quality Standards (1973) (Table 4.5).

A. Surface Water Hydrology

The study area is geographically and hydrologically divided into three water systems, John Redmond Reservor, the Neosho River, and Wolf Creek (Figure 4.1).

Rainfall plays an important role in influencing both the hydrology and water quality of the three water systems. The most rain in 1975 occurred in June and the least in July (Figure 4.2). Precipitation was above normal in January, February, March, June, and November, and below during the rest of the year.

John Redmond Reservoir has a conservation pool elevation of 315.77 m (1036 msl) with a capacity of 69.7 x 10^6 m^3 (56450 acre-ft) (U. S. Army Corps of Engineers 1975). The maximum storage volume recorded during 1975 was 181,321 acre-ft on 25 June and the minimum was 56568 acre-ft on 30 December 1975 (U. S. Army Corps of Engineers 1975) (Figure 4.3). During 1975 the maximum storage volume as well as the highest inflow and outflow recordings at the reservoir occurred during June (Figure 4.3). This was a result of above-normal precipitation in the John Redmond Reservoir-Neosho River drainage basin during this period.

Flow in the reach of the Neosho River studied is regulated by discharge from John Redmond Reservoir. During 1975, flow was greater in April and June and lower in September and December. This is similar to the pattern observed in 1974 (Bowling and Ellis 1975).

Rainfall and snowmelt runoff are the main water sources for Wolf Creek, and in 1975 flow in the creek was intermittent. There was sufficient precipitation during April and June to maintain flow in the creek, but in September and December the creek was reduced to a series of isolated pools due to lack of adequate precipitation. This caused marked changes in the physical, chemical, and biological characteristics of the creek.

In general, the water quality of the Neosho River and John Redmond Reservoir was similar. However, in April, and particularly in June, the water quality of the Neosho River was significantly affected by water from Wolf Creek.

Rainfall had a greater impact on the water quality of the Neosho River and Wolf Creek than on John Redmond Reservoir. This was also observed in 1974 (Bowling and Ellis 1975). Precipitation, drought, and changes in stream flow had major impacts on water quality during 1975.

B. Surface Water Quality Characteristics

Results of water analyses and physical and meteorological measurements made in April, June, September, and December 1975 are tabulated in Appendix C. The minimum, maximum, and mean concentrations for each parameter on each sampling date of the 1975 surface water study are listed in Table 4.6. Comparisons of data from 1973 (Kansas Gas and Electric Company 1974), 1974 (Bowling and Ellis

1975), and 1975 for John Redmond Reservoir, the Neosho River, and Wolf Creek are presented in Tables 4.7, 4.8, and 4.9, respectively.

1. General Water Quality Parameters

The ranges of concentration measured for most of the general water quality parameters in John Redmond Reservoir and the Neosho River were similar to previous studies (Tables 4.7 and 4.8), although slightly wider ranges of filtrable residue, specific conductance, and sulfate were recorded in both water systems during 1975. However, in Wolf Creek during 1975 the ranges of concentration for most general water quality parameters showed much more variability than in previous studies (Table 4.9). When the creek was flowing, the concentrations of the general water quality parameters were similar to previous years. However, when the creek was reduced to a series of isolated pools, major changes in the concentration of most parameters occurred. This change in hydrology resulted in lower concentrations of dissolved oxygen, pH, total alkalinity, filtrable residue, specific conductance, and sulfate. It also resulted in higher concentrations of nonfiltrable residue, turbidity, and true color.

Water temperatures ranged from 0.0C (32.0F) to 24.1C (75.4F) and followed a normal seasonal trend being highest in summer and lowest in winter (Figure 4.4). Water temperatures were generally similar in the reservoir, the Neosho River, and Wolf Creek on all sampling dates.

Dissolved oxygen concentrations ranged from 5.9 to 13.5 mg/l in the reservoir, 5.6 to 13.6 mg/l in the Neosho River, and 0.2 to 9.6 mg/l in Wolf Creek (Figure 4.4). Dissolved oxygen in the reservoir and Neosho River was highest during the winter and lowest in summer, reflecting the increase in oxygen solubility with decreasing water temperatures (Reid 1961). The ranges of dissolved oxygen concentrations in John Redmond Reservoir and the Neosho River were similar in 1975 and were comparable to those observed in previous studies (Tables 4.7 and 4.8).

Dissolved oxygen concentrations in Wolf Creek were similar to concentrations measured in the reservoir and river only during April and June when water was flowing in the creek. Dissolved oxygen in the pools of Wolf Creek ranged from 4.3 to 5.8 mg/l in September and from 0.2 to 5.2 mg/l in December (Table 4.6). Although the concentrations observed in September were low, they were adequate to support aquatic life (McKee and Wolf 1963). In December, dissolved oxygen at Locations 5 and 7 in Wolf Creek was slightly lower than in September at these locations (Figure 4.4), but was also adequate to support aquatic life. The lower oxygen was due in part to a slight ice cover preventing reaeration from the atmosphere and increased oxygen demand due to bacterial decomposition and oxidation of organic material (Reid 1961; Hynes 1966; Slack and Feltz 1968).

The concentrations recorded at Locations 2 and 3 in the creek in December were not adequate to support most aquatic life (McKee and Wolf 1963). Dissolved oxygen in the pool at Location 2 ranged from 1.4 to 4.0 mg/l. A large accumulation of decomposing leaves and rat-tailed maggots, Tubifera (formerly Eristalis), were present in this pool (Chapter 8). This benthic

organism is generally indicative of poor water quality (Hynes 1966). Near anoxic conditions (0.2 mg/l) were recorded at Location 3. This pool was very shallow, and thick ice cover prevented reaeration. It had the largest accumulation of decomposing leaves, putrefaction was advanced, and rat-tailed maggots were again present (Chapter 8). Similar conditions of near anoxia resulting from ice cover, large amounts of decomposing leaves, and the presence of Tubifera in isolated pools of an intermittent stream were recorded by Larrimore et al. (1959).

Oxygen saturation ranged from 59 to 106% in the reservoir and river; the highest levels in the reservoir and river were recorded in April and December, respectively (Table 4.6). Saturations were lowest in both the reservoir and river in June. Saturation levels ranged from 2 to 93% in Wolf Creek. They were highest when water was flowing in the creek and lowest when pools existed.

The pH was usually similar in the reservoir and the Neosho River (Figure 4.5) ranging from 7.1 to 8.2; however, on 9 June lower pH values were recorded at the river locations. The pH of Wolf Creek ranged from 6.0 to 7.7 and in April and June was lower than in the reservoir, but similar to the river (Figure 4.5). The lowest pH's were recorded in December when values ranged from 6.0 to 6.4. The decrease in pH may have been caused by increased bacterial decomposition in the shallow pools which increased carbon dioxide concentrations and ultimately reduced the buffering capacity of the pools (Welch 1952; Slack and Feltz 1968). The pH was generally similar at all of the creek locations over the study period with the exception of 8 September when significant differences were observed between all creek locations (Figure 4.5).

Total alkalinity was similar in the reservoir and Neosho River on all sampling dates with the exception of 10 June when lower alkalinities were recorded at the river locations (Figure 4.5). Concentrations ranged from 139 to 201 mg/l-$CaCO_3$ with the highest concentrations observed in December and the lowest in June.

In Wolf Creek, alkalinities ranged from 52 to 198 mg/l-$CaCO_3$ (Table 4.6), with the values being higher in April and lower in June and December. The lower concentrations in June resulted from dilution after periods of heavy rainfall (Figure 4.2) and at this time also caused a decrease in the alkalinity of the Neosho River below its confluence with Wolf Creek (Figure 4.5).

The low alkalinities measured in December in the isolated pools may have been due to the reduced volume of the pools, the accumulation of organic matter, and the release of carbon dioxide from bacterial decomposition (Hynes 1966). Although the creek is in a limestone-rich area, the deposition of organic matter along the bottom of the pools may have reduced the buffering capacity by preventing the water from coming into contact with the limestone (Neel 1951). Increases in free carbon dioxide and carbonic acid may have occurred and resulted in lower pH and alkalinity.

Filtrable residue (total dissolved solids) concentrations were similar in the reservoir and river and ranged from 262 to 420 mg/l, while

concentrations in Wolf Creek ranged from 181 to 440 mg/l (Table 4.6). Significant differences between the Neosho River locations upstream (10) and downstream (4) of Wolf Creek were observed in April and June (Figure 4.6). In April, the concentrations at the downstream location (4) were much higher than upstream because water from Wolf Creek contained higher amounts of filtrable residue. In June concentrations at Location 4 were lower as a result of dilution by water from the creek which contained less filtrable residue.

Filtrable residue was directly related to specific conductance (Figure 4.7) which ranged from 273 to 662 μmhos/cm (25C) in the reservoir and river and from 160 to 651 μmhos/cm (25C) in the creek. Conductance was generally similar in the reservoir and river and lower in Wolf Creek (Figure 4.6). Conductance at the downstream location (4) in the river was significantly lower than upstream in June, due to dilution by water from Wolf Creek. Conductance values in Wolf Creek were highest in April and decreased thereafter. There was wide variability among all sampling locations in Wolf Creek on each sampling date.

Relative to the other water bodies, nonfiltrable residue (total suspended solids) and turbidity were always low in the reservoir ranging from 4 to 59 mg/l and 14 to 45 NTU, respectively (Figure 4.8). Nonfiltrable residue and turbidity ranged from 2 to 350 mg/l and 8 to 190 NTU in the Neosho River, with higher concentrations recorded in April and June. With the exception of April, turbidity and nonfiltrable residue were always higher in Wolf Creek than in the reservoir or river. Turbidity ranged from 12 to 250 NTU and nonfiltrable residue ranged from 6 to 548 mg/l in the creek (Table 4.9). Turbidity and nonfiltrable residue concentrations were directly related in all three aquatic ecosystems (Figure 4.9).

High nonfiltrable residue and turbidity were measured in the Neosho River and Wolf Creek in April and June, because surface runoff transported soil particles into the water systems. Turbidity and nonfiltrable residue concentrations during September and December in the Wolf Creek pools were primarily a result of leaf litter and decaying organic matter which accumulated in the pools.

True color values were generally similar in the reservoir and river ranging from 8 to 38 color units (Table 4.6). Color was normally much higher in Wolf Creek than in either the reservoir or river and ranged from 13 to 104 color units. In all three water systems, color was directly related to nonfiltrable residue (Figure 4.9). A similar relationship was observed in 1974 (Bowling and Ellis 1975).

Color at the downstream location (4) in the Neosho River was significantly higher than at the upstream location (10) in June because highly turbid and colored water from Wolf Creek emptied into the river. The highest color values were recorded in Wolf Creek in December, as a result of leaching of organic matter which accumulated in the isolated pools (Larrimore et al. 1959; Hem 1970).

Sulfate concentrations in the reservoir and river were similar, ranging from 29 to 99 mg/l (Table 4.6). Slightly lower concentrations in the

river in June resulted from dilution following periods of heavy rainfall (Figure 4.2). Sulfate concentrations in Wolf Creek were much more variable than in the reservoir or river and ranged from 7.0 to 148 mg/l, with the highest concentration measured in April and the lowest in December (Table 4.6). Reduction of sulfate to hydrogen sulfide as the oxygen levels became depressed probably contributed to the low sulfate concentrations in the pools in December (Welch 1952; Hynes 1966). This reduction was particularly evident at Location 3 where only 0.2 mg/l of dissolved oxygen were measured in December and sulfate levels had decreased to 7.0 mg/l.

2. Aquatic Nutrients

The range of concentration observed for ammonia, nitrate, total organic nitrogen, orthophosphate, and total phosphorus in John Redmond Reservoir and the Neosho River were similar and were within ranges observed in previous studies (Tables 4.7 and 4.8). Silica and nitrate concentrations in the reservoir and river were generally lower than in previous studies. The range of concentration for all aquatic nutrients showed more variability in Wolf Creek in 1975 than in previous years (Table 4.9) due to the change in hydrology from a lotic or flowing environment to a series of isolated pools.

Ammonia concentrations ranged from 0.01 to 0.09 mg/l-N in the reservoir, <0.01 to 0.20 mg/l-N in the river, and <0.01 to 0.11 mg/l-N in Wolf Creek (Figure 4.10). Concentrations in the reservoir and river were high in April and June and low in September and December. The higher ammonia concentrations occurred when surface runoff from pasturelands and drainage from fertilized croplands in the study area were high. Ammonia was also increased at all Wolf Creek locations in April and June by the surface runoff. In September, concentrations in the creek were much higher at the northernmost location (7) than elsewhere because this pool was being used by domestic livestock as a watering hole. The decomposition of wastes from these animals may have caused higher ammonia levels in this pool. In December, ammonia was higher in the creek at Locations 2 and 3 because of the decomposition of organic matter which had accumulated in these two pools.

Nitrate concentrations were similar in the reservoir and river, ranging from 0.50 to 1.4 mg/l-N with higher concentrations measured in April and June (Figure 4.10). Nitrate ranged from 0.04 to 1.1 mg/l-N in Wolf Creek with higher concentrations also recorded in April. The higher concentrations in all three aquatic systems resulted from surface runoff and the oxidation of ammonia to nitrate. Concentrations were substantially lower in June at Location 4 in the Neosho River downstream from the confluence with Wolf Creek due to dilution by water from the creek.

Nitrite concentrations ranged from 0.019 to 0.065 mg/l-N in the reservoir, 0.013 to 0.033 mg/l-N in the river, and 0.0007 to 0.13 mg/l-N in the creek. Concentrations were higher in the reservoir in June and September, highest in the river in September, and highest in the creek in December (Table 4.6).

Total organic nitrogen concentrations were generally similar in the reservoir and river, with the exception of June when slightly higher concentrations were measured in Neosho River (Figure 4.11). The ranges of concentrations measured were 0.55 to 0.90 mg/l and 0.42 to 1.4 mg/l in the reservoir and river, respectively. Total organic nitrogen in Wolf Creek ranged from 0.50 to 2.1 mg/l with higher concentrations in June. Concentrations were generally higher in Wolf Creek than in either the reservoir or river with the exception of April. The high concentrations in both the river and creek in June resulted from increased surface runoff at this time.

Total organic nitrogen was significantly higher at the downstream location (4) in the Neosho River than at the upstream location (10) in June (Figure 4.11) due to influence from Wolf Creek. In September and December, wide, random differences were observed between the creek locations. This probably resulted from differences in the relative amounts of organic matter decomposing in each pool.

Soluble orthophosphate concentrations followed the same pattern in both the reservoir and river; higher concentrations were measured in June and lower concentrations were measured in April (Table 4.6). Concentrations ranged from 0.002 to 0.048 mg/l-P in the reservoir and 0.015 to 0.099 mg/l-P in the river. Higher concentrations in both the river and reservoir in June can be attributed to increased surface runoff. Concentrations in the reservoir-river system declined after June, probably a result of uptake by phytoplankton populations in summer and fall (Chapter 5).

Soluble orthophosphate concentrations in Wolf Creek ranged from <0.001 to 0.35 mg/l-P, with lower concentrations measured in April and higher concentrations in December. The high concentrations in the pools in December resulted from the conversion of organic phosphorus to orthophosphate. The rate of this conversion increases as the pH is decreased (Sawyer and McCarty 1967).

Total phosphorus concentrations followed a pattern similar to that of orthophosphate in all three aquatic environments. Concentrations ranged from 0.044 to 0.14 mg/l-P in the reservoir, and from 0.034 to 0.36 mg/l-P in the river (Table 4.6). Total phosphorus concentrations in the creek ranged from 0.005 to 0.62 mg/l and were highest in December.

Silica concentrations were similar in the reservoir and river ranging from 0.34 to 8.5 mg/l-SiO_2. Concentrations were highest during June and decreased thereafter, probably as a result of depletion by diatom populations. Silica ranged from 0.26 to 11.3 mg/l-SiO_2 in Wolf Creek in 1975 and in June concentrations were similar to the reservoir and river. In September and December silica concentrations were much greater in the isolated pools of Wolf Creek than in either the reservoir or river (Table 4.6).

3. Industrial and Municipal Contaminants

The range of counts observed for fecal coliform and bacteria in the reservoir-river system was within ranges previously reported. The ranges observed for biochemical oxygen demand, chemical oxygen demand,

and hexane solubles in John Redmond Reservoir and the Neosho River were slightly higher in 1975 than in previous years (Tables 4.7 and 4.8). In Wolf Creek, the ranges of concentrations observed for all parameters indicative of industrial and municipal discharges, with the exception of fecal coliform counts, were much greater in 1975 than in previous years (Table 4.9).

Fecal coliform bacteria densities in the reservoir ranged from 0 to 2 organisms per 100 ml with the exception of April when densities ranging from 170 to 380 organisms per 100 ml were recorded. Fecal coliforms ranged from 10 to 290 organisms per 100 ml in the Neosho River, with the higher counts recorded in April and June. The higher counts in these months were due to increased surface runoff. Bacteria densities were generally greater at the downstream location in the Neosho River (4) than at the upstream location (10), especially when Wolf Creek was emptying into it (Table 4.6).

Fecal coliform densities in Wolf Creek ranged from 67 to 750 organisms/100 ml (Table 4.6). There was little temporal variation in the counts, although slightly lower counts were recorded in June; there was usually wide variation among locations on each sampling date (Table 4.6). Localized runoff of animal wastes was the probable origin of fecal coliform bacteria in all three aquatic environments (Bowling and Ellis 1975).

Biochemical oxygen demand (B.O.D.) ranged from 0.4 to 4.1 mg/l in the reservoir and river and followed the same pattern in both, being highest in April and lowest in September (Figure 4.12). The B.O.D. in Wolf Creek ranged from 1.3 to 5.2 mg/l and was greatest in December. With the exception of April, B.O.D. was usually higher in Wolf Creek than in either the reservoir or river. The higher B.O.D. in the creek in December reflected the environmental stress occurring in the isolated pools (Larrimore et al. 1959).

Chemical oxygen demand (C.O.D.) ranged from 13 to 27 mg/l in the reservoir, and was highest in April and lowest in June (Figure 4.12). Chemical oxygen demand ranged from 13 to 37 mg/l in the river and from 18 to 50 mg/l in Wolf Creek; concentrations were highest in spring and summer and decreased thereafter. The high C.O.D. concentrations in April and June were a result of surface runoff which increased the amount of suspended solids and their associated constituents in the water systems (Delfino and Byrnes 1975). Chemical oxygen demand was generally higher in Wolf Creek than in the reservoir or river. Biochemical oxygen demand and C.O.D. appeared to be directly related in all three aquatic environments. Chemical oxygen demand was significantly higher at the downstream location (4) in the Neosho River than at the upstream location (10) in June because water emptying into the river from Wolf Creek contained a higher C.O.D.

Total organic carbon (T.O.C.) ranged from 8.6 to 25 mg/l in the reservoir with the highest concentrations measured in June and the lowest in December (Figure 4.11). Total organic carbon in the Neosho River ranged from 13 to 37 mg/l and was highest in the spring and summer as a result of surface runoff and lowest in the winter. Total organic carbon ranged from 8 to 37 mg/l in Wolf Creek with a mean concentration of 26 mg/l. Higher T.O.C. concentrations in April and June probably resulted from surface runoff; however, the high

concentrations in December resulted from the accumulation of organic matter in the pools. The relationship between T.O.C. and C.O.D. was somewhat obscure, but C.O.D. was generally highest when T.O.C. was greatest (Figure 4.13).

Hexane soluble materials ranged from 0.8 to 2.0 mg/l in the reservoir with the highest concentrations measured in September. Concentrations ranged from 0.5 to 2.3 mg/l in the river and 0.2 to 4.1 mg/l in the creek. Concentrations in both the river and creek were highest in June, probably a result of surface runoff.

4. Trace Metals

The ranges of trace metal concentrations in the reservoir-river system in 1975 were similar to previous years (Table 4.7 and 4.8). The ranges of trace metal concentrations observed in Wolf Creek in April and June of 1975 were similar to previous years. However, in September and December 1975 copper, iron, manganese, and zinc concentrations were much higher than in 1974 (Table 4.9).

Total copper concentrations in John Redmond Reservoir ranged from 1.8 to 5.3 μg/l and varied little from the yearly mean of 3.1 μg/l. Copper concentrations in the Neosho River ranged from 1.5 to 10 μg/l and were highest in June as a result of surface runoff. Concentrations in Wolf Creek ranged from 1.2 to 19 μg/l and were also highest in June. High copper concentrations were also measured in December in Wolf Creek and probably were partially due to bacterial decomposition of organic matter in the isolated pools (Hutchinson 1967).

Total iron and total manganese concentrations followed essentially the same trends in all three aquatic environments during 1975. Iron concentrations ranged from 0.32 to 2.5 mg/l and manganese ranged from 0.025 to 0.10 mg/l in the reservoir (Figure 4.14). Iron concentrations were highest in the reservoir in June, whereas manganese was highest in September. Iron concentrations ranged from 0.19 to 11.0 mg/l in the river and from 0.58 to 17.9 mg/l in the creek; manganese ranged from 0.030 to 0.22 mg/l in the river and 0.10 to 1.1 mg/l in the creek (Table 4.6). Concentrations of both were highest in June in the river and creek, and were directly related to turbidity and suspended solids increases at this time. Similar relationships have been found in previous studies (Bowling and Ellis 1975).

Iron and manganese concentrations at the downstream location (4) in the Neosho River were significantly increased in June as a result of loading from Wolf Creek. Iron and manganese concentrations also were high in Wolf Creek in September and December because of decomposition of leaf litter in the isolated pools. Decomposition of leaf material is known to increase total iron and manganese concentrations (Larrimore et al. 1959; Slack and Feltz 1968).

Total lead, total mercury, and total zinc concentrations varied randomly during the study period. Lead concentrations ranged from <1 μg/l to 2 μg/l in the reservoir, from <1 to 9 μg/l in Neosho River, and from <1 μg/l to 30 μg/l in Wolf Creek (Table 4.6). Concentrations were always lowest in the reservoir and generally highest in Wolf Creek. Mercury ranged from 0.76 to

9.2 μg/l in the reservoir, from 0.45 to 6.7 μg/l in the river, and from 0.18 to 6.4 μg/l in Wolf Creek. Mercury concentrations were greatest in all three aquatic environments in April probably as a result of surface runoff. Zinc concentrations ranged from 4.6 to 8.3 μg/l in John Redmond Reservoir and were highest in April. Concentrations of zinc in the Neosho River and Wolf Creek ranged from 1.6 to 52 μg/l and 2.0 to 80 μg/l, respectively, and were highest in June because of increased surface runoff.

C. Comparisons to Water Quality Criteria

The results of the comparisons of observed water quality in the reservoir, river, and creek with the Kansas State Board of Health regulations (1973) are summarized in Table 4.5. All water temperatures and fecal coliform bacteria counts complied with the regulations.

Dissolved oxygen concentrations were always above the recommended minimum level of 5.0 mg/l in John Redmond Reservoir and the Neosho River. Concentrations were below 5.0 mg/l in Wolf Creek at Locations 2 and 3 in September and at all locations in December. The change in creek hydrology from a flowing stream to a series of isolated pools during these months promoted physical and chemical changes in the creek environment which ultimately caused the depressed oxygen levels.

The pH at all Wolf Creek sampling locations was below the minimum criterion of 6.5 in December. This was also a result of chemical changes induced by the change in the hydrology of Wolf Creek.

Ammonia concentrations complied with state standards because they were always below the maximum limit of 0.15 mg/l-N in John Redmond Reservoir and Wolf Creek. Concentrations exceeded 0.15 m/gl at both locations in the Neosho River in April due to increased surface runoff.

There was no evidence of increases in turbidity, solids, color, taste, and odor producing substances or toxic substances resulting from any sources other than natural origins. There was also no evidence of oil or grease at any of the sampling locations.

D. Groundwater

1. Hydrology

The groundwater province in which the eight wells are located is known as the South Central Paleozoic. The aquifers in this area are classified as alluvial, soil and weathered bedrock, and consolidated bedrock. The regional alluvial aquifer is comprised of silts, sands, and gravels. The soil and weathered bedrock aquifer is comprised of shale, siltstone, sandstone, and limestone and the soils derived from them. The overlying alluvial aquifer is hydraulically connected to the lower weathered bedrock aquifer. Recharge to both is from local precipitation percolating through the soil. Thus, the water table elevation is responsive to local precipitation-drought conditions (Kansas Gas and Electric Company 1974).

2. Water Quality Characteristics

In general, there was little temporal variation in the water quality of any of the wells sampled (Appendix C, Table C.3); however, there was some wide spatial variation among the wells.

Water temperature was generally similar in all the wells ranging from 11.2 to 23.5C. The pH values were also similar in the wells ranging from 6.6 to 7.6. Slightly lower pH levels were measured at most of the wells in September and December. This was similar to the trend observed in surface waters.

Alkalinity ranged from 135 at well D-65 to 462 mg/l-$CaCO_3$ (well B-12), with lower alkalinities consistently measured at D-65 and higher concentrations at wells B-12 and C-50 (Figure 4.1). Alkalinity was generally much higher in the groundwater than in surface waters, due to the limestone-rich nature of the geological strata.

Filtrable residue and specific conductance were very high in most groundwater samples ranging from 302 to 3580 mg/l and 740 to 4795 μmhos/cm (25C), respectively. All of the wells with the exception of D-55 exceeded the U. S. Public Health Service drinking water standard of 500 mg/l nonfiltrable residue. The highest nonfiltrable residue concentrations and specific conductance were consistently measured in well D-65.

Calcium and magnesium ranged from 71 to 166 mg/l and 10.0 to 83.8 mg/l, respectively, and were consistently higher in wells C-20, C-50, and D-28.

Sodium concentrations ranged from 6.2 to 259 mg/l while chloride concentrations ranged from <0.5 to 385 mg/l; both were always highest in well D-65. Potassium ranged from 0.83 to 6.5 mg/l and was highest in well D-28 and lowest in D-42.

Sulfate concentrations ranged from 9 to 300 mg/l. Sulfate showed larger temporal variability than many of the other parameters measured, with concentrations being higher in spring and summer and lowest in winter. Sulfate was generally highest in well D-28 and lowest in D-65. Sulfate exceeded the U. S. Public Health Service drinking water standard of 250 mg/l in April at wells D-28 and D-42, in June at C-50 and D-42, and in September at D-42.

Nitrate concentrations ranged from 0.05 to 120 mg/l-N with the exception of well D-65 where nitrate ranged from 420 to 550 mg/l-N. Concentrations were highest in the spring at all wells and may have been due to percolation of fertilizer into the groundwater (Hem 1970). Total phosphorus concentrations were lower in groundwater than in surface water, ranging from 0.012 to 0.73 mg/l. Silica concentrations ranged from 3.2 to 25.3 mg/l-SiO_2 and were generally higher in groundwaters than in surface water.

Total iron and total manganese concentrations in the groundwater ranged from 0.027 to 23.0 mg/l and 0.027 to 1.8 mg/l, respectively, and were generally lower than in surface waters. Soluble iron and soluble manganese

concentrations ranged from 0.015 to 2.7 mg/l and 0.0020 to 1.7 mg/l, respectively. In most aquifers, iron is present as soluble ferrous hydroxide or bicarbonate due to the reducing environment (Ruttner 1963; Hem 1971). When groundwaters are brought to the surface and come into contact with oxygen, the iron is quickly oxidized into insoluble ferric hydroxide; this was observed in the well water collected in the study area. Shortly after the water was collected, it became clouded from the brown precipitate, ferric hydroxide. This reduced the measured soluble iron concentration in the sample to less than it actually was in the aquifer.

The ranges observed for total alkalinity, filtrable residue, specific conductance, calcium, sodium, silica, and total iron were greater than those observed in groundwater during previous studies. Sulfate and nitrate concentrations in 1975 had smaller ranges than in previous studies (Kansas Gas and Electric Company 1974; Bowling and Ellis 1975).

E. Summary and Conclusions

1. John Redmond Reservoir and the Neosho River were chemically similar but were different from Wolf Creek.

2. John Redmond Reservoir complied with all of the water quality criteria established by the Kansas State Board of Health. Ammonia concentrations in the Neosho River exceeded the criteria (0.15 mg/l-N maximum) in April. Dissolved oxygen concentrations were below the minimum standard of 5.0 mg/l at two Wolf Creek locations in September and at all locations in the creek in December. Hydrogen ion (pH) values were below the recommended minimum of 6.5 at all Wolf Creek locations in December. The low oxygen levels and pH were indicative of the severe environmental conditions in the isolated pools of Wolf Creek in December.

3. The flow in Wolf Creek in 1975 was intermittent. The change in hydrology from a flowing creek in April and June to a series of isolated pools in September and December induced physical, chemical, and biological changes causing severe environmental stresses.

4. Precipitation and associated runoff resulted in higher concentrations of ammonia, nitrate, total organic nitrogen, soluble orthophosphate, total phosphorus, turbidity, nonfiltrable residue, total organic carbon, chemical oxygen demand, total iron, and total manganese in both the Neosho River and Wolf Creek during the spring and summer. Increased runoff also resulted in lower filtrable residue, specific conductance and total alkalinity.

5. Wolf Creek affected the water quality of the Neosho River in June, when concentrations of turbidity, nonfiltrable residue, total organic nitrogen, chemical oxygen demand, total iron, and total manganese were higher in the Neosho River below its confluence with Wolf Creek. Concentrations of total alkalinity, filtrable residue, specific conductance, ammonia, and nitrate were lower in the river downstream of the confluence in June.

6. Aquatic nutrient levels were at all times sufficient to support aquatic life.

7. Groundwater characteristics varied widely among wells. The ranges of concentrations observed for total alkalinity, filtrable residue, specific conductance, calcium, silica, and total iron were greater in 1975 than in previous years.

8. The quality of surface water, with the exception of Wolf Creek in September and December 1975, has not changed greatly on an annual basis.

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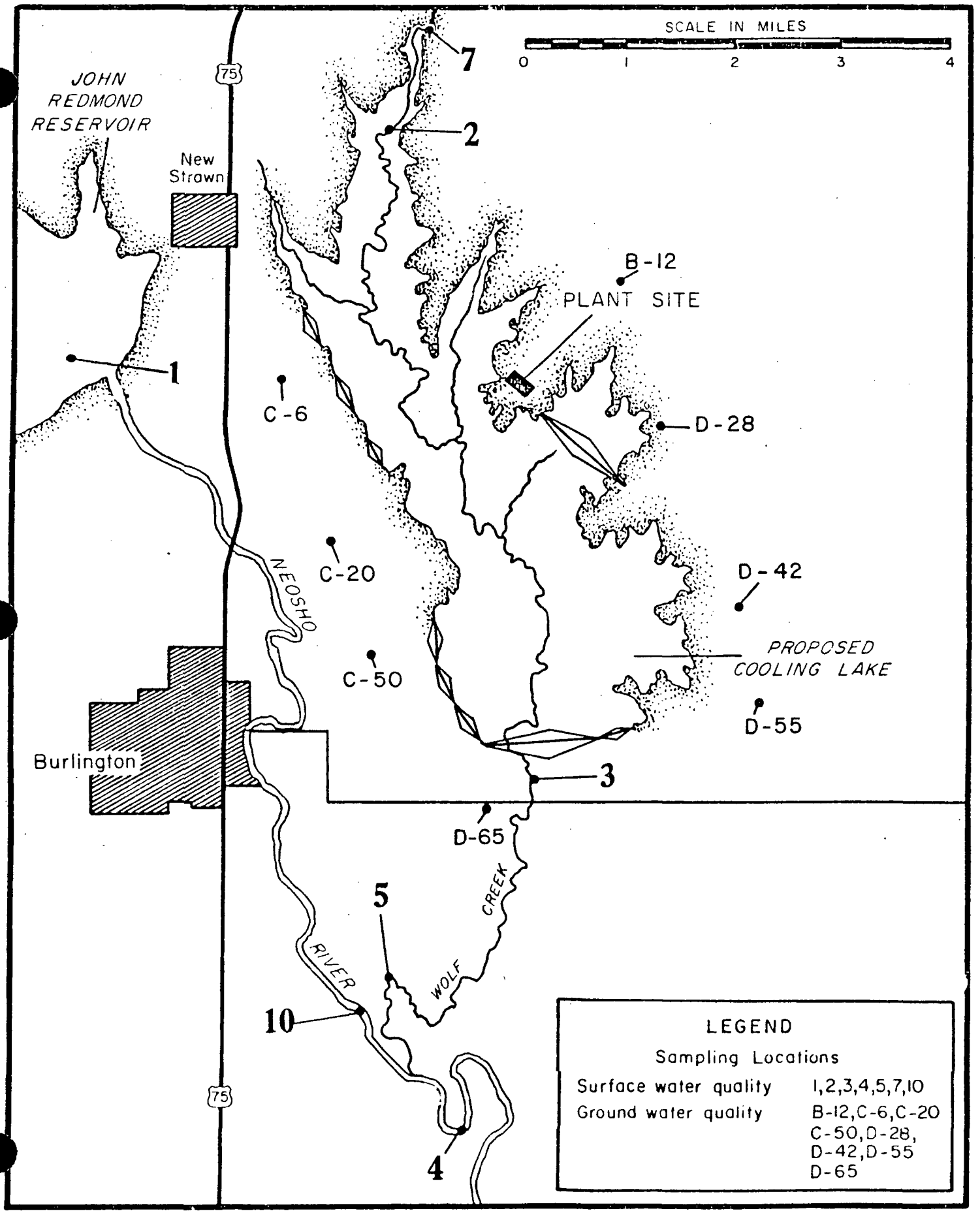

Figure 4.1. Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

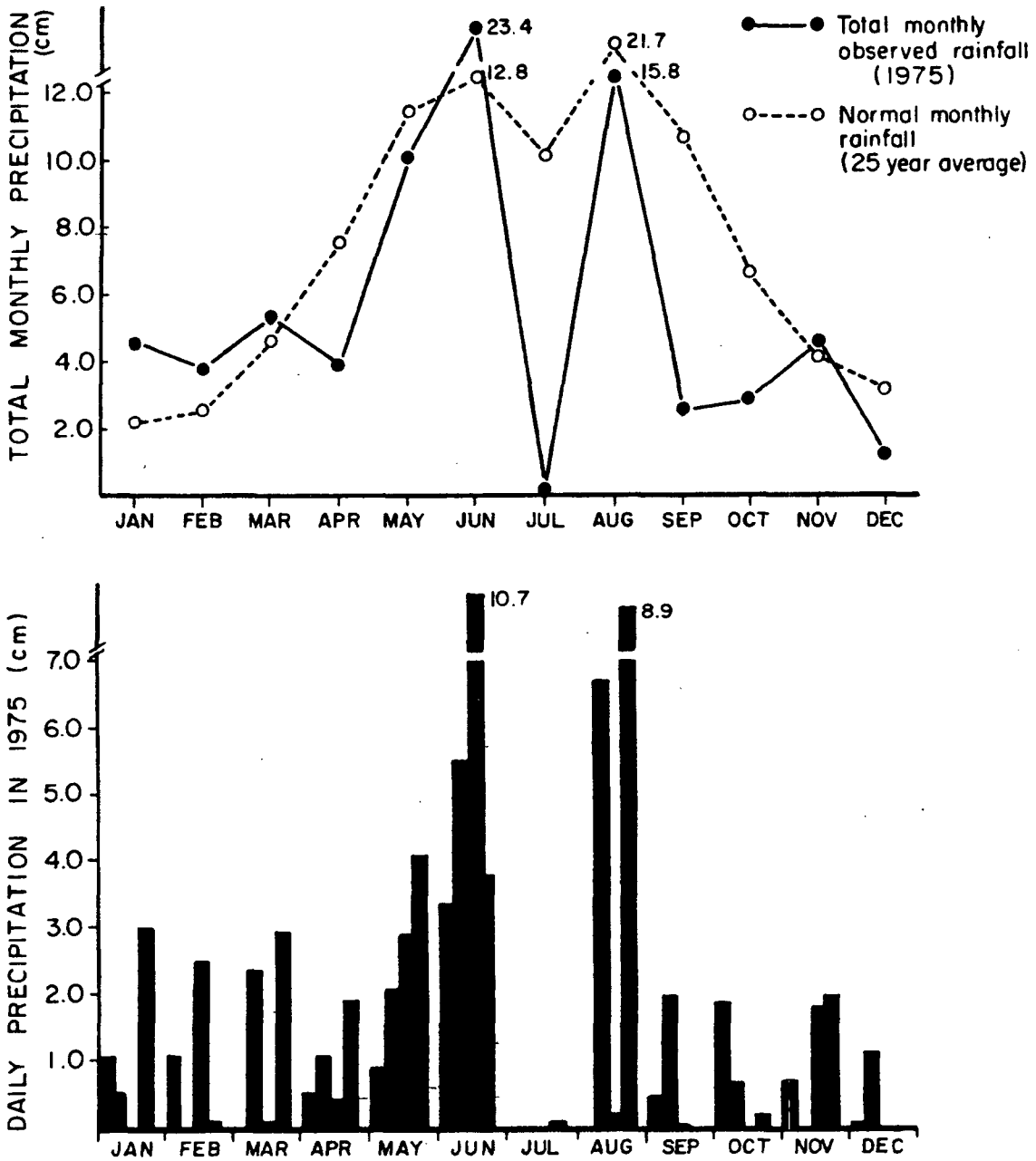

Figure 4.2. Precipitation recorded at the John Redmond Dam, 1975 (U. S. Army, Corps of Engineers 1975).

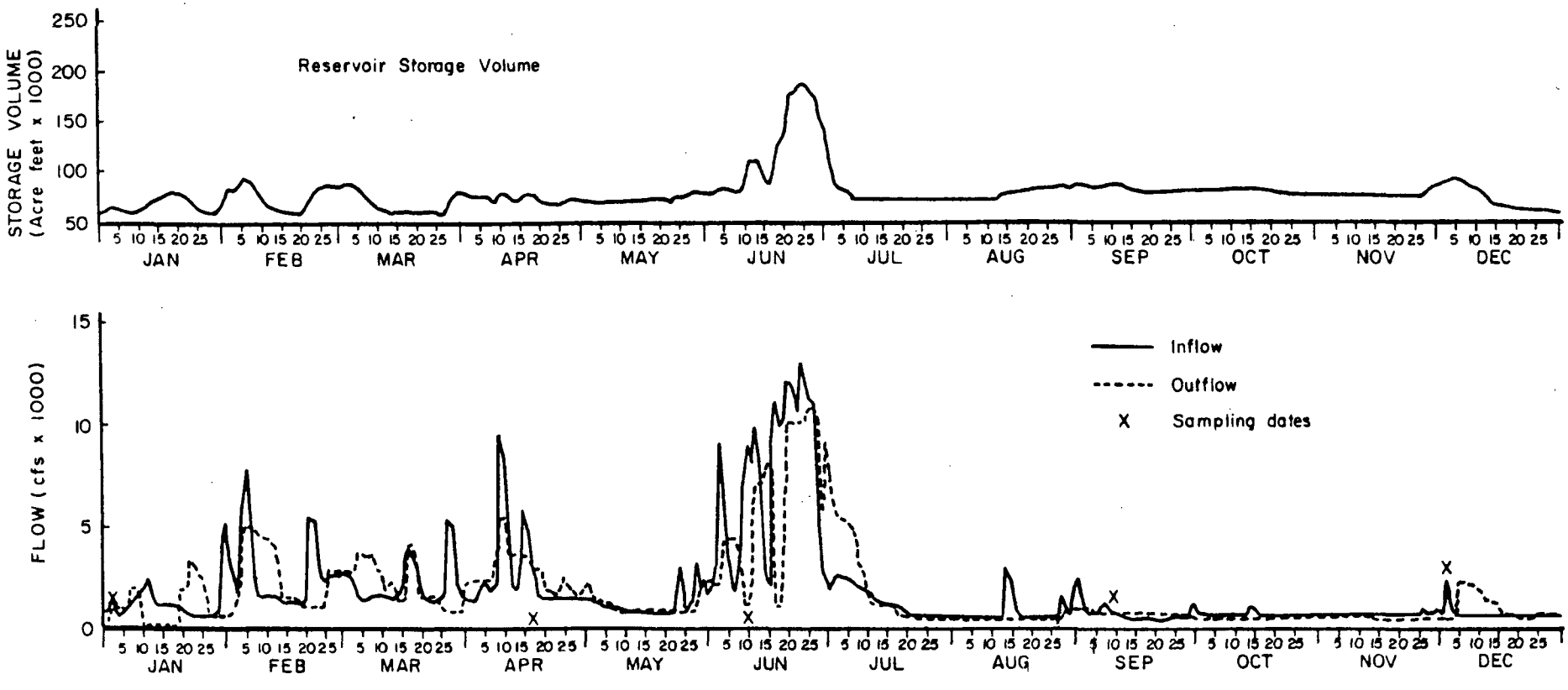

Figure 4.3. Hydrological conditions including reservoir storage volume, reservoir inflow and outflow for John Redmond Reservoir, 1975 (U. S. Army, Corps of Engineers 1975).

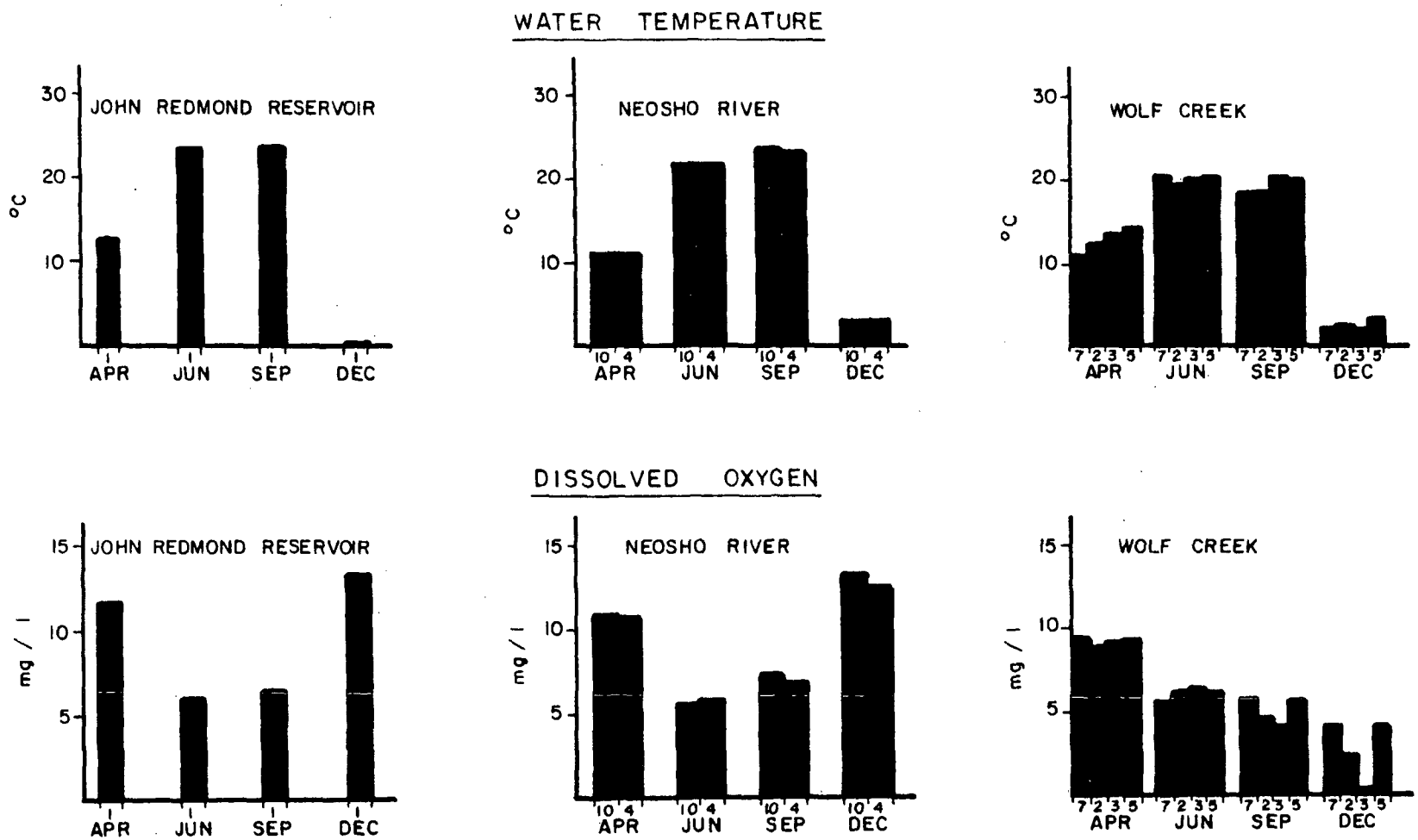

Figure 4.4. Water temperature and dissolved oxygen concentrations recorded in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975.

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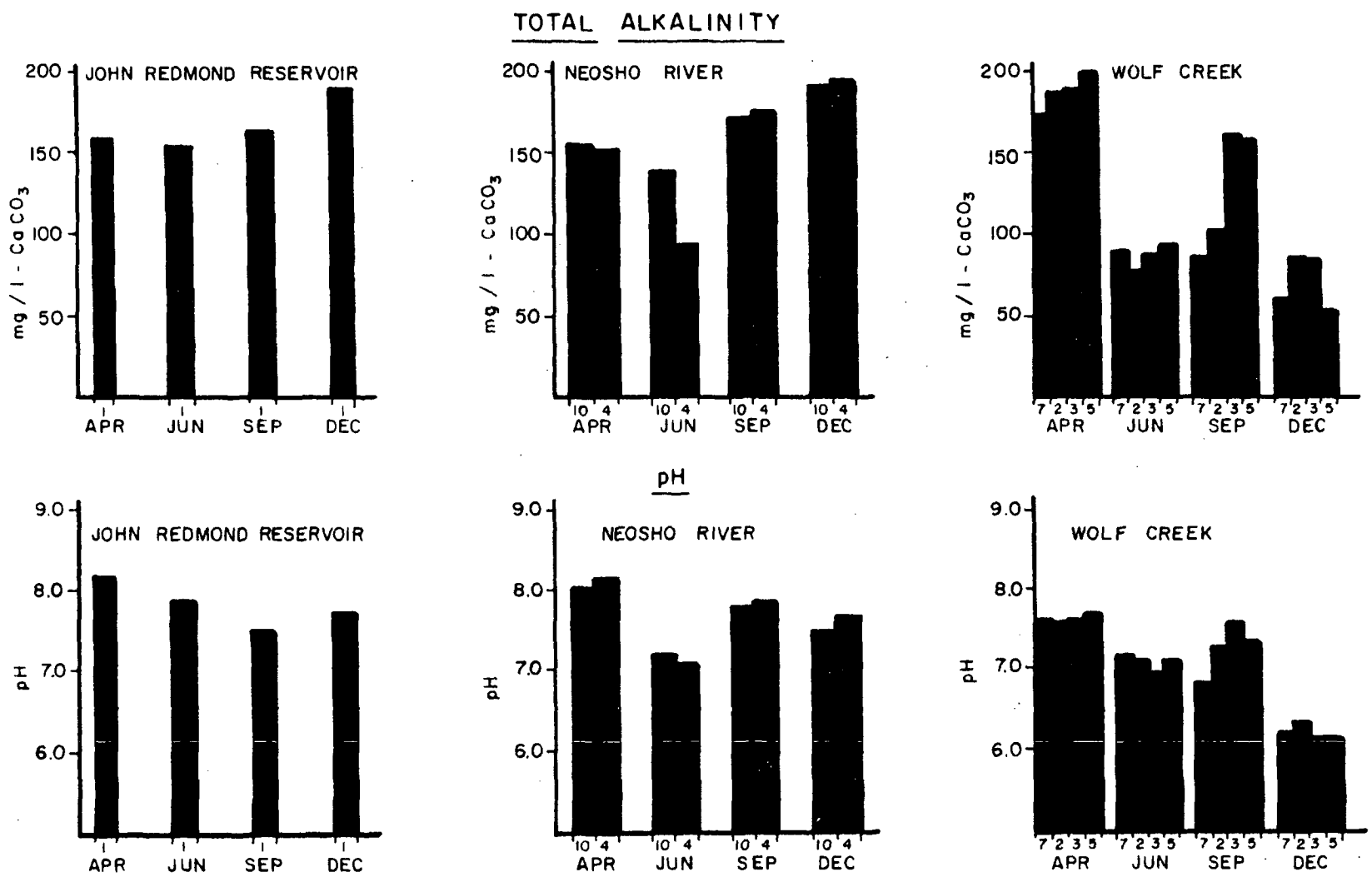

Figure 4.5. Total alkalinity concentrations and pH measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975.

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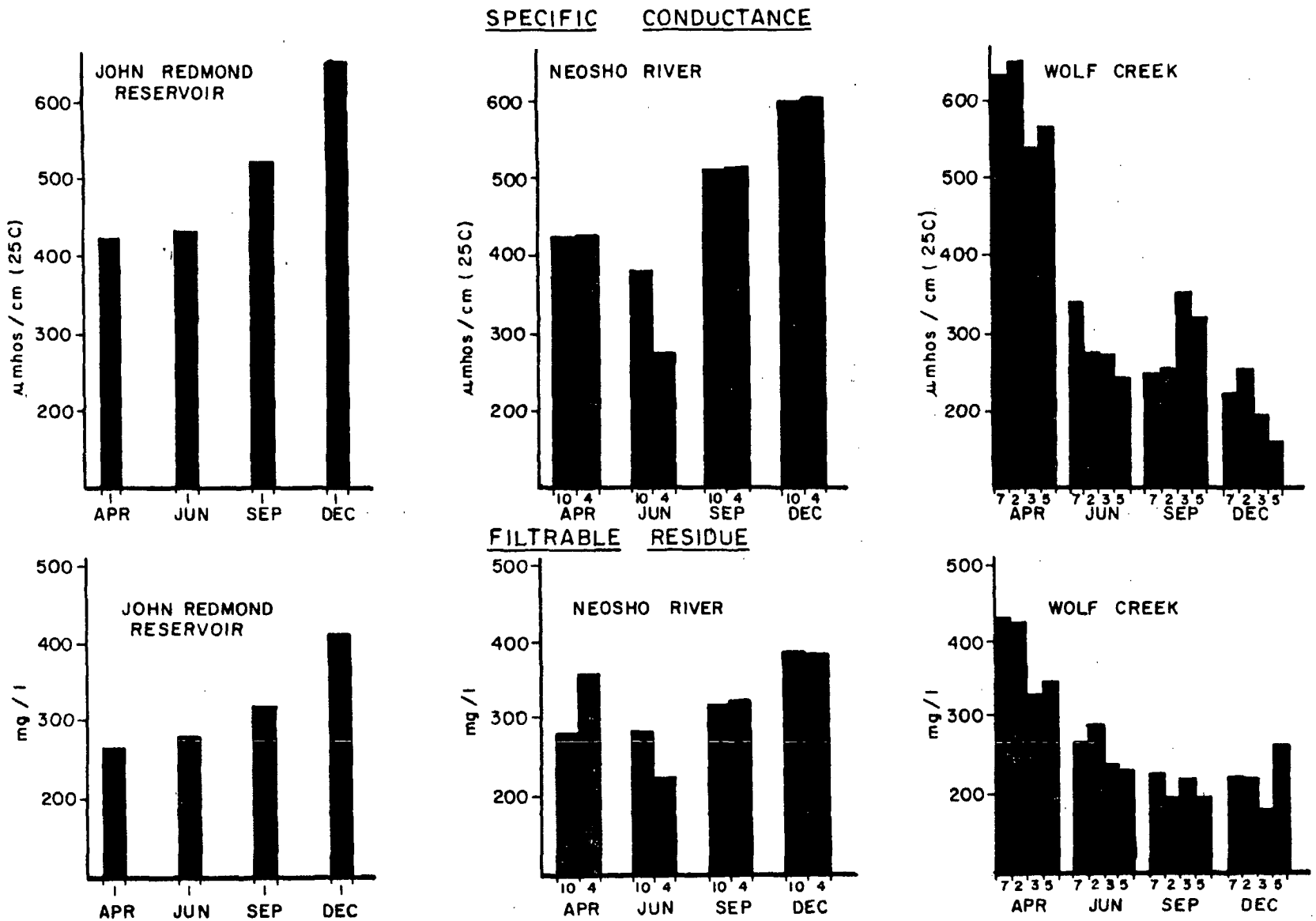

Figure 4.6. Filtrable residue and specific conductance measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975.

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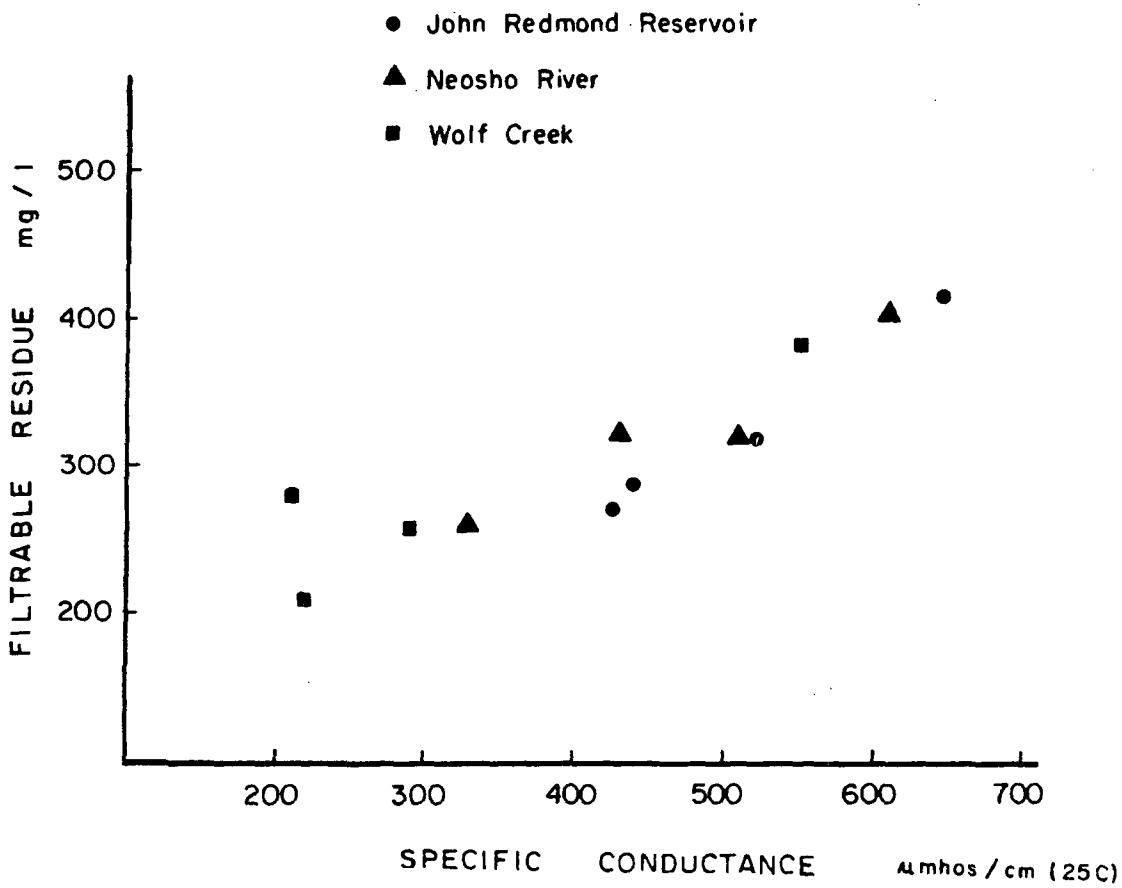

Figure 4.7. Relationship between filtrable residue and specific conductance in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975.

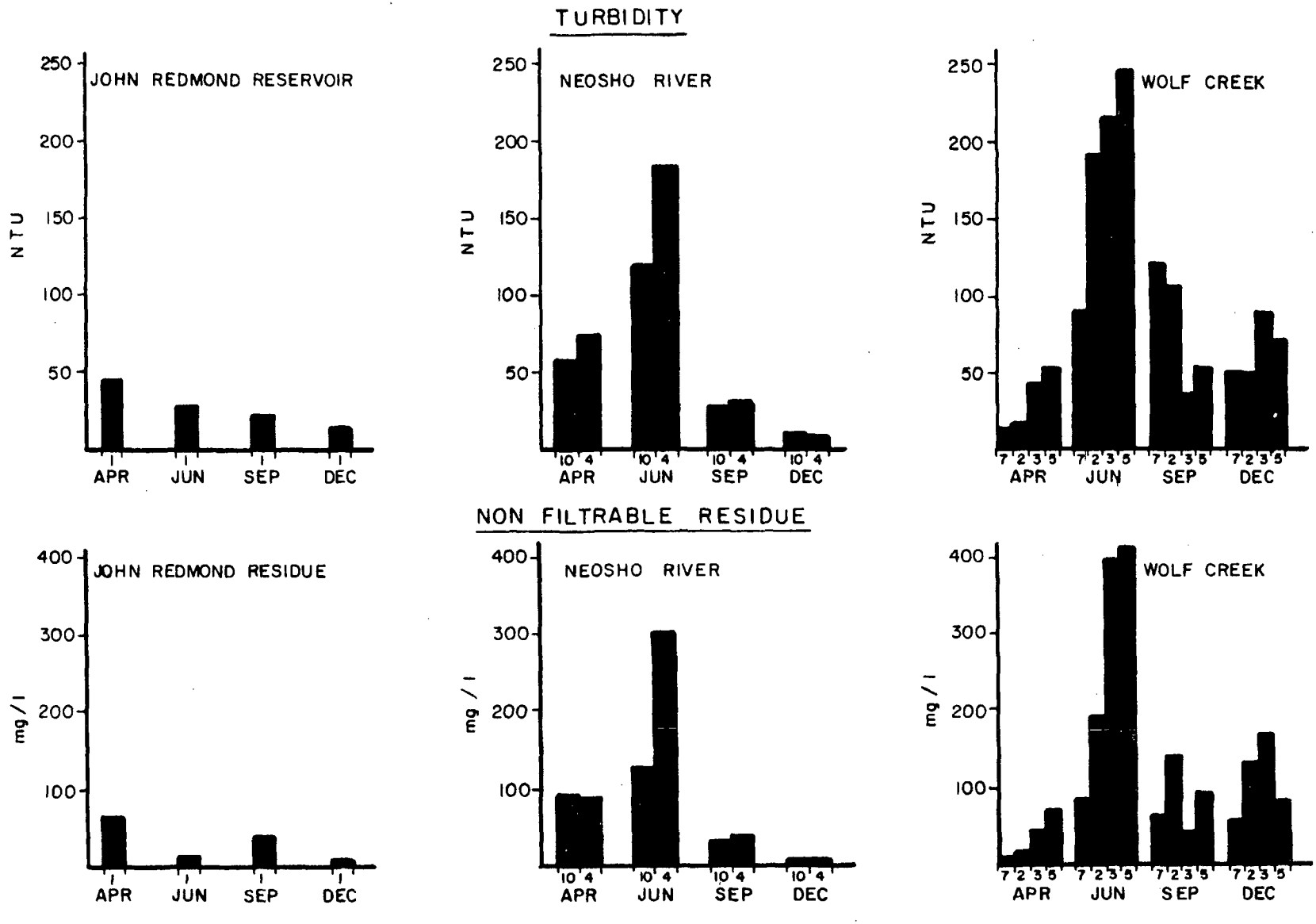

Figure 4.8. Nonfiltrable residue and turbidity concentrations measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975.

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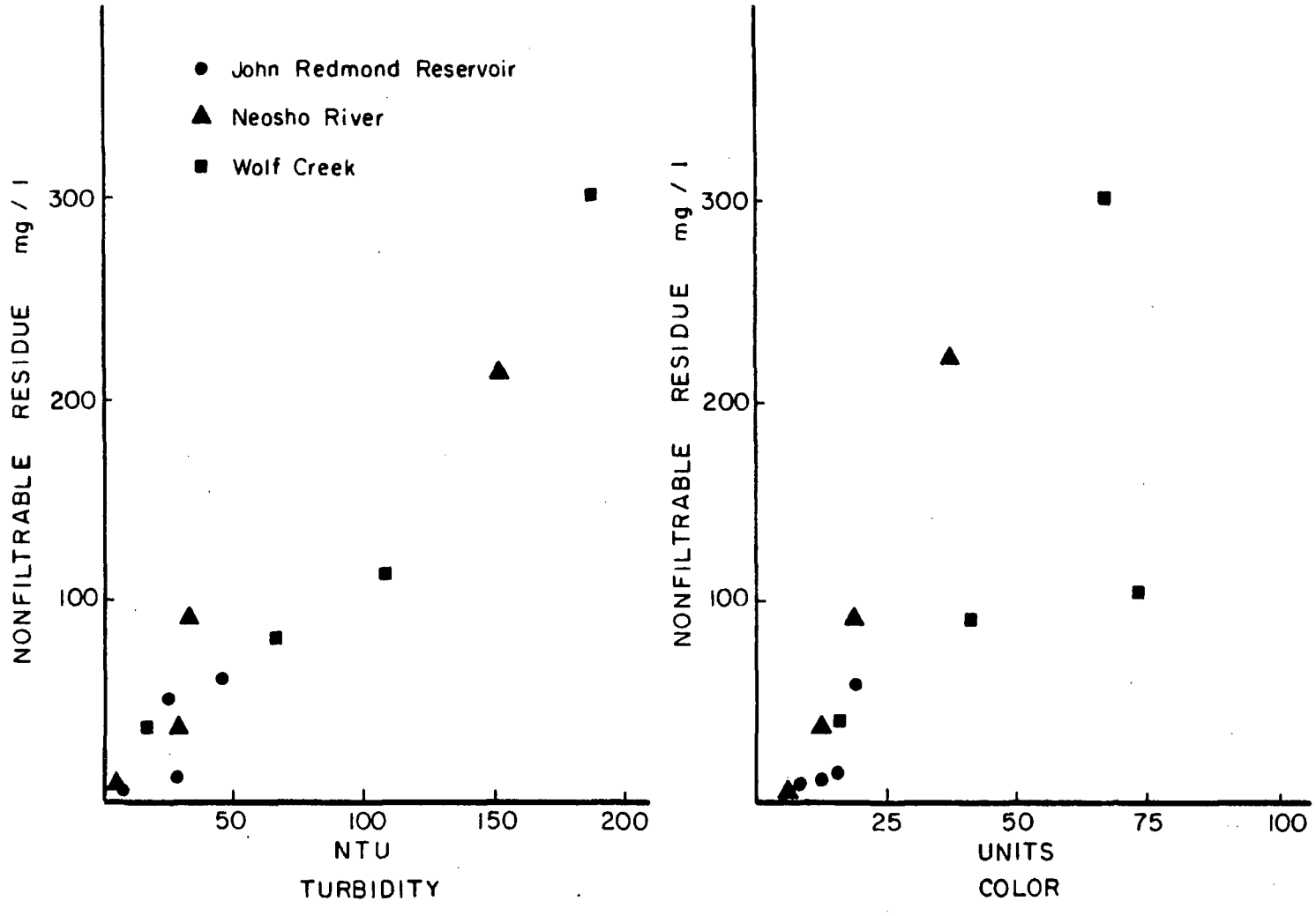

Figure 4.9. Relationships between nonfiltrable residue, turbidity, and color in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975.

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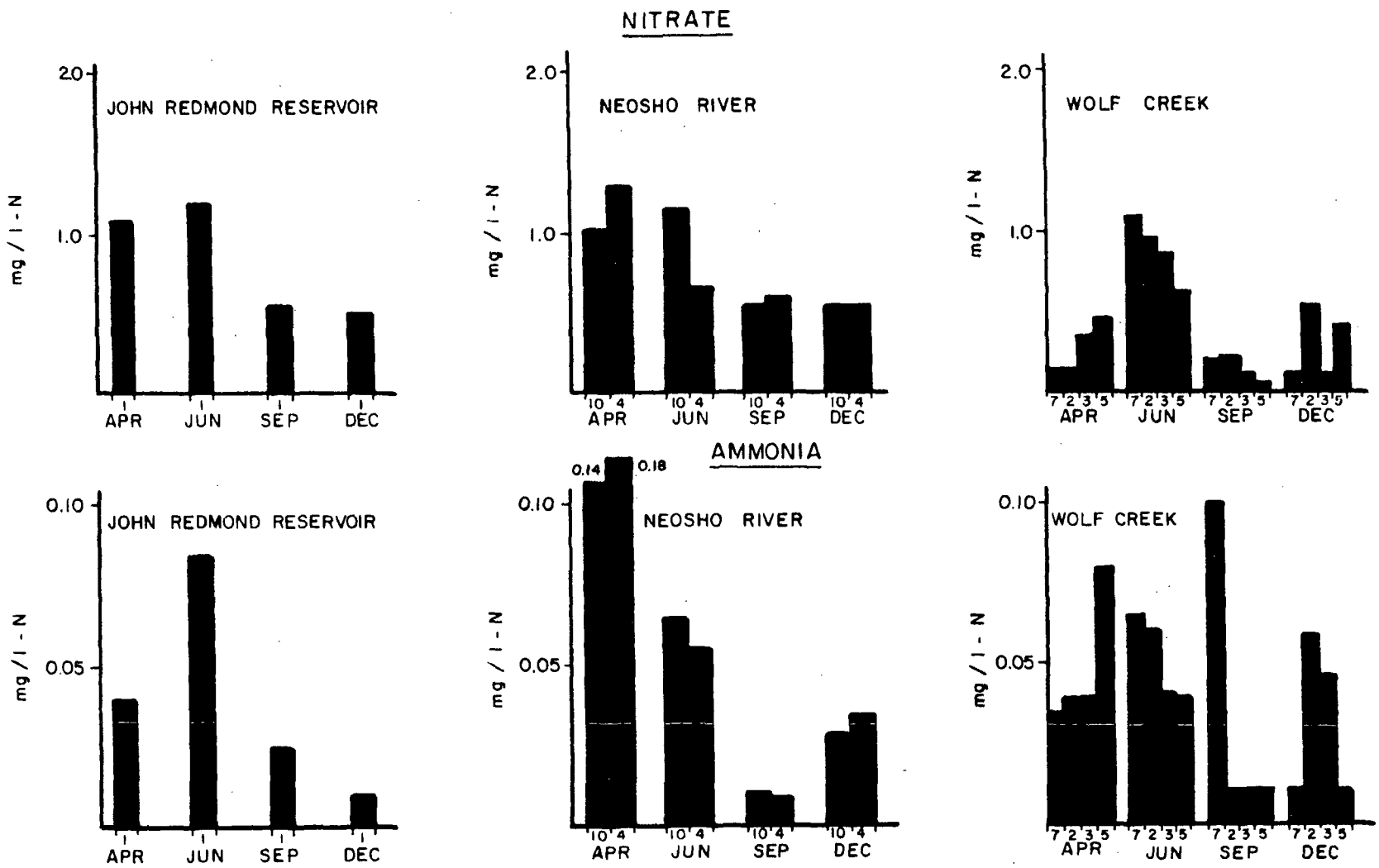

Figure 4.10. Ammonia and nitrate concentrations measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975.

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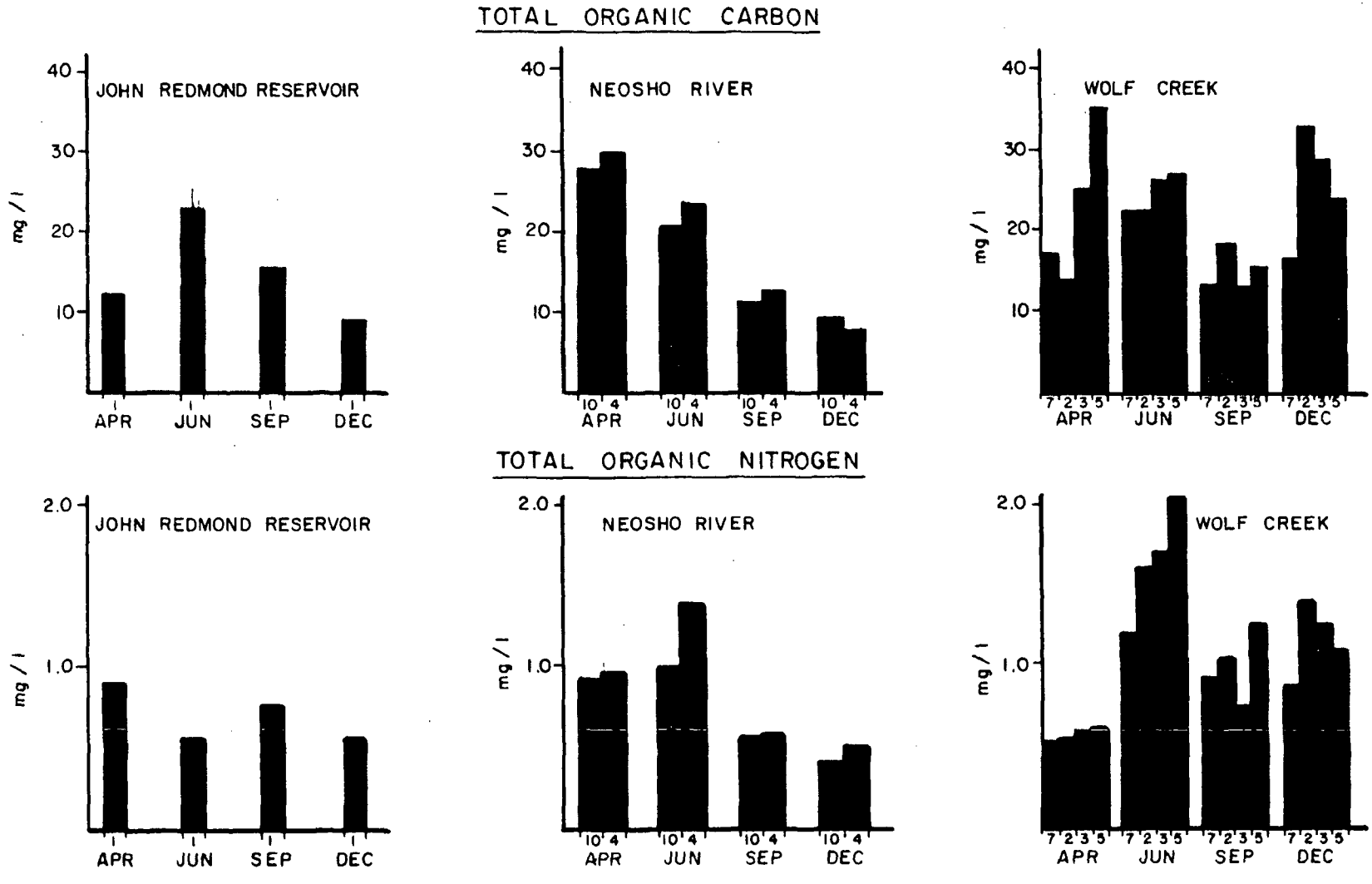

Figure 4.11. Total organic nitrogen and total organic carbon concentrations measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975.

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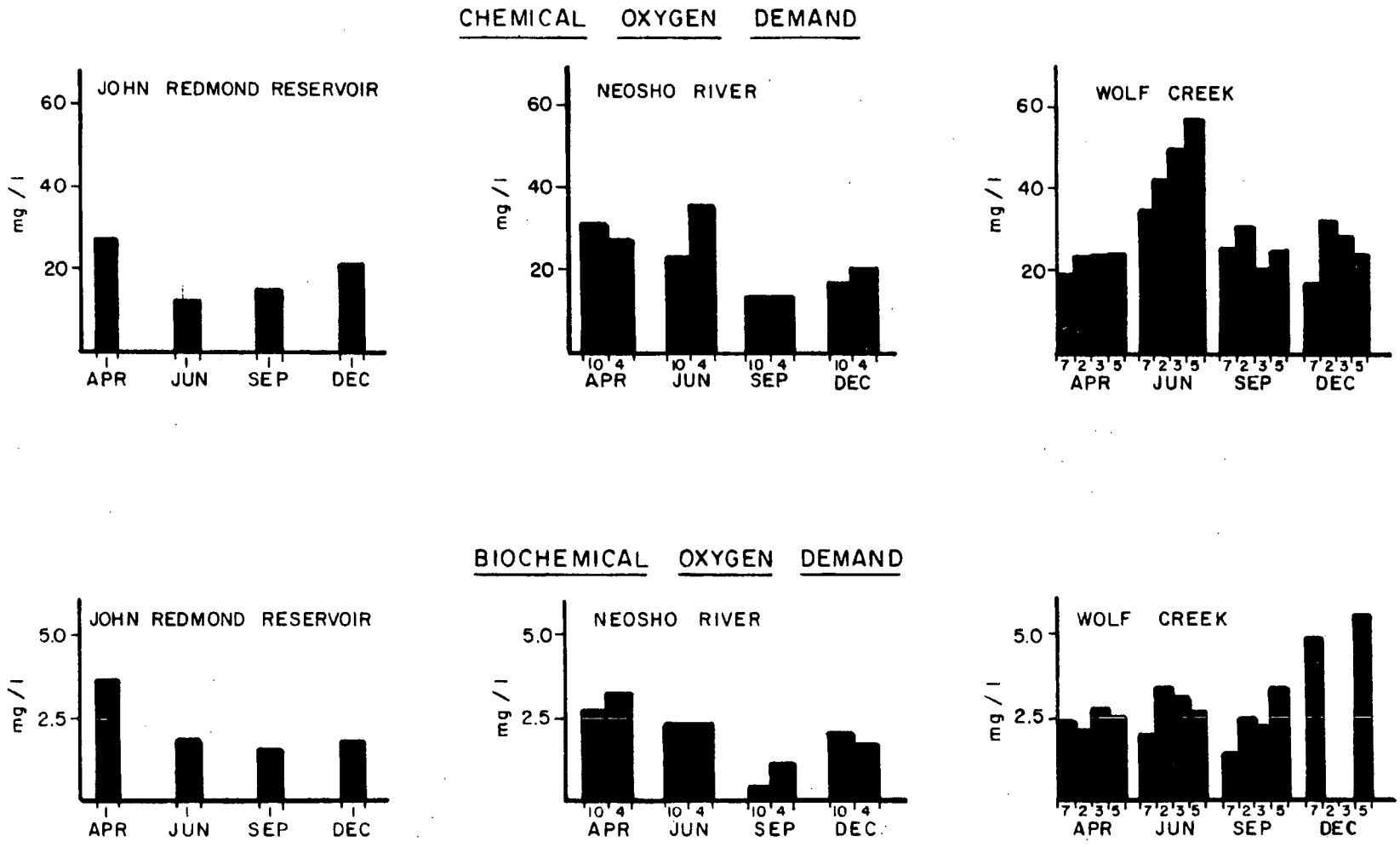

Figure 4.12. Biochemical oxygen demand and chemical oxygen demand concentrations measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975.

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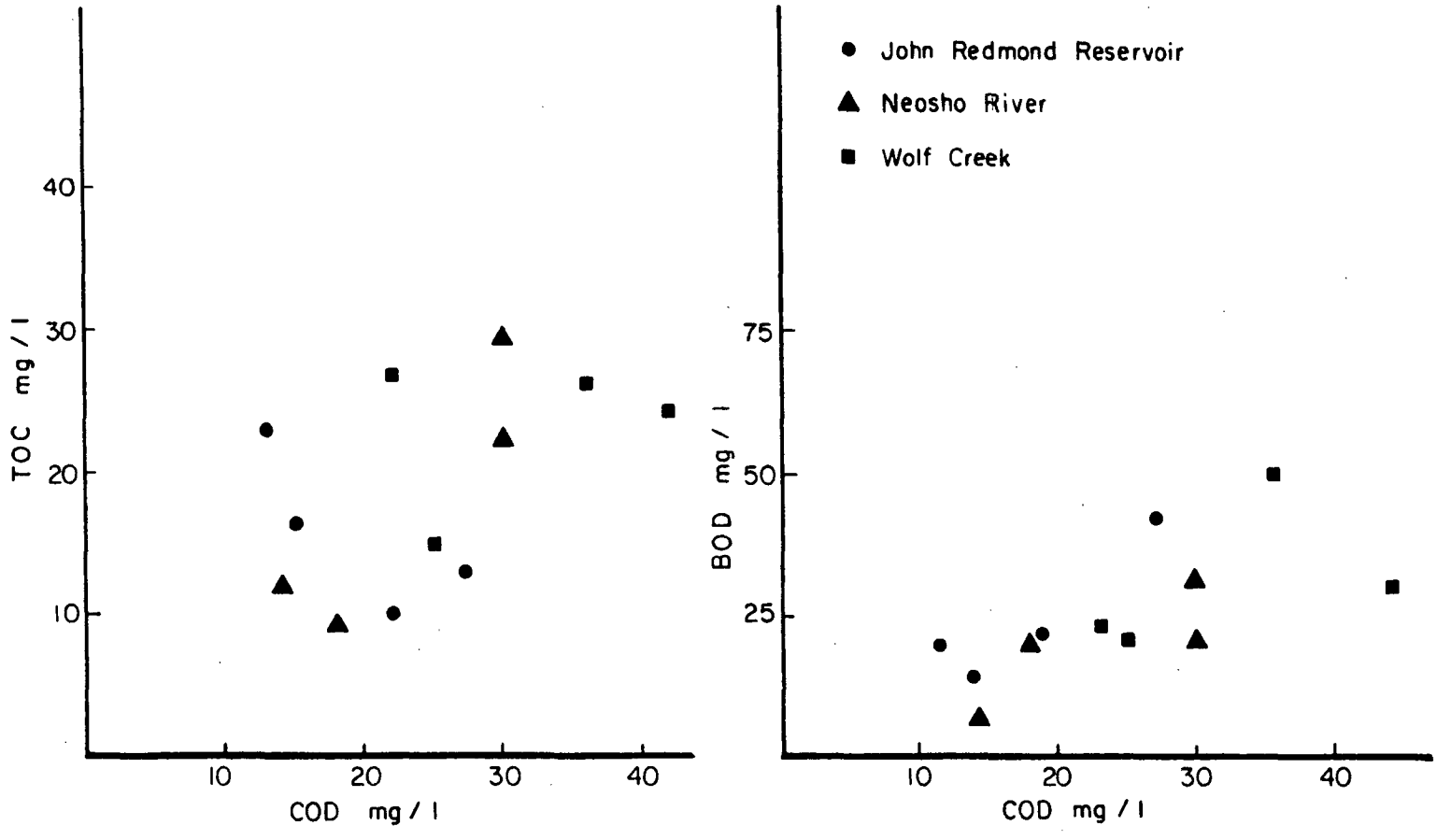

Figure 4.13. Relationships between biochemical oxygen demand (BOD) and chemical oxygen demand (COD) and between COD and total organic carbon (TOC) in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975.

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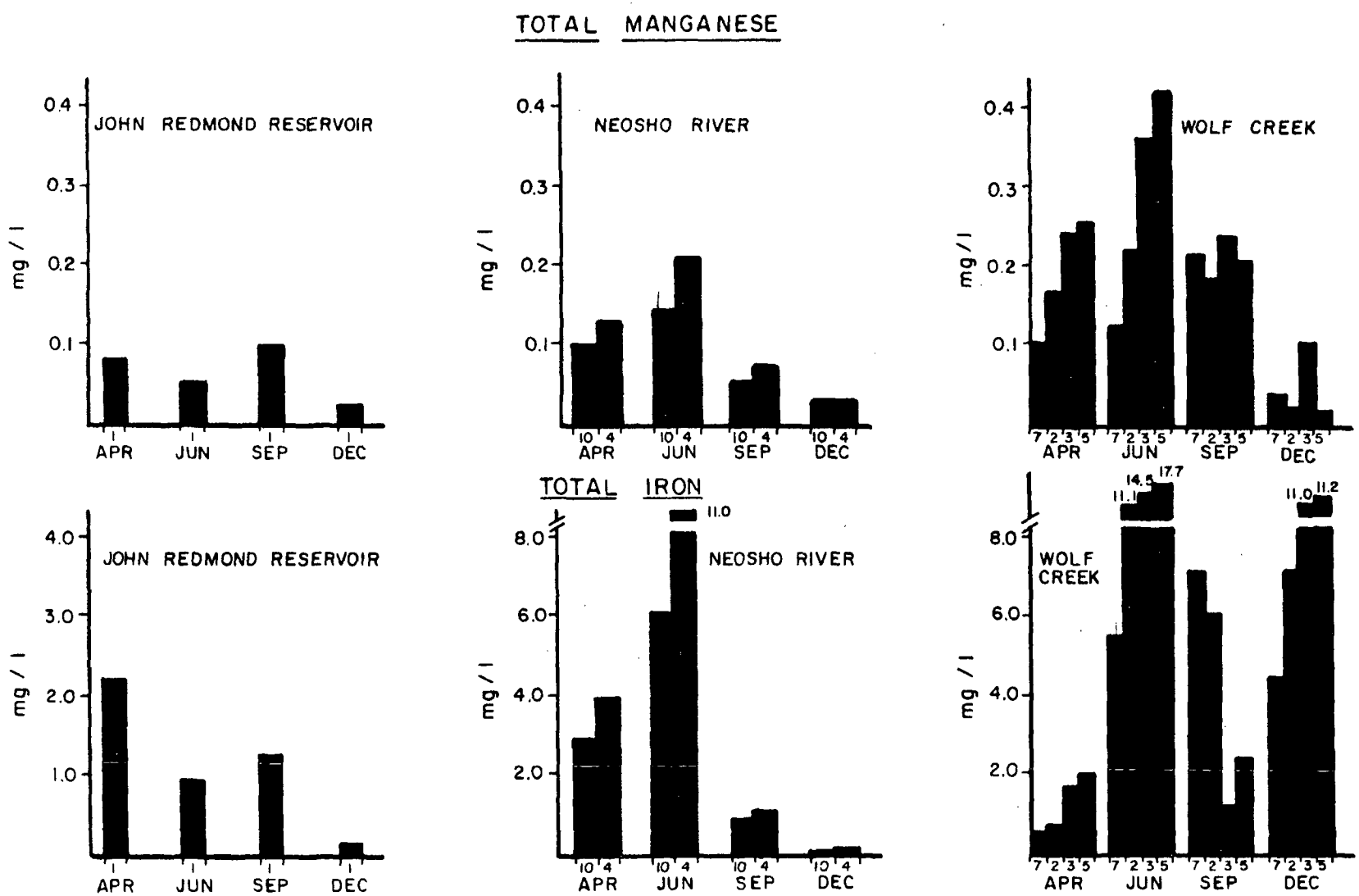

Figure 4.14. Total manganese and iron concentrations measured in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975.

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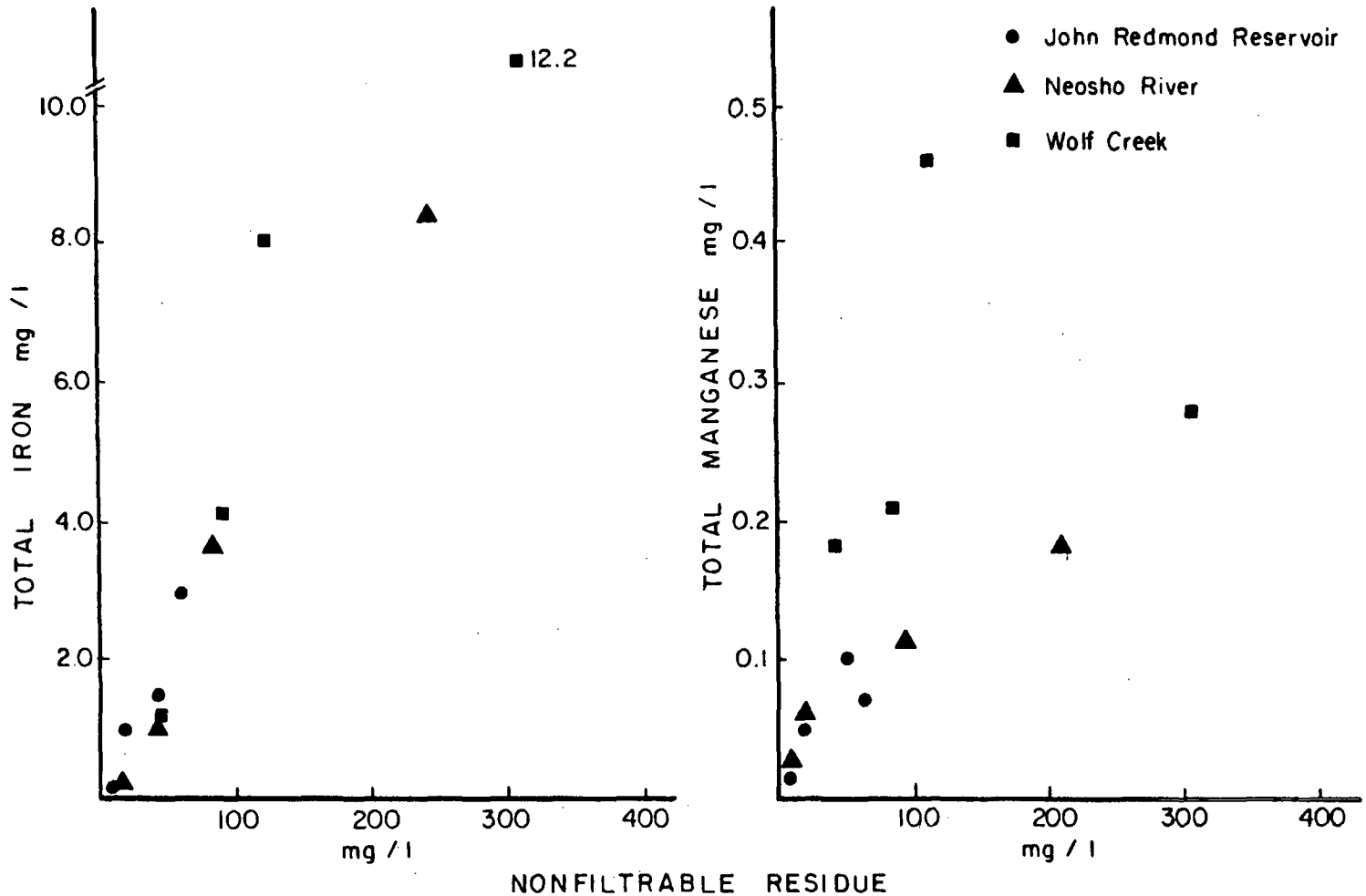

Figure 4.15. Relationships between total iron, total manganese, and filtrable residue in John Redmond Reservoir, the Neosho River, and Wolf Creek, 1975.

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Table 4.1 Physical measurements and instrumentation used in this study.

Measurement	Instrument	Precision of Measurement
Air temperature wet and dry bulb	Bendix Psychrometer Model 566 or Taylor Sling Psychrometer	± 0.5 C
Cloud cover	Field Observer	± 5%
Relative humidity	Psychrometric Slide Rule	± 1%
Wind velocity	Field Observer Dwyer Wind Meter	- ± 1 mph
Current velocity	General Oceanics Digital Flowmeter Model 2031-2035	± 1 m/sec

Table 4.2 Water quality parameters measured in surface water samples.

General Water Quality Parameters

1. Alkalinity, total
2. Color, true
3. Conductance, specific
4. Oxygen, dissolved
5. Oxygen, saturation
6. pH
7. Residue, filtrable (total dissolved solids)
8. Residue, nonfiltrable (total suspended solids)
9. Sulfate
10. Temperature, water
11. Turbidity

Aquatic Nutrients

12. Ammonia
13. Nitrate
14. Nitrite
15. Organic nitrogen, total
16. Orthophosphate, soluble
17. Phosphorus, total
18. Silica, soluble

Indicators of Industrial and Municipal Contaminants

19. Bacteria, fecal coliform
20. Biochemical oxygen demand (5 day)
21. Chemical oxygen demand
22. Organic carbon, total
23. Hexane soluble materials

Trace Metals

24. Copper
25. Iron
26. Lead
27. Manganese
28. Mercury
29. Zinc

Table 4.3 Water quality parameters measured in groundwater samples in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas.

General Water Quality Parameters	Aquatic Nutrients
1. Alkalinity, total	11. Nitrate
2. Calcium	12. Phosphorus, total
3. Chloride	13. Silica, soluble
4. Conductance, specific	
5. Magnesium	
6. pH	**Trace Metals**
7. Potassium	
8. Residue, filtrable (total dissolved solids)	14. Iron, soluble
	15. Iron, total
9. Sodium	16. Manganese, soluble
10. Sulfate	17. Manganese, total
11. Temperature, water	

Table 4.4. Methods for analyses of water quality parameters.

Parameter	Method	Preservation Technique	Reference	Detection Limit
** Alkalinity, total	Method 102	Refrigeration	A.P.H.A. et al. 1971	1 mg/l-$CaCO_3$
* Ammonia	Gas diffusion electrode	$HgCl_2$, refrigeration	Thomas and Booth 1973; Howe and Holley 1969	0.01 mg/l-N
	Method 132C	$HgCl_2$, refrigeration	A.P.H.A. et al. 1971; Howe and Holley 1969	0.01 mg/l-N
	Autoanalyzer colorimetric phenate method	$HgCl_2$, refrigeration	U.S.E.P.A. 1974 Howe and Holley 1969	0.01 mg/l-N
* Bacteria, fecal coliform	Method 408B	$Na_2S_2O_3$, sterile bottle, refrigeration	A.P.H.A. et al. 1971	0 organisms/ 100 ml
* Biochemical oxygen demand (5-day)	Method 219	Refrigeration	A.P.H.A. et al. 1971	0.5 mg/l
*** Calcium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	2 ug/l
*** Chloride	Method 112B	None required	A.P.H.A. et al. 1971	0.5 mg/l
	Autoanalyzer	None required	U.S.E.P.A. 1974	0.1 mg/l
* Chemical oxygen demand	Low level mehhod	Refrigeration	U.S.E.P.A. 1974	0.1 mg/l
* Color, true	Method 118	None required	A.P.H.A. et al. 1971	1 unit
** Conductance, specific	Method 154	None required	A.P.H.A. et al. 1971	1 umho/cm
* Copper	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.01 mg/l
	Atomic absorption chelation	HNO_3	Fishman and Midgett 1968	0.1 ug/l
	Atomic absorption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	0.2 ug/l
* Hexane soluble	Soxhlet extraction	H_2SO_4 refrigeration	U.S.E.P.A. 1974	0.1 mg/l
** Iron[a]	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.03 mg/l
	Atomic absorption chelation	HNO_3	Fishman and Midgett 1968	1 ug/l
	Atomic absorption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	0.5 ug/l
* Lead	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.1 um/l

Table 4.4. Continued.

Parameter	Method	Preservation Technique	Reference	Detection Limit
	Atomic absorption chelation	HNO_3	Fishman and Midgett 1968	1 ug/l
	Atomic absorption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	1 ug/l
*** Magnesium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	1 ug/l
** Manganese[b]	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.01 mg/l
* Mercury	Flameless atomic absorption	HNO_3	U.S.E.P.A. 1974	0.05 ug/l
** Nitrate	Method 213C	$HgCl_2$, refrigeration	A.P.H.A. et al. 1971; Howe and Holley 1969	0.01 mg/l-N
	Autoanalyzer cadmium reduction	$HgCl_2$, refrigeration	U.S.E.P.A. 1974; Howe and Holley 1969	0.01 mg/l-N
* Nitrite	Method II.6.	$HgCl_2$, refrigeration	Strickland and Parsons 1972; Howe and Holley 1969	0.1 ug/l-N
* Organic carbon, total	Method 138A	HCl, refrigeration	A.P.H.A. et al. 1971; Ocean. Int. Corp. (1974)a,b	1 mg/l
	Ocean. Int. Analyzer wet oxidation	HCl, refrigeration	Ocean. Inter. Corp. (1974)b.	0.2 mg/l
* Organic nitrogen, total	Methods 135 then 132C	$HgCl_2$, refrigeration	A.P.H.A. et al. 1971; Howe and Holley 1969	0.01 mg/l
* Orthophosphate, soluble	Method II.1.	Filtration, refrigeration	Strickland and Parsons 1972; Ryden et al. 1972	1 ug/l-P
* Oxygen, dissolved	Method 218B	Measured in the field	A.P.H.A. et al. 1971	0.1 mg/l
* Oxygen, saturation	Calculated method 218B	-	A.P.H.A. et al. 1971	Expressed as percent
* pH	Method 144A	Measured in the field	A.P.H.A. et al. 1971	0.1 pH
** Phosphorus, total	Method 223C then method II.1.	None required	A.P.H.A. et al. 1971; Strickland and Parsons 1972	1 ug/l-P
*** Potassium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	5 ug/l
** Residue, filtrable (total dissolved solids)	Method 148B	None required	A.P.H.A. et al. 1971	2 mg/l
* Residue, nonfiltrable (total suspended solids)	Method 148C	None required	A.P.H.A. et al. 1971	1 mg/l

Table 4.4. Continued.

Parameter	Method	Preservation Technique	Reference	Detection Limit
** Silica, soluble	Method 151C	Filtration	A.P.H.A. et al. 1971	0.01 mg/l-SiO_2
	Autoanalyzer method 105-71W	Filtration	Technicon Industrial Systems 1974	0.01 mg/l-SiO_2
*** Sodium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	2 ug/l
** Sulfate	Method 156C	None required	A.P.H.A. et al. 1971	5 mg/l
	Autoanalyzer method 118-71 W	None required	Technicon Industrial System 1974	1 mg/l
** Temperature	Whitney Thermometer, method 162	Measured *in situ*	A.P.H.A. et al. 1971	0.1 C
* Turbidity	Hach Turbidimeter, method 163A	None required	A.P.H.A. et al. 1971	0.1 N.T.U.
* Zinc	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.01 mg/l
	Atomic absorption chelation	HNO_3	Fishman and Midgett 1968	1 ug/l
	Atomic abosrption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	0.1 ug/l

* Measured in surface water samples only.

** Measured in surface water and groundwater samples.

*** Measured in groundwater samples only.

[a] Soluble iron in groundwater samples determined by same method with prior filtration of sample.

[b] Soluble manganese in groundwater samples determined by same method with prior filtration of sample.

Table 4.5 Numerical water quality criteria for Kansas surface waters.

Parameter	Criterion	Locations and Months in which the Standards were Exceeded
Temperature, water	32.2 C (90 F)	None
Oxygen, dissolved	Not less than 5 mg/l	Locations 2, 3 (Wolf Creek) in September Locations 2, 3, 5, 7 (Wolf Creek) in December
pH	6.5 to 8.5	Locations 2, 3, 5, 7 (Wolf Creek) were below 6.5 in December
Ammonia	0.15 mg/l-N maximum	Locations 4, 10 (Neosho River) in April
Bacteria, fecal coliform	Not to exceed 2000 per 100 ml sample (all locations except John Redmond Reservoir)	None
	Not to exceed 400 per 100 ml sample in more than 10% of total samples in any 30 day period (John Redmond Reservoir)	None
Oil and grease	No evidence of visible oil or grease	None
Turbidity and total suspended solids	No increases from other than natural origin	None
Color	No man-made point source discharges of color producing substances	None
Taste and odor producing substances	No increases from man-made point discharges	None
Toxic substances	Man-made point discharges limited to concentrations in receiving water that will not harm human or aquatic life	None

Table 4.6. Summary of minimum, maximum and mean values for water quality data in the vicinity of the Wolf Creek Generating, Burlington, Kansas, 1975.

Parameter	Range	John Redmond Reservoir[a] April	June	September	December	Neosho River[b] April	June	September	December	Wolf Creek[c] April	June	September	December
General Water quality Parameters													
Water temperature (°C)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	12.3	23.3	23.9	0	11.0	21.2	23.6	2.8	11.1	19.8	18.5	2.2
	Max	12.3	23.3	23.9	0	11.1	21.2	24.1	2.8	14.1	20.3	20.1	3.6
	Mean	12.3	23.3	23.9	0	11.0	21.2	23.8	2.8	12.8	20.1	19.3	2.7
Oxygen, dissolved (mg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	11.5	5.9	6.0	13.3	10.3	5.6	6.9	12.5	8.8	5.6	4.3	0.2
	Max	11.6	6.0	6.8	13.5	10.5	6.0	7.5	13.6	9.6	6.5	5.8	5.2
	Mean	11.6	6.0	6.4	13.4	10.4	5.8	7.3	12.9	9.2	6.3	5.1	2.9
Oxygen, saturation (%)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	105	63	64	91	92	59	73	92	81	58	45	2
	Max	106	64	72	93	95	63	80	101	93	67	60	40
	Mean	106	64	68	92	94	61	77	95	86	65	53	22
pH (units)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	8.2	7.8	7.5	7.7	8.0	7.1	7.8	7.4	7.5	6.9	6.8	6.0
	Max	8.2	8.0	7.6	7.8	8.2	7.2	7.9	7.8	7.7	7.2	7.5	6.4
	Mean	8.2	7.9	7.6	7.8	8.1	7.2	7.8	7.6	7.6	7.1	7.3	6.2
Alkalinity, total ($mg/l\ CaCO_3$)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	158	157	156	185	150	92	170	191	170	76	84	52
	Max	164	158	175	201	160	139	180	195	198	91	164	96
	Mean	159	158	166	193	154	117	173	193	186	84	128	76
Color, true (units)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	18	15	10	8	16	24	10	7	13	56	20	40
	Max	20	15	11	8	22	52	13	9	19	65	70	104
	Mean	19	15	11	8	19	38	11	8	15	60	40	73
Conductance, specific (µmhos/cm at 25 C)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	427	433	520	649	428	273	512	600	546	244	234	160
	Max	428	441	522	662	433	381	515	606	651	346	363	255
	Mean	428	437	521	656	430	327	513	603	600	284	292	214
Residue, filtrable (Solids, total dissolved) (mg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	262	282	306	406	268	210	313	384	330	222	181	163
	Max	269	286	318	414	420	302	317	388	440	294	254	274
	Mean	266	284	312	410	345	253	315	386	387	257	211	226
Residue, nonfiltrable (Solids, total suspended) (mg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	58	10	40	4	86	116	29	2	6	76	33	52
	Max	59	14	60	6	98	350	41	4	79	548	179	176
	Mean	58	12	50	5	90	217	34	3	36	304	82	109

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Table 4.6. Continued.

Parameter	Range	John Redmond Reservoir[a] April	June	September	December	Neosho River[b] April	June	September	December	Wolf Creek[c] April	June	September	December
Sulfate (mg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	40	43	70	88	40	29	66	81	76	28	20	7.0
	Max	42	52	74	89	46	38	68	99	148	58	28	46
	Mean	41	48	72	89	44	33	67	91	108	41	24	24
Turbidity (N.T.U.)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	45	27	21	14	55	120	26	8.0	12	100	36	100
	Max	45	29	23	14	90	190	35	10	52	250	125	150
	Mean	45	28	23	14	66	153	30	9.0	31	188	80	115
Aquatic Nutrients													
Ammonia (mg/l-N)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	0.03	0.08	0.02	0.01	0.12	0.05	<0.01	0.02	0.02	0.03	<0.01	0.01
	Max	0.05	0.09	0.03	0.01	0.20	0.07	0.01	0.04	0.10	0.07	0.11	0.07
	Mean	0.04	0.09	0.03	0.01	0.16	0.06	0.01	0.02	0.05	0.05	0.03	0.03
Nitrate (mg/l-N)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	1.1	1.1	0.50	0.50	0.18	0.62	0.54	0.51	0.12	0.62	0.04	0.07
	Max	1.1	1.3	0.60	0.52	1.4	1.2	0.65	0.53	0.45	1.1	0.23	0.55
	Mean	1.1	1.2	0.55	0.51	1.2	0.91	0.57	0.52	0.27	0.89	0.14	0.28
Nitrite (mg/l-N)	N	2	2	2	2	4	4	4	4	8	8	8	7
	Min	0.019	0.062	0.061	0.0031	0.020	0.013	0.027	0.0044	0.0007	0.013	0.0055	0.0031
	Max	0.020	0.065	0.064	0.0031	0.022	0.018	0.033	0.0045	0.0039	0.024	0.061	0.13
	Mean	0.020	0.064	0.063	0.0031	0.021	0.015	0.029	0.0045	0.0025	0.017	0.010	0.042
Organic nitrogen (mg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	0.87	0.56	0.69	0.55	0.89	1.0	0.56	0.42	<0.50	1.2	0.73	0.80
	Max	0.90	0.59	0.84	0.55	1.0	1.4	0.61	0.54	0.65	2.1	1.4	1.3
	Mean	0.89	0.58	0.77	0.55	0.94	1.2	0.59	0.46	0.56	1.7	0.98	1.2
Orthophosphate, soluble (mg/l-P)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	0.002	0.026	0.013	0.015	0.015	0.049	0.031	0.025	<0.001	0.011	0.007	0.098
	Max	0.013	0.048	0.022	0.018	0.020	0.099	0.039	0.032	0.009	0.018	0.025	0.35
	Mean	0.008	0.037	0.019	0.017	0.017	0.071	0.036	0.029	0.004	0.013	0.015	0.17
Phosphorus, total (mg/l-P)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	0.12	0.070	0.10	0.044	0.13	0.24	0.085	0.034	0.005	0.14	0.070	0.26
	Max	0.14	0.072	0.11	0.047	0.24	0.36	0.091	0.044	0.10	0.47	0.25	0.62
	Mean	0.13	0.071	0.11	0.046	0.19	0.29	0.087	0.039	0.038	0.31	0.16	0.39
Silica, soluble (mg/l-SiO_2)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	4.9	6.8	3.6	0.8	4.9	8.3	3.7	0.30	1.0	9.4	7.7	5.9
	Max	5.4	6.8	3.7	0.8	5.2	8.5	3.9	0.34	5.4	10.0	9.2	11.3
	Mean	5.2	6.8	3.7	0.8	5.1	8.4	3.8	0.32	3.2	9.6	8.6	9.0
Industrial Municipal Contaminants													
Bacteria, fecal coliform (No./100 ml)	N	2	1	2	2	4	3	4	4	8	8	8	8
	Min	170	0	0	0	140	170	73	10	100	110	67	110
	Max	380	0	2	2	290	240	150	65	730	530	600	750
	Mean	220	0	1	1	220	210	120	41	300	310	200	300

NALCO ENVIRONMENTAL SCIENCES

Table 4.6. Continued.

Parameter	Range	John Redmond Reservoir[a] April	June	September	December	Neosho River[b] April	June	September	December	Wolf Creek[c] April	June	September	December
Biochemical oxygen demand (5-day) (mg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	3.4	1.8	1.1	1.8	2.6	2.0	0.4	1.6	2.1	1.4	1.3	4.6
	Max	4.1	1.8	1.7	2.0	3.5	2.5	1.2	2.0	2.7	3.5	3.6	5.2
	Mean	3.8	1.8	1.4	1.9	3.0	2.3	0.8	1.8	2.4	2.7	2.3	5.0
Chemical oxygen demand (mg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	27	13	15	21	27	23	13	16	18	34	20	30
	Max	27	14	17	22	32	37	15	20	25	50	31	46
	Mean	27	13	16	22	30	30	14	18	23	46	25	36
Organic carbon, total (mg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	12	21	14	8.6	26	18	10	6.8	8	21	12	14
	Max	14	25	17	10.0	30	24	13	9.8	37	30	19	34
	Mean	13	23	15	9.3	29	22	12	8.4	27	24	15	26
Hexane soluble materials (mg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	0.8	1.1	1.9	0.9	0.5	1.2	1.4	0.9	0.5	0.8	0.6	0.2
	Max	0.9	1.7	2.0	1.5	0.8	2.3	1.7	1.8	1.0	4.1	2.0	2.4
	Mean	0.9	1.4	2.0	1.2	0.6	1.9	1.6	1.4	0.8	1.8	1.3	1.1
Trace Metals													
Copper, total (µg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	3.4	2.1	2.7	1.8	3.0	6.4	1.5	1.5	1.2	5.2	1.7	3.5
	Max	3.5	2.8	5.3	2.3	6.0	10.0	2.5	2.7	3.0	19.0	6.6	8.8
	Mean	3.5	2.5	4.0	2.1	4.5	8.2	1.9	2.1	2.0	13.0	4.0	5.9
Iron, total (mg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	2.5	1.0	1.3	0.32	2.8	6.0	0.90	0.19	0.58	5.4	1.2	4.2
	Max	2.5	1.1	1.7	0.35	5.0	11.0	1.1	0.25	2.1	17.9	7.2	11.2
	Mean	2.5	1.1	1.5	0.34	3.5	8.5	1.0	0.22	1.3	12.2	4.2	8.0
Lead, total (µg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	1.0	1.0	1.0	<1.0	2.0	5.0	<1.0	<1.0	<1.0	2.0	1.0	3.0
	Max	2.0	1.0	1.0	<1.0	4.0	9.0	1.0	1.0	1.0	15.0	5.0	30.0
	Mean	2.0	1.0	1.0	<1.0	3.0	7.0	1.0	<1.0	1.0	9.0	3.0	10.0
Manganese, total (mg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	0.084	0.054	0.10	0.022	0.10	0.14	0.055	0.030	0.10	0.12	0.14	0.17
	Max	0.086	0.056	0.10	0.025	0.15	0.22	0.081	0.012	0.26	0.42	0.25	1.1
	Mean	0.085	0.055	0.10	0.024	0.11	0.18	0.066	0.041	0.19	0.28	0.21	0.46
Mercury, total (µg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	9.1	1.4	1.3	0.76	3.5	0.94	0.75	0.45	0.86	1.1	0.18	0.31
	Max	9.2	1.6	6.6	1.0	6.7	1.8	1.0	1.3	6.4	1.9	2.7	0.84
	Mean	9.2	1.5	4.0	0.88	5.1	1.3	0.83	0.85	3.4	1.4	1.0	0.53
Zinc, total (µg/l)	N	2	2	2	2	4	4	4	4	8	8	8	8
	Min	8.1	6.0	7.3	4.6	9.3	27.0	5.2	1.6	2.0	19.0	7.4	21.0
	Max	10.0	5.5	83.0	6.6	18.0	52.0	7.4	4.4	10.0	80.0	25.0	52.0
	Mean	9.1	5.8	45.0	5.6	15.0	37.0	6.2	2.5	5.4	56.0	16.0	36.0

[a] Values are means of duplicate samples.
[b] Values are means of duplicate samples from two locations.
[c] Values are means of duplicate samples from four locations.

NALCO ENVIRONMENTAL SCIENCES

Table 4.7. Mean water quality data from John Redmond Reservoir, 1973-75.[a]

Parameter	Year	Location 1 March[b]	June	September	December
General Water Quality Parameters					
Temperature, water (°C)	1973	9.2	24.5	23.0	2.2
	1974	6.0	19.9	18.7	0.8
	1975	12.3	23.3	23.9	0
Oxygen, dissolved (mg/l)	1973	10.4	7.0	8.0	12.5
	1974	12.2	8.4	6.9	12.9
	1975	11.6	6.0	6.4	13.4
Oxygen, saturation (%)	1973	90	83	92	91
	1974	98	92	75	90
	1975	106	64	68	92
pH	1973	8.2	8.2	8.1	7.4
	1974	7.9	7.9	7.8	8.2
	1975	8.2	7.9	7.6	7.8
Alkalinity, total (mg/l-$CaCO_3$)	1973	116	172	193	128
	1974	205	156	128	177
	1975	161	158	166	193
Sulfate (mg/l)	1973	27	50	60	37
	1974	66	60	30	41
	1975	41	48	72	89
Filtrable residue (mg/l)	1973	209	317	327	220
	1974	338	303	234	252
	1975	266	284	312	410
Conductance, specific (μmhos/cm at 25 C)	1973	288	506	495	356
	1974	536	486	365	460
	1975	428	437	521	656
Nonfiltrable residue (mg/l)	1973	53	39	20	49
	1974	23	43	16	83
	1975	59	12	40	5
Turbidity[c] (N.T.U.)	1973	58	41	15	55
	1974	14	32	2	38
	1975	45	28	23	14
Color, true (units)	1973	26	11	9	25
	1974	16	14	21	15
	1975	19	15	11	8
Aquatic Nutrients					
Ammonia (mg/l-N)	1973	0.15	0.05	0.02	0.17
	1974	0.19	0.05	0.03	0.23
	1975	0.04	0.09	0.03	0.01
Nitrate (mg/l-N)	1973	0.90	1.2	0.70	0.67
	1974	1.2	1.9	0.20	0.37
	1975	1.1	1.2	0.55	0.51
Nitrite (mg/l-N)	1973	0.017	0.14	0.0019	0.0017
	1974	0.024	0.042	0.036	0.011
	1975	0.020	0.063	0.062	0.0031
Organic Nitrogen, total (mg/l-N)	1973	0.61	0.70	0.75	0.75
	1974	0.56	0.77	0.56	0.61
	1975	0.89	0.57	0.77	0.55

Table 4.7. Continued.

Parameter	Year	Location 1 March[b]	June	September	December
Orthophosphate, soluble (mg/l-P)	1973	0.12	0.15	0.046	0.076
	1974	0.068	0.081	0.055	0.092
	1975	0.007	0.037	0.018	0.017
Phosphorus, total (mg/l-P)	1973	0.20	0.15	0.078	0.16
	1974	0.12	0.14	0.090	0.16
	1975	0.13	0.071	0.11	0.046
Silica, soluble (mg/l-SiO_2)	1973	10.4	8.4	4.6	8.1
	1974	9.2	10.7	3.7	10.3
	1975	5.3	6.8	3.7	0.8
Industrial and Municipal Contaminants					
Bacteria, fecal coliform (No./100 ml)	1973	25	35	7	635
	1974	60	420	0	67
	1975	230	0	1	1
Biochemical oxygen demand (5-day) (mg/l)	1973	1.8	2.3	1.4	1.3
	1974	5.1	2.6	1.2	1.2
	1975	3.9	1.8	1.4	1.9
Chemical oxygen demand (mg/l)	1973	19	21	15	21
	1974	16	16	21	18
	1975	27	14	16	22
Organic carbon, total (mg/l)	1973	7	19	13	11
	1974	24	7	9	14
	1975	13	23	16	9.3
Hexane soluble materials (mg/l)	1973	0.1	0.3	<0.1	1.8
	1974	0.1	1.8	0.1	0.4
	1975	0.9	1.4	1.9	1.2
Trace Metals					
Copper (μg/l)	1973	3.0	8.0	2.9	4.5
	1974	4.5	4.5	3.6	5.0
	1975	3.5	2.5	4.0	2.1
Iron, total (mg/l)	1973	3.4	2.7	0.80	3.0
	1974	0.74	1.4	1.5	1.8
	1975	2.5	1.1	1.5	0.32
Lead (μg/l)	1973	<1.0	7.0	1.0	3.0
	1974	<1.0	12.0	3.0	8.0
	1975	2.0	<1.0	1.0	<1.0
Manganese (mg/l)	1973	0.053	0.21	0.038	0.11
	1974	0.066	0.053	0.039	0.057
	1975	0.085	0.055	0.10	0.024
Mercury (μg/l)	1973	0.09	0.64	0.06	0.18
	1974	0.07	0.07	<0.05	0.36
	1975	9.2	1.5	4.0	4.3
Zinc (μg/l)	1973	<1.0	12.0	<1.0	13.0
	1974	40.0	11.0	17.0	10.0
	1975	9.0	5.7	45.0	5.5

[a] All values are means of duplicate samples.
[b] Water quality data collected in March during 1973-74 and in April of 1975.
[c] Turbidity previous to April 1975 reported in JTU.

Table 4.8. Mean water quality data from the Neosho River upstream and downstream of the confluence with Wolf Creek, 1973-75.[a]

Parameter	Year	Upstream Location 10 March[b]	June	September	December	Downstream Location 4 March[b]	June	September	December
General Water Quality Parameters									
Temperature, water (°C)	1973	-[c]	-[c]	-[c]	-[c]	9.2	24.6	23.0	2.5
	1974	5.0	19.7	19.6	0.9	-[d]	20.0	19.5	0.9
	1975	11.0	21.2	24.1	2.8	11.0	21.2	23.6	2.8
Oxygen, dissolved (mg/l)	1973	-[c]	-[c]	-[c]	-[c]	12.1	7.7	7.4	14.1
	1974	13.5	8.8	8.7	13.5	13.5	8.8	8.7	13.5
	1975	10.4	5.7	7.5	13.3	10.5	5.9	7.1	12.6
Oxygen, saturation (%)	1973	-[c]	-[c]	-[c]	-[c]	102	92	85	120
	1974	90	91	94	99	-[d]	97	94	100
	1975	93	60	80	98	95	62	75	93
pH	1973	-[c]	-[c]	-[c]	-[c]	8.2	8.2	7.9	7.6
	1974	7.9	8.0	7.7	8.2	7.8	8.2	7.6	8.0
	1975	8.1	7.2	7.8	7.5	8.2	7.1	7.9	7.7
Alkalinity, total (mg/l-$CaCO_3$)	1973	-[c]	-[c]	-[c]	-[c]	114	173	194	135
	1974	190	154	141	175	200	164	140	178
	1975	155	139	171	191	153	97	175	195
Sulfate (mg/l)	1973	-[c]	-[c]	-[c]	-[c]	27	46	56	40
	1974	46	60	33	39	89	59	40	41
	1975	41	37	66	82	45	30	68	99
Filtrable residue (mg/l)	1973	-[c]	-[c]	-[c]	-[c]	213	307	223	238
	1974	315	297	218	228	325	284	214	263
	1975	281	283	313	338	348	223	315	385
Conductance, specific (µmhos/cm at 25 C)	1973	-[c]	-[c]	-[c]	-[c]	293	462	510	375
	1974	525	459	367	462	538	458	368	475
	1975	430	380	512	600	431	274	514	606
Nonfiltrable residue (mg/l)	1973	-[c]	-[c]	-[c]	-[c]	98	48	41	43
	1974	29	89	39	115	42	194	40	93
	1975	93	140	30	4	86	192	37	3
Turbidity[e] (N.T.U.)	1973	-[c]	-[c]	-[c]	-[c]	70	50	23	51
	1974	21	50	6	44	28	80	7	46
	1975	58	120	27	10	73	185	33	8
Color, true (units)	1973	-[c]	-[c]	-[c]	-[c]	27	14	12	24
	1974	16	17	18	15	16	18	20	15
	1975	21	24	11	8	17	52	12	9

NALCO ENVIRONMENTAL SCIENCES

Table 4.8. Continued.

Parameter	Year	Upstream Location 10 March[b]	June	September	December	Downstream Location 4 March[b]	June	September	December
Aquatic Nutrients									
Ammonia (mg/l-N)	1973	–[c]	–[c]	–[c]	–[c]	0.12	0.03	0.01	0.18
	1974	0.19	0.04	0.03	0.22	0.17	0.05	0.02	0.21
	1975	0.15	0.07	0.01	0.03	0.18	0.06	<0.01	0.04
Nitrate (mg/l-N)	1973	–[c]	–[c]	–[c]	–[c]	0.77	1.2	0.70	0.79
	1974	–	2.0	0.49	0.93	1.4	2.2	0.28	0.89
	1975	1.1	1.2	0.55	0.53	1.3	0.67	0.60	0.52
Nitrite (mg/l-N)	1973	–[c]	–[c]	–[c]	–[c]	0.015	0.12	0.0018	0.012
	1974	0.025	0.040	0.026	0.011	0.023	0.044	0.032	0.011
	1975	0.020	0.018	0.031	0.0045	0.022	0.014	0.028	0.0045
Organic nitrogen, total (mg/l)	1973	–[c]	–[c]	–[c]	–[c]	0.62	0.57	0.86	0.73
	1974	0.50	0.66	0.62	0.66	0.56	0.83	0.60	0.63
	1975	0.93	1.0	0.57	0.42	0.96	1.4	0.60	0.51
Orthophosphate, soluble (mg/l-P)	1973	–[c]	–[c]	–[c]	–[c]	0.11	0.16	0.066	0.073
	1974	0.067	0.075	0.055	0.093	0.066	0.079	0.057	0.091
	1975	0.015	0.080	0.034	0.031	0.018	0.061	0.037	0.026
Phosphorus, total (mg/l-P)	1973	–[c]	–[c]	–[c]	–[c]	0.23	0.15	0.12	0.21
	1974	0.11	0.16	0.089	0.16	0.12	0.21	0.11	0.16
	1975	0.21	0.24	0.088	0.041	0.18	0.35	0.088	0.034
Silica, soluble (mg/l-SiO_2)	1973	–[c]	–[c]	–[c]	–[c]	10.3	7.3	5.5	8.9
	1974	8.8	11.5	4.9	10.4	8.9	8.4	5.9	10.7
	1975	5.1	8.4	3.7	0.31	5.2	8.5	3.8	0.34
Industrial and Municipal Contaminants									
Bacteria, fecal coliform (No./100 ml)	1973	–[c]	–[c]	–[c]	–[c]	67	43	46	680
	1974	81	41	–[d]	170	81	52	370	190
	1975	215	170	97	38	170	230	135	45
Biochemical oxygen demand (5-day) (mg/l)	1973	–[c]	–[c]	–[c]	–[c]	2.6	2.4	1.5	1.3
	1974	4.8	1.7	0.8	1.1	5.1	2.1	0.7	1.2
	1975	2.7	2.3	0.5	2.0	3.3	2.3	1.1	1.7
Chemical oxygen demand (mg/l)	1973	–[c]	–[c]	–[c]	–[c]	22	20	16	21
	1974	15	17	15	16	16	21	17	17
	1975	32	23	14	17	28	37	15	21
Organic carbon, total (mg/l)	1973	–[c]	–[c]	–[c]	–[c]	8	6	20	13
	1974	18	9	10	14	21	9	9	14
	1975	28	21	11	9.1	30	24	13	7.6
Hexane soluble materials (mg/l)	1973	–[c]	–[c]	–[c]	–[c]	<0.1	0.2	1.7	1.6
	1974	1.1	1.7	<0.1	0.2	0.5	1.2	<0.1	0.2
	1975	0.7	2.2	1.4	1.7	0.5	1.5	1.7	0.9

NALCO ENVIRONMENTAL SCIENCES

Table 4.8. Continued.

Parameter	Year	Upstream Location 10				Downstream Location 4			
		March[b]	June	September	December	March[b]	June	September	December
Trace Metals									
Copper, total (μg/l)	1973	–[c]	–[c]	–[c]	–[c]	3.0	4.1	1.8	2.2
	1974	1.5	4.9	5.7	5.7	1.6	8.5	5.0	5.3
	1975	3.8	6.5	2.3	1.6	5.3	9.9	1.6	2.6
Iron, total (mg/l)	1973	–[c]	–[c]	–[c]	–[c]	3.8	2.9	1.1	2.4
	1974	0.85	2.1	2.1	2.1	0.88	3.7	2.2	2.3
	1975	3.0	6.1	0.92	0.22	3.9	11.0	1.1	0.23
Lead, total (μg/l)	1973	–[c]	–[c]	–[c]	–[c]	1.0	2.0	1.0	1.0
	1974	<1.0	13.0	4.0	2.0	<1.0	30.0	2.0	2.0
	1975	2.0	5.0	<1.0	<1.0	3.0	9.0	1.0	1.0
Manganese, total (mg/l)	1973	–[c]	–[c]	–[c]	–[c]	0.057	0.18	0.090	0.11
	1974	0.066	0.068	0.071	0.074	0.068	0.13	0.072	0.082
	1975	0.10	0.15	0.056	0.030	0.13	0.22	0.075	0.032
Mercury, total (μg/l)	1973	–[c]	–[c]	–[c]	–[c]	0.14	0.07	0.06	0.11
	1974	0.08	0.07	<0.05	0.61	0.05	0.05	<0.05	0.32
	1975	6.5	1.0	0.76	0.54	8.7	1.7	0.92	1.2
Zinc, total (μg/l)	1973	–[c]	–[c]	–[c]	–[c]	<1.0	8.0	<1.0	<1.0
	1974	15.0	60.0	39.0	12.0	18.0	26.0	47.0	11.0
	1975	17.0	28.0	5.8	1.8	13.0	46.0	6.4	3.3

[a] All values are means of duplicate samples.
[b] Water quality data collected in March during 1973-74 and in April of 1975.
[c] Location 10 not included in 1973 study.
[d] Not determined.
[e] Turbidity previous to April 1975 reported in JTU.

NALCO ENVIRONMENTAL SCIENCES

Table 4.9. Mean water quality data from Wolf Creek, 1973-75.[a]

Parameter	Year	Upstream Location 2 March[b]	June	September[c]	December[c]	Downstream Location 3 March[b]	June	September[c]	December[c]
General Water Quality Parameters									
Temperature, water (°C)	1973	11.4	22.0	20.5	2.4	9.5	22.5	20.5	2.4
	1974	9.4	18.1	19.1	0.8	8.6	18.9	19.7	0.7
	1975	12.2	19.8	18.5	2.5	13.5	20.1	20.1	2.2
Oxygen, dissolved (mg/l)	1973	9.5	3.8	3.2	11.0	9.9	3.5	1.4	11.4
	1974	13.0	5.9	7.1	13.5	13.0	6.0	6.5	13.9
	1975	8.9	6.4	4.7	2.6	9.1	6.5	4.3	0.3
Oxygen saturation (%)	1973	85	43	35	80	88	40	15	97
	1974	114	63	77	94	112	65	72	97
	1975	82	66	48	20	86	67	45	2
pH	1973	7.8	7.5	7.6	7.1	7.9	7.7	7.3	7.3
	1974	8.0	6.9	7.2	8.1	7.9	7.1	7.5	8.0
	1975	7.6	7.1	7.3	6.4	7.7	7.0	7.6	6.2
Alkalinity, total (mg/l-$CaCO_3$)	1973	96	130	144	173	112	147	121	194
	1974	207	85	117	207	224	87	164	228
	1975	187	77	102	89	189	87	162	83
Sulfate (mg/l)	1973	45	56	14	70	37	41	10	59
	1974	106	60	52	125	68	49	56	82
	1975	129	43	25	22	79	36	27	7.0
Filtrable residue (mg/l)	1973	258	251	182	343	223	236	153	386
	1974	420	230	252	451	352	210	279	376
	1975	430	292	194	221	332	238	225	193
Conductance, specific (μmhos/cm at 25 C)	1973	311	407	278	521	300	395	229	504
	1974	632	339	360	696	580	310	391	611
	1975	651	276	258	254	548	272	359	194
Nonfiltrable residue (mg/l)	1973	81	50	110	23	125	108	69	25
	1974	7	149	23	20	20	370	43	19
	1975	15	192	140	131	50	397	35	166
Turbidity[d] (N.T.U.)	1973	81	42	73	28	87	58	58	26
	1974	9	117	5	6	13	250	5	10
	1975	16	190	105	100	44	215	37	140
Color, true (units)	1973	50	34	15	26	50	30	18	21
	1974	13	62	37	13	11	67	25	11
	1975	15	–[e]	52	103	19	65	20	60

NALCO ENVIRONMENTAL SCIENCES

Table 7.9. Continued.

Parameter	Year	Upstream Location 2 March[b]	June	September[c]	December[c]	Downstream Location 3 March[b]	June	September[c]	December[c]
Aquatic Nutrients									
Ammonia (mg/l-N)	1973	0.05	0.10	0.03	0.04	0.04	0.10	0.01	0.04
	1974	0.02	0.09	0.01	0.02	<0.01	0.10	0.02	<0.01
	1975	0.04	0.06	0.01	0.06	0.04	0.04	<0.01	0.05
Nitrate (mg/l-N)	1973	0.77	1.4	0.06	0.52	1.1	1.3	0.04	0.79
	1974	-[e]	3.0	0.22	0.08	-[e]	2.9	0.47	0.14
	1975	0.15	0.97	0.20	0.54	0.36	0.86	0.12	0.09
Nitrite (mg/l-N)	1973	0.0086	0.068	0.0005	0.0052	0.0096	0.057	0.0008	0.0057
	1974	0.0022	0.073	0.0080	0.0014	0.0034	0.069	0.010	0.0019
	1975	0.0019	0.024	0.011	0.119	0.0031	0.0016	0.0056	0.0038
Organic nitrogen, total (mg/l)	1973	0.91	0.71	0.60	0.69	0.83	0.85	0.58	0.58
	1974	0.40	1.0	0.71	0.42	0.48	1.5	0.76	0.42
	1975	0.53	1.6	1.0	1.4	0.59	1.7	0.74	1.3
Orthophosphate, soluble (mg/l-P)	1973	0.042	0.066	0.020	0.018	0.042	0.13	0.005	0.023
	1974	0.007	0.030	0.020	0.007	0.009	0.039	0.030	0.021
	1975	0.001	0.013	0.017	0.11	0.006	0.012	0.011	0.11
Phosphorus, total (mg/l-P)	1973	0.16	0.13	0.16	0.077	0.19	0.20	0.16	0.090
	1974	0.032	0.19	0.079	0.031	0.054	0.36	0.11	0.040
	1975	0.008	0.26	0.19	0.27	0.053	0.38	0.073	0.40
Silica, soluble (mg/l-SiO_2)	1973	12.2	14.4	9.9	13.0	11.7	14.2	6.6	13.0
	1974	3.9	11.4	3.9	4.4	5.8	13.8	4.3	3.8
	1975	1.1	9.8	9.0	10.4	4.7	9.6	8.1	-[e]
Industrial and Municipal Contaminants									
Bacteria, fecal coliform (No./100 ml)	1973	340	290	290	205	480	260	370	370
	1974	82	690	200	33	270	5200	-[e]	93
	1975	120	230	460	200	290	330	70	110
Biochemical oxygen demand (5-day) (mg/l)	1973	2.5	2.9	2.8	1.4	1.9	3.2	3.9	1.5
	1974	5.0	3.1	1.1	1.1	5.1	3.6	1.3	1.1
	1975	2.1	3.4	2.4	-[e]	2.6	3.0	2.1	-[e]
Chemical oxygen demand (mg/l)	1973	32	31	29	20	35	31	29	16
	1974	13	39	24	15	13	51	21	13
	1975	24	42	31	46	24	50	20	36
Organic carbon, total (mg/l)	1973	11	13	23	14	10	12	21	11
	1974	28	17	14	14	28	21	12	13
	1975	14	23	19	33	26	26	13	29
Hexane soluble materials (mg/l)	1973	0.3	0.2	<0.1	1.7	<0.1	0.3	1.1	1.8
	1974	0.2	1.9	0.2	0.4	<0.1	1.2	<0.1	0.5
	1975	1.0	1.3	0.9	0.3	0.9	1.2	1.4	1.0

NALCO ENVIRONMENTAL SCIENCES

Table 4.9. Continued.

Parameter	Year	Upstream Location 2 March[b]	June	September[c]	December[c]	Downstream Location 3 March[b]	June	September[c]	December[c]
Trace Metals									
Copper, total	1973	20.0	3.3	2.5	1.1	3.0	3.6	1.5	1.8
(µg/l)	1974	0.8	8.2	3.2	1.8	1.0	17.0	3.5	1.8
	1975	1.7	11.0	6.0	6.0	2.4	17.0	1.9	5.6
Iron, total	1973	6.2	3.0	3.7	1.8	6.3	4.2	3.5	1.8
(mg/l)	1974	0.34	6.9	1.6	0.28	0.55	11.	1.8	0.38
	1975	0.69	11.1	6.1	7.2	1.7	15.0	1.2	9.1
Lead, total	1973	3.0	<1.0	2.0	<1.0	2.0	2.0	2.0	<1.0
(µg/l)	1974	<1.0	30.0	<1.0	<1.0	<1.0	43.0	<1.0	<1.0
	1975	<1.0	7.0	4.0	17.0	1.0	12.0	<1.0	8.0
Manganese, total	1973	0.12	0.33	0.050	0.20	0.16	0.43	1.6	0.26
(mg/l)	1974	0.17	0.22	0.080	0.087	0.24	0.41	0.16	0.10
	1975	0.17	0.22	0.18	0.24	0.25	0.36	0.25	1.1
Mercury, total	1973	1.2	0.07	<0.05	0.08	0.06	<0.05	0.29	0.11
(µg/l)	1974	0.05	<0.05	<0.05	0.48	.05	<0.05	<0.05	0.52
	1975	4.5	1.7	1.1	0.66	6.3	1.5	1.8	0.95
Zinc, total[f]	1973	<1.0	11.0	<1.0	3.0	1.0	7.0	1.0	4.0
(µg/l)	1974	34.0	28.0	18.0	2.4	26.0	61.0	52.0	2.1
	1975	2.8	51.0	19.0	3.4	7.6	74.0	8.3	40.0

[a] All values are means of duplicate samples.
[b] Water quality data collected in March 1973-74 and in April 1975.
[c] Creek locations existed as isolated pools in September and December 1975.
[d] Turbidity previous to April 1975 reported in JTU.
[e] Not determined.
[f] Analytical detection limit changed from 0.001 to 0.0001 mg/l between 1973 and 1974.

NALCO ENVIRONMENTAL SCIENCES

Chapter 5

PHYTOPLANKTON STUDIES

By

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I. Introduction

The phytoplankton community is an essential component of the aquatic environment. These organisms represent the initial link in the food chain from which other biological communities, either directly or indirectly, derive their nutrient requirements. While adequate phytoplankton quantities are required for aquatic food chains, large populations of some taxa can impair water quality.

Baseline data describing the phytoplankton community of the Neosho River basin near the proposed Wolf Creek Generating Station (WCGS) were obtained in 1973 and 1974 (Kansas Gas and Electric Company 1974; Wilde et al. 1975). The present report discusses results of continuing investigations conducted during 1975 to provide additional preconstruction data on the area which may be affected by construction and operation of WCGS.

Specific objectives of the study were:

1. To provide additional baseline data on the phytoplankton of the site and its environs; and

2. To document seasonal and year-to-year variations in phytoplankton composition, abundance, biomass (biovolume and chlorophyll a concentrations), and primary productivity (carbon fixation rate) for inclusion in the future evaluation of environmental impacts from construction or operation of the proposed Wolf Creek Generating Station.

II. Field and Analytical Procedures

Duplicate composite water samples for phytoplankton analyses were collected quarterly at six locations (Figure 5.1). All samples were collected within one meter of the surface with a nonmetallic water sampler. Subsamples were immediately placed in appropriately labeled 1.9 l polyethelene bottles containing 60 ml of "M^3" preservative (Meyer 1971) for later algal identification, enumeration, and biovolume determinations. Carbon fixation rate and chlorophyll a concentration were assessed from the remaining portion of the duplicate samples.

Two separate procedures were used to analyze the preserved samples. A subsample volume of 10 to 100 ml was used for diatom analyses. Diatoms were cleaned with a concentrated nitric acid/potassium dichromate solution and collected on a 0.45 μ pore size membrane filter. The filter was air-dried and a portion was placed on a glass slide, cleared with immersion oil, and covered with a coverslip. The slide was then examined at 1250 X magnification with a microscope equipped with phase contrast. A modification of Lackey's (1938) microtransect method was used to analyze the non-diatom phytoplankton. An 875 ml subsample volume from each sample was placed in a 1000 ml beaker. Liquid detergent was added to break the surface tension (Mackenthun 1969), and the organisms were allowed to settle overnight. The supernatant was removed with a suction pump, and the organisms were further concentrated in successively smaller containers until a density suitable for counting was attained. A 0.1 ml aliquot of the concentrate was placed in a slide and examined at 500 X magnification with a microscope equipped with phase contrast.

An area of the coverslip large enough to permit the accurate estimation of the density and diversity of phytoplankton populations was examined for each preparation. All undamaged organisms were identified to the lowest positive taxonomic level using keys by Hustedt (1930), Huber-Pestalozzi (1941, 1968), Smith (1950), Hortobagyi (1960), Prescott (1962, 1964), Patrick and Reimer (1966), Cocke (1967), Stoermer and Yang (1969), Taft and Taft (1971), Weber (1971), and Whitford and Schumacher (1973). Densities were reported as the number of units per milliliter of water (units/ml). A reporting unit consisted of a single frustule for diatoms. For algae other than diatoms, a reporting unit consisted of a single cell for unicellular forms, a 100 μ length for filamentous forms and four cells for all colonial forms other than species of Aphanocapsa, Aphanothece, and Microcystis in which 50 cells comprised a reporting unit.

Biovolume (cell volume) determinations were made using methods described by Cowell (1960) and Hohn (1969). Biovolume was computed for each taxon using the formula for the geometric configuration that most resembled the shape of the organism. The average biovolume of at least 10 randomly selected individuals was used for abundant forms, and the average biovolume of all individuals examined was used for those observed less than 10 times. All biovolumes were expressed as microliters per liter (μl/l).

Species diversity index values were calculated with data from each sampling location on each sampling date using the Shannon (1948) formula and log base e. The data were statistically analyzed each sampling period using a one-way analysis of variance (ANOVA) to determine if significant differences existed in phytoplankton densities among sampling locations. Tukey's multiple comparison procedure was employed following the ANOVA whenever significant differences were detected.

The non-preserved portion of the composite samples were analyzed for carbon fixation rate and chlorophyll a concentration. Carbon fixation rate was estimated by the light-dark bottle ^{14}C method (Wetzel 1964; Parkos et al. 1969; Strickland and Parsons 1972). Three 50 ml subsamples were taken from each composite, inoculated with 4-5 microcuries of aqueous ^{14}C bicarbonate solution, and incubated for 3 hr in a constant light (≈1000 ft-c) and temperature (adjusted to near ambient) chamber. The subsamples were then filtered through 0.45 μ porosity filters. The filters were returned to the laboratory, dried, fumed with concentrated HCl for 10 min (Wetzel 1965), and placed in low potassium scintillation vials. Seventeen milliliters of scintillation fluid (12 g/l Butyl PBD, 0.4 g/l PBBO, and 180 ml/l Scintisol-GB in spectrophotometric grade toluene) were added to each vial and the activity was measured with a refrigerated liquid scintillation counter. Carbon fixation rate was expressed as milligrams of carbon fixed per cubic meter per hour (mg C/m^3 per hr).

Chlorophyll a concentration was determined by flouorometric techniques of Lorenzen (1966) and Strickland and Parsons (1972). Three 50 ml subsamples from each composite sample were filtered through glassfiber filter papers on a thin layer of $MgCO_3$. The filters were eluted with 90% acetone for at least 24 hr, ultrasonically disrupted, and centrifuged. The fluorescence was measured before and after the addition of 1 N HCl. Chlorophyll a concentration was expressed as milligrams per cubic meter of water (mg Chl a/m^3).

III. Results and Discussion

A. Phytoplankton Composition, Abundance, and Distribution

The phytoplankton collected in April, June, September, and December 1975 from John Redmond Reservoir, the Neosho River, and Wolf Creek consisted of 226 taxa which represented 91 genera and eight algal divisions. Diatoms (Bacillariophyta) and green algae (Chlorophyta) were the most diverse groups with 108 and 70 taxa, respectively. A comprehensive species list and a tabulation of density and biovolume for each taxon are presented by sampling date and location in Appendix D.

Total phytoplankton densities and biovolumes ranged from 509 units/ml and 0.185 μl/l at Location 2 in December to 17791 units/ml and 7.866 μl/l at Location 4 in April (Tables 5.1 and 5.2). The reservoir (Location 1) and river (Locations 4 and 10) communities were similar on all four sampling dates, while the assemblages collected from Wolf Creek (Locations 2, 3, 5, and 7) were substantially different from those of the reservoir and river and were generally different among locations. Centric diatoms were generally the dominant algal group in the reservoir and river, whereas pennate diatoms and cryptomonads were the major components of the creek community. Densities and biovolumes were highest in the reservoir and river in April and at most creek locations in September. No consistent seasonal or year-to-year patterns of abundance were observed in the three systems during the 1973 through 1975 period (Figures 5.2, 5.3, and 5.4).

Diatoms constituted a major portion of the phytoplankton in all samples. Centric diatoms were more abundant than pennate diatoms in the reservoir and river on all sampling dates, except June, and comprised 17.7 to 91.6% of the total phytoplankton density and biovolume (Tables 5.1 and 5.2). Pennate diatoms were abundant in the creek where they accounted for 10.5 to 95.5% of the total density. The most frequently observed centric diatoms in the reservoir and river were *Stephanodiscus astraea*, *S. minutus*, *Stephanodiscus* sp., and *Cyclotella meneghiniana* v. *plana* (Table 5.3). These taxa were also dominant in the reservoir and river in 1973 and 1974 (Kansas Gas and Electric Company 1974; Wilde et al. 1975). Centric diatoms are typically abundant members of the potamoplankton (true river plankton) (Hynes 1970). *Stephanodiscus astraea*, *S. minutus*, and *C. meneghiniana* v. *plana* have been associated with eutrophic conditions (Stoermer and Yang 1969; Hynes 1970); however, Williams (1972) has shown that little evidence exists to support the pollution-indicator concept among the dominant phytoplankters of major rivers. He believes that the dominant diatoms in most rivers are related more to edaphic factors of the watershed than to the degree of pollution. The most abundant diatoms in Wolf Creek were species of the pennate genera *Navicula* and *Nitzschia*. These taxa are primarily littoral organisms of benthic origin (Patrick and Reimer 1966; Hutchinson 1967).

The spring and fall pulses of diatoms observed in the reservoir and river during 1975 were typical for this group (Patrick and Reimer 1966; Hutchinson 1967). These normal seasonal patterns of distribution were not detected in 1973 and 1974 (Figures 5.2 and 5.3). A fall pulse of diatoms occurred in Wolf Creek, and the group was least abundant there in December.

Minimal diatom densities were also observed in the creek during December of 1973 and 1974 (Figure 5.4).

Densities and biovolume of green algae (Chlorophyta) ranged from 17 units/ml and 0.005 µl/l at Location 5 in June to 3263 units/ml and 0.920 µl/l at Location 3 in September, accounting for 0.4 to 46.4% of the total phytoplankton (Tables 5.1 and 5.2). This group displayed considerable temporal and spatial variability, and there was no striking distinction among populations of the reservoir, river, or creek. The major taxa were Dictyosphaerium pulchellum, Chlamydomonas sp., Oocystis pusilla, O. borgei, and Ankistrodesmus spiralis (Table 5.3). Populations were largest in the creek and reservoir in September, and in the river in December (Figures 5.2, 5.3, and 5.4). Greatest abundances of this group typically occur in late spring or early fall (Hutchinson 1967). Quantities of green algae were larger at most sampling locations in 1975 than during the previous two years (Figures 5.2, 5.3, and 5.4).

Blue-green algae (Cyanophyta) were more abundant in the reservoir and river than in the creek. They were observed in all samples from the reservoir and river, but were absent from several creek samples. The largest populations occurred in the Neosho River in September (Table 5.1). This pulse was primarily comprised of Merismopedia tenuissima, a very small colonial taxon, and consequently, biovolumes were low (Table 5.2). Spatial and seasonal distribution patterns were similar during all three years. In 1973 and 1974, blue-green populations were negligible except in September when pulses of M. tenuissima occurred in the reservoir and river. Blue-greens usually occur in abundance only during the warm months of the year (Smith 1950).

Cryptomonads (Cryptophyta) were observed in all samples except those from Location 2 in December. The highest density (4744 units/ml) occurred at Location 3 in September; however, this group accounted for the largest percentage (68.5%) of the total density at Location 3 in April (Tables 5.1). Densities and biovolumes were largest in September at most sampling locations, and the group was generally more abundant in 1975 than 1973 or 1974 (Figures 5.2, 5.3, and 5.4). Rhodomonas minuta v. nannoplanctica and Cryptomonas sp. were the only cryptomonads observed in the study. Both were abundant in the reservoir, river, and creek (Table 5.3). This group is widely distributed in the U. S. (Smith 1950) and generally occurs throughout the year (Hutchinson 1967). They apparently have no typical seasonal distribution pattern, and maxima have reportedly occurred in spring (Birge and Juday 1922), summer (Wilde and Paulishen 1974), and winter (Staker 1974).

Euglenoids (Euglenophyta) were more abundant in the creek than in the reservoir or river. They were observed in all samples, except those from the reservoir in June. Largest quantities (1200 units/ml and 4.021 µl/l) occurred at Location 5 in September, comprising 10.5 and 55.4% of the total density and biovolume, respectively (Tables 5.1 and 5.2). Although less abundant (295 units/ml and 0.718 µl/l) at Location 5 in December, they accounted for 57.8% of the total density and 93.3% of the total biovolume, due to a scarcity of other algae. Major euglenoid taxa were Euglena acus, E. gracilis, E. polymorpha, Euglena sp., Lepocinclis sp., Trachelomonas sp., and Phacus longicauda (Table 5.3). These organisms often become abundant in small pools rich in organic matter (Hutchinson 1967). Their abundance in Wolf Creek during September and

December may have been prompted by the low water level which resulted in the formation of temporary pools. A similar phenomenon was reported in 1973 (Kansas Gas and Electric Company 1974). Euglenoids were of little quantitative importance in 1974 (Wilde et al. 1975).

Yellow-brown algae (Chrysophyta) were abundant in Wolf Creek in April and September but were never quantitatively important in the reservoir and river (Tables 5.1 and 5.2). The group was virtually absent from all locations in June and December. The largest quantity (2575 units/ml and 0.243 μl/l) occurred at Location 3 in September and accounted for 20.8 and 9.4% of the total density and biovolume, respectively. Mallomonas sp. and Ochromonas sp. were the most abundant members of the group. The seasonal distribution pattern observed was typical, since these organisms are most abundant during spring and fall (Smith 1950). Yellow-brown algae were an insignificant component of the phytoplankton on all sampling dates of the 1973 and 1974 studies.

Other algal groups observed in the study included dinoflagellates (Pyrrhophyta) and chloromonads (Chloromonadophyta). These algae were of little quantitative importance during all three years.

Species diversity indices (mathematical expressions of community structure based on the density of organisms, number of species, and relative abundance of each component) have been used as indicators of environmental conditions (Warren 1971). The diversity values computed for the reservoir, river, and creek during 1975 ranged from 1.52 at Location 10 in April to 3.37 at Location 2 in June (Table 5.4). The relatively low values (1.52 to 1.78) at reservoir and river locations in April were primarily due to large populations of centric diatoms (mostly Stephanodiscus spp.).

Few significant differences in phytoplankton density were detected among sampling locations in the reservoir and river (Tables 5.5 to 5.8). Significant differences were common among creek locations, but no consistent pattern was noted. The large number of differences in densities observed among all locations in the area was due to the variety of habitats sampled.

B. Carbon Fixation Rate and Chlorophyll a Concentration

1. John Redmond Reservoir and the Neosho River

Carbon fixation rate and chlorophyll a concentration were highest in April and lowest in June at Locations 1, 10, and 4 (Table 5.9). Values were generally similar among locations during each sampling period, which corresponds with the similarity in species composition and total phytoplankton abundance. Highest carbon fixation (130.65 mg C/m^3 per hr) and chlorophyll a concentration (34.97 mg Chl a/m^3) coincided with peak total phytoplankton and centric diatom abundance in April. A positive relationship between centric diatom abundance and carbon fixation rate and chlorophyll a concentration for John Redmond Reservoir and Neosho River locations was also reported in 1973 (Kansas Gas and Electric Company 1974) and 1974 (Wilde et al. 1975). No seasonal patterns have been evident during the three-year study period. This indicates that factors other than temperature and light, including retention time in John Redmond Reservoir and turbidity, have been more important in determining

the extent of phytoplankton development.

With the exception of the June collection, Wolf Creek had no discernible effect on carbon fixation rate or chlorophyll a concentration in the Neosho River. During June, relatively high flow in Wolf Creek was accompanied by low flow in the Neosho River, and, as a result, values obtained at Location 4 were more similar to those obtained at Wolf Creek locations than to Locations 1 and 10.

2. Wolf Creek

Carbon fixation rate and chlorophyll a concentration in Wolf Creek varied among locations and sampling periods (Table 5.9). Carbon fixation rate and chlorophyll a concentration showed a progressive downstream increase in April and a slight downstream decrease in June. Values were variable and no trends were evident in September and December when low water levels necessitated the collection of samples from isolated pools. The downstream increase in April corresponded to an increase in abundance of cryptomonads (Table 5.1). The lowest carbon fixation rate (0.36 mg C/m^3 per hr), chlorophyll a concentration (1.75 mg Chl a/m^3), and total phytoplankton abundance (509 units/ml) were recorded from samples collected in a pool at Location 2 in December. Highest carbon fixation rate (93.34 mg C/m^3 per hr) and chlorophyll a concentration (30.00 mg Chl a/m^3) were recorded at Location 5 in September when phytoplankton were abundant (11465 units/ml).

Wide variation in carbon fixation rates and chlorophyll a concentrations among samples from Wolf Creek was also reported in 1973 (Kansas Gas and Electric Company 1974) and 1974 (Wilde et al. 1975). Values have generally been low during high flow periods and high when flow was reduced. As flow decreases, turbidity is reduced and phytoplankton development reaches its maximum (Hynes 1970).

C. Relationships between Phytoplankton and the Environment

Environmental factors affecting seasonal and year-to-year phytoplankton development patterns include: flow rate, turbidity, temperature, light, nutrients, and predation. It is difficult to correlate these factors with phytoplankton dynamics because there are usually several interacting factors involved, and no two phytoplankton species react in exactly the same way to a given set of environmental conditions (Fogg 1965). Rate of flow is generally considered the most important factor influencing phytoplankton periodicity in lotic (running water) systems (Blum 1956; Whitford and Schumacher 1963; Williams 1964).

Reinhardt (1931), Blum (1956), and Whitford and Schumacher (1963) have stressed that the development of potamoplankton (the major component of the reservoir and river phytoplankton) is primarily dependent upon "age" (retention time) of the water. Many rivers have drastically smaller phytoplankton populations which include a higher percentage of bottom (benthic) dwelling forms during periods of high flow (Williams 1964; Hynes 1970). It has also been demonstrated that rivers such as the Illinois, Ohio, and upper Mississippi generally exhibit their highest phytoplankton densities during periods of lowest flow, regardless of the season of the year (Williams 1964).

Phytoplankton densities in the reservoir and river have generally been inversely proportional to the amount of rainfall occurring in the 30-day period prior to each sampling in 1973, 1974, and 1975 (Figure 5.5). An exception to this typical relationship between phytoplankton and rainfall was reported in the fall (September) of 1975 when densities were high although heavy rainfall had occurred during the preceding 30 days. However, the August rainfall followed a July drought and did not significantly increase the storage volume of or outflow from the reservoir. Thus, retention time was not greatly affected. The unusually large phytoplankton quantities in the spring of 1975 can be attributed to low flow and a later spring sampling date (April instead of March), characterized by considerably higher water temperatures that were more favorable for diatom growth. Small populations of centric diatoms and green algae, and increases in the percentages of pennate diatoms (primarily of benthic origin) occurred in June. This was due to the heavy rainfall which increased flow and decreased retention time.

Rainfall was well below average during the second half of 1975 (Chapter 4) which increased retention time and resulted in relatively large quantities of diatoms and green algae in the reservoir and river on the September and December sampling dates (Figures 5.2 and 5.3). Wolf Creek was reduced to a series of small pools during September and December because of the lack of rainfall. This resulted in a great deal of variation in the phytoplankton populations from location to location since each pool represented a specific habitat.

Variations in nutrient concentrations (Chapter 4) showed no distinct relationship with the seasonal or year-to-year variations of phytoplankton in the reservoir, river, or creek.

IV. Summary and Conclusions

Phytoplankton communities of the John Redmond Reservoir, Neosho River, and Wolf Creek were analyzed qualitatively and quantitatively in April, June, September, and December 1975. Key findings from the study are summarized below:

1. Two hundred twenty-six taxa which represented 91 genera and eight algal divisions were collected. Diatoms and green algae were the most diverse groups.

2. The communities of the reservoir and river were similar and were dominated by centric diatoms. Assemblages in the creek were substantially different from those of the reservoir and river and were usually dominated by pennate diatoms and cryptomonads.

3. The only consistent seasonal pattern of abundance was a pulse of the blue-green alga *Merismopedia tenuissima* which occurred in the reservoir and river during each September of the 1973 to 1975 period.

4. Amount of rainfall was the major factor influencing the abundance and composition of phytoplankton in the reservoir and river.

5. The creek was reduced to a series of isolated pools during September and December because of a lack of rainfall. This resulted in considerable variation in phytoplankton among locations since each pool represented a specific habitat.

6. Carbon fixation rate and chlorophyll a concentration were generally similar between John Redmond Reservoir and Neosho River locations. Variation among sampling periods and years was attributed to variation in total phytoplankton and centric diatom abundance.

7. Considerable variation in carbon fixation rate and chlorophyll a concentration corresponding to differences in the phytoplankton populations usually occurred among Wolf Creek locations. Variation among locations increased as flow decreased and was most apparent in September and December.

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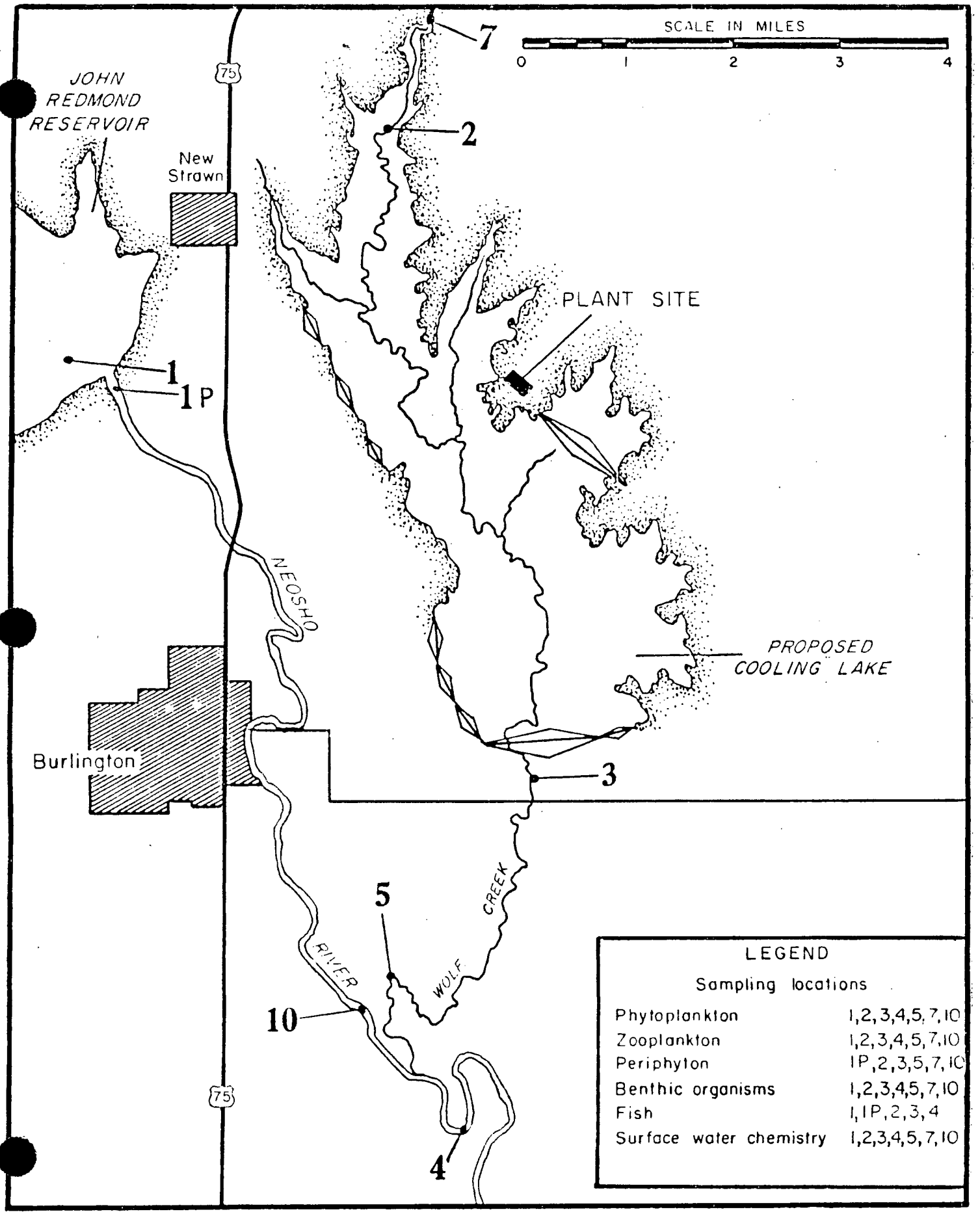

Figure 5.1. Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

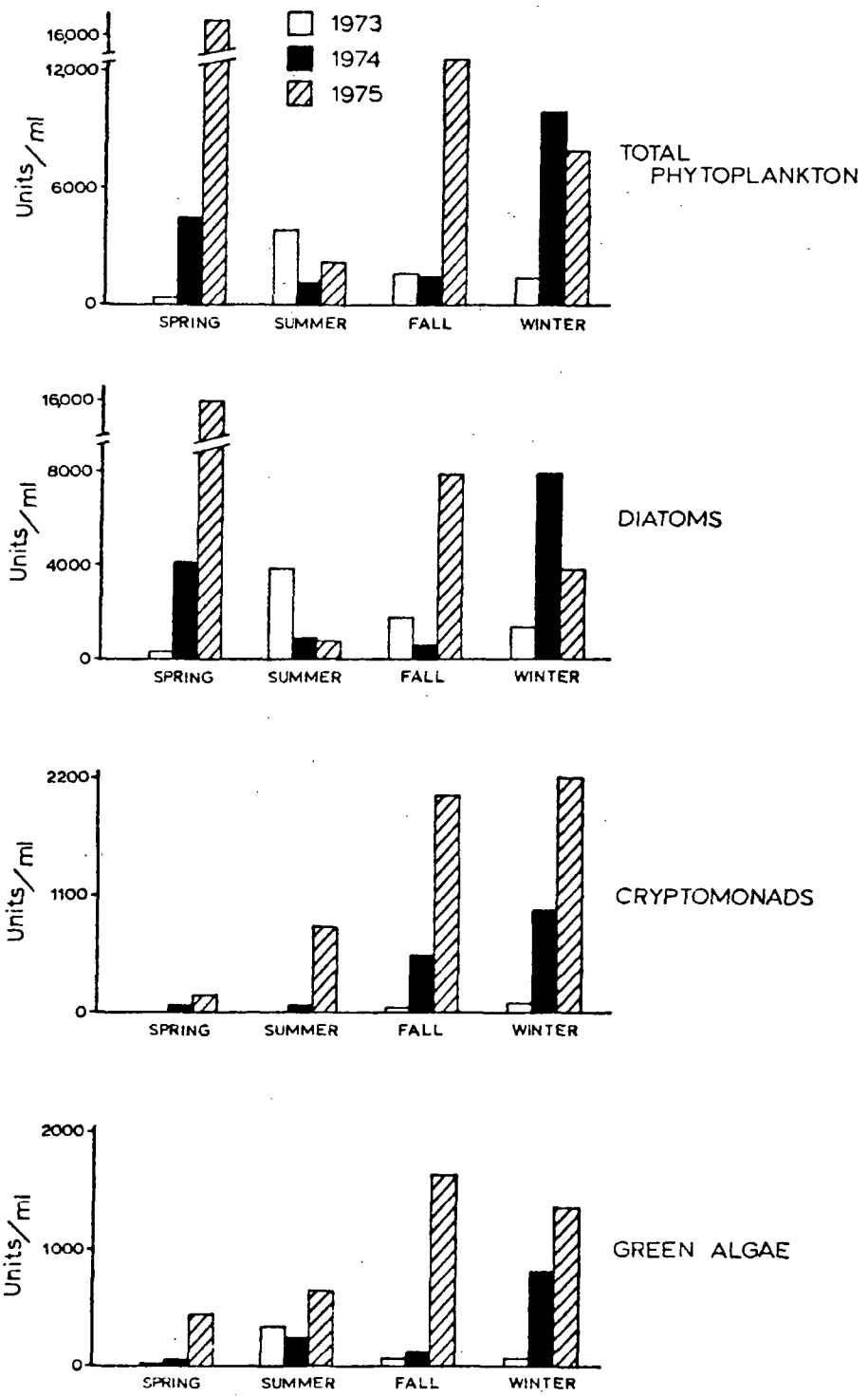

Figure 5.2. Seasonal and year-to-year variations of phytoplankton in John Redmond Reservoir (Location 1) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, spring, summer, fall and winter 1973, 1974 and 1975.

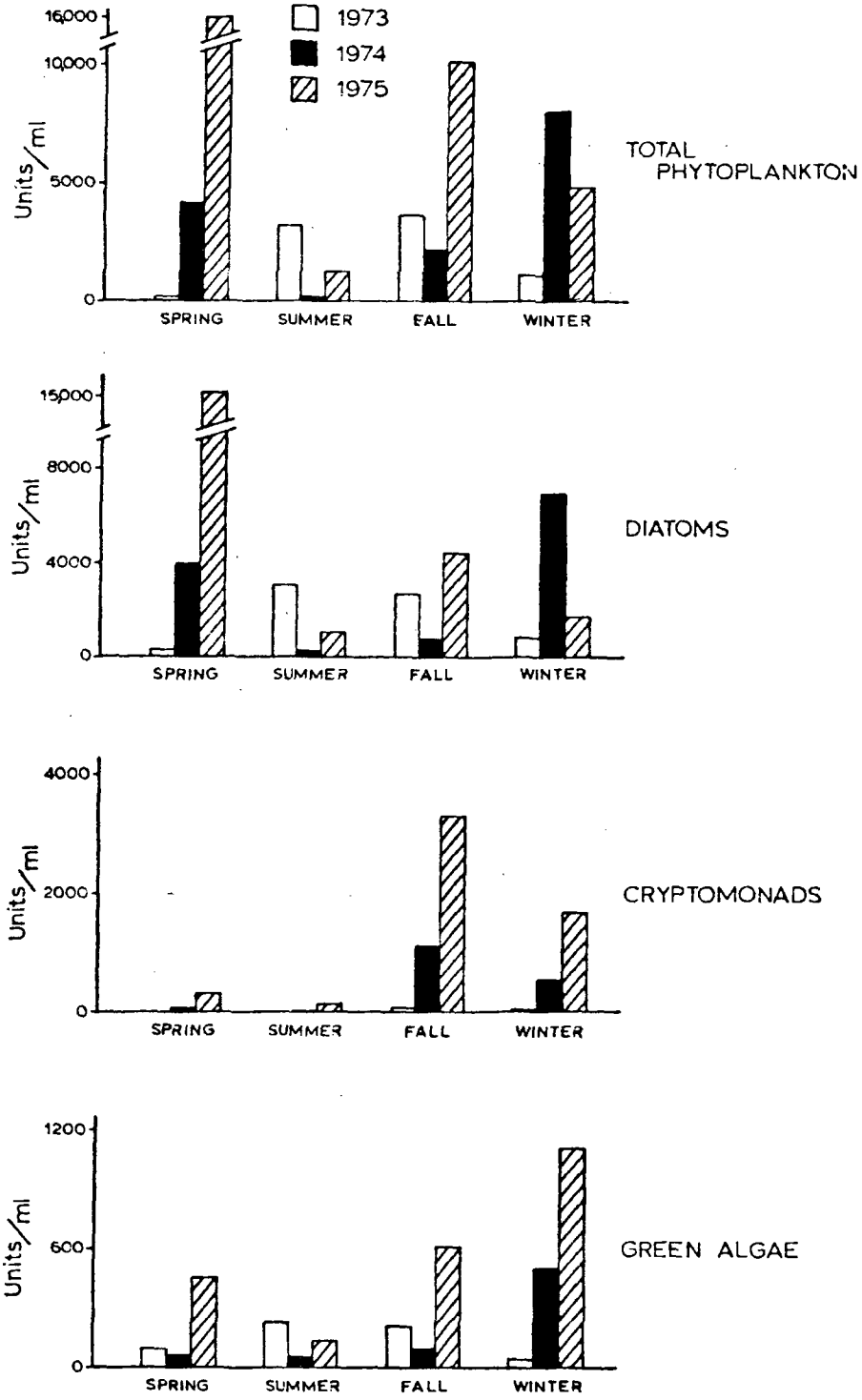

Figure 5.3. Seasonal and year-to-year variations of phytoplankton in the Neosho River (mean of Locations 4 and 10) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, spring, summer, fall and winter 1973, 1974 and 1975.

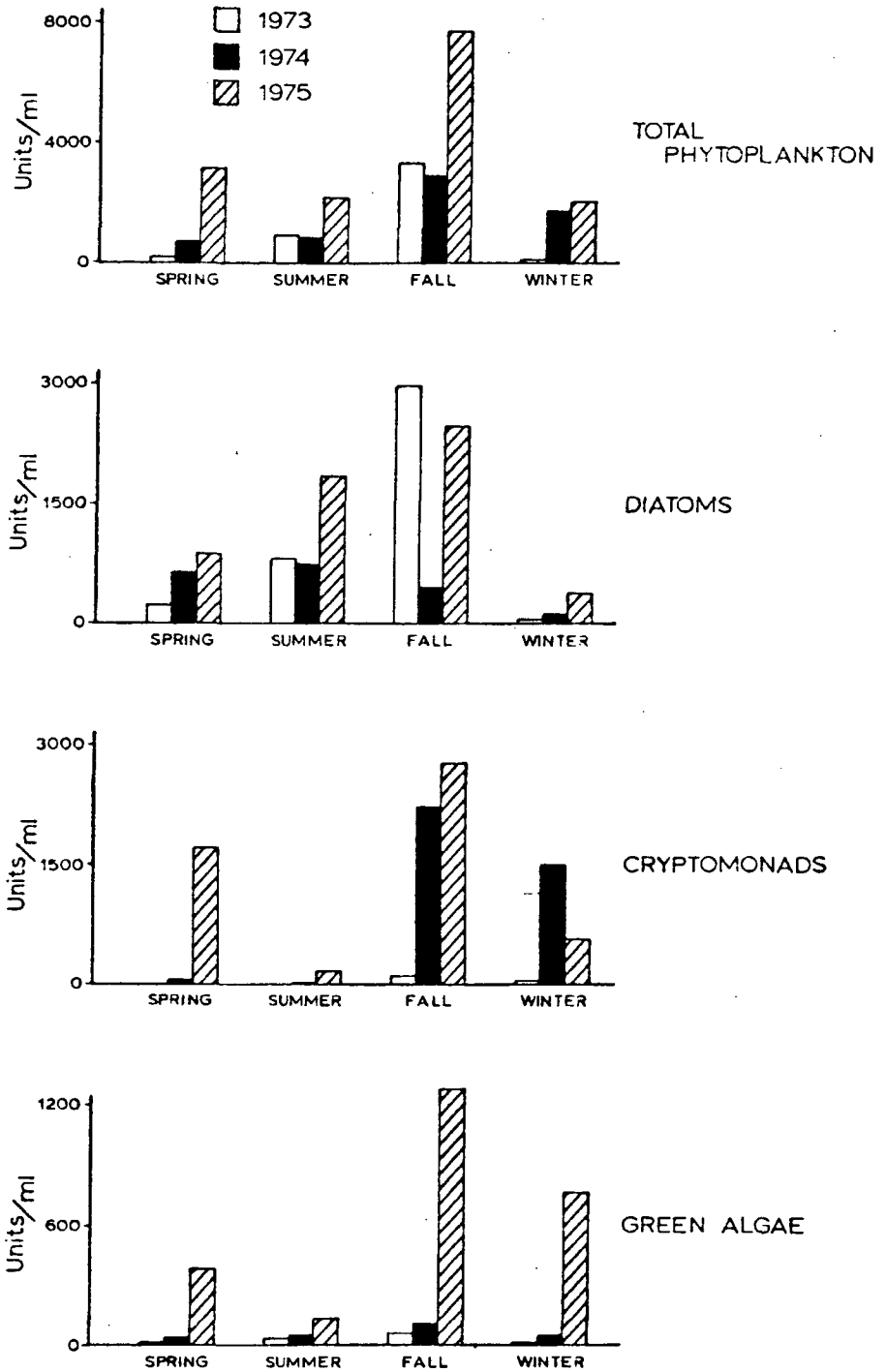

Figure 5.4. Seasonal and year-to-year variation of phytoplankton in Wolf Creek (mean of Locations 2,3,5 and 7) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, spring, summer, fall and winter 1973, 1974 and 1975.

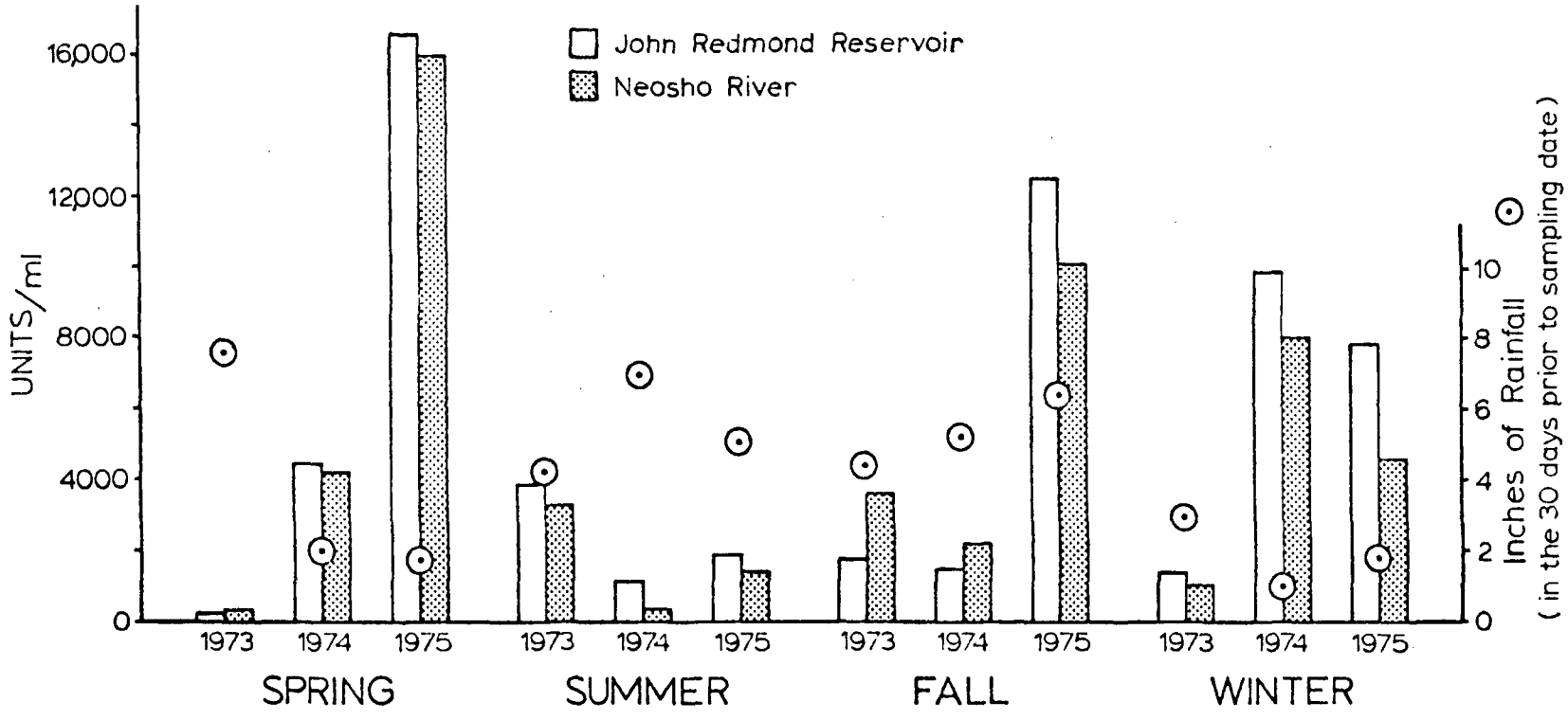

Figure 5.5. Total phytoplankton density compared with rainfall in the 30 days prior to sampling in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, spring, summer, fall and winter 1973, 1974 and 1975.

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Table 5.1. Phytoplankton density and percent composition of major algal groups in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, April, June, September and December 1975.

Date And Sampling Locations	Total Phytoplankton Units/ml	Centric Diatoms		Pennate Diatoms		Green Algae		Blue-green Algae		Cryptomonads		Euglenoids		Yellow-brown Algae	
		Units/ml	Percent	Units/ml	Percent	Units/ml	Percent	Units/ml	Percent	Units/ml	Percent	Units/ml	Percent	Units/ml	Percent
16 April															
1	16627	15212	91.5	743	4.5	449	2.7	16	<0.1	142	0.9	16	<0.1	4	<0.1
10	14126	12942	91.6	508	3.6	375	2.7	6	<0.1	243	1.8	31	0.2	5	<0.1
4	17791	16120	90.6	574	3.2	555	3.1	27	0.2	404	2.3	53	0.3	42	0.2
7	2193	423	19.3	335	15.3	447	20.4	11	0.5	584	26.7	55	2.5	321	14.6
2	2113	116	5.5	510	24.2	318	15.1	6	0.26	952	45.0	82	3.9	128	5.7
3	4537	191	4.2	810	17.9	315	7.0	1	0.03	3106	68.5	71	1.6	4	<0.11
5	3819	232	6.1	803	21.0	452	11.8	0	0	2186	57.2	93	2.4	35	1.0
10 June															
1	1946	345	17.7	439	22.6	653	33.6	49	2.5	802	41.2	0	0	0	0
10	1270	384	30.2	344	27.1	233	18.3	24	1.8	271	21.4	14	1.1	0	0
4	1506	257	17.1	1122	74.5	52	3.4	5	0.3	61	4.1	8	0.5	1	<0.1
7	1203	39	3.2	605	50.3	175	14.6	44	3.6	319	26.5	20	1.7	1	0.1
2	2164	97	4.5	1623	75.0	205	9.5	30	1.4	205	9.5	5	0.3	0	0
3	2196	70	3.2	1870	85.2	105	4.8	26	1.2	102	4.7	22	1.0	1	<0.1
5	3056	107	3.5	2918	95.5	17	0.6	4	0.1	9	0.3	1	<0.1	0	0
9 Sept															
1	12604	7567	60.0	361	2.9	1613	12.8	751	6.0	2045	16.2	153	1.2	104	0.8
10	9486	3876	40.9	387	4.1	674	7.1	1456	15.4	2962	31.2	71	0.7	60	0.6
4	10571	4167	39.4	481	4.6	545	5.2	1429	13.5	3655	34.6	76	0.7	213	2.0
7	2871	48	1.7	1750	60.9	140	4.9	0	0	709	24.7	11	0.4	213	7.4
2	3908	104	2.7	938	24.0	451	11.6	4	0.1	1904	48.7	49	1.3	458	11.7
3	12405	881	7.1	1878	15.1	3263	26.3	151	1.2	4244	34.2	262	2.1	2575	20.8
5	11465	1672	14.6	2580	22.5	1234	10.8	0	0	4216	36.8	1200	10.5	524	4.6
3 Dec															
1	7827	3854	49.2	40	0.5	1366	17.5	325	4.2	2209	28.2	33	0.4	0	0
10	4638	1587	34.2	166	3.6	1096	23.6	229	4.9	1516	32.7	38	0.8	0	0
4	4994	1477	29.6	235	4.7	1117	22.4	295	5.9	1833	36.7	38	0.8	0	0
7	3669	43	1.2	524	14.3	1703	46.4	18	0.5	1031	28.1	349	9.5	0	0
2	509	60	11.8	381	74.7	60	11.8	3	0.6	0	0	5	1.1	0	0
3	3345	53	1.6	391	11.7	1222	36.5	21	0.6	1265	37.8	393	11.7	0	0
5	510	33	6.6	53	10.5	95	18.7	0	0	33	6.4	295	57.8	0	0

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Table 5.2. Phytoplankton biovolume and percent composition of major algal groups in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, April, June, September and December 1975.

Date and Sampling Location	Total Phytoplankton µl/l	Centric Diatoms		Pennate Diatoms		Green Algae		Blue-green Algae		Cryptomonads		Euglenoids		Yellow-brown Algae	
		µl/l	%	µl/l	%	µl/l	%	µl/l	%	µl/l	%	µl/l	%	µl/l	%
16 April															
1	6.554	5.818	88.8	0.335	5.1	0.128	2.0	0.014	0.2	0.146	2.2	0.035	0.5	<0.001	<0.1
10	5.726	4.975	86.9	0.187	3.3	0.112	2.0	0.005	<0.1	0.364	6.4	0.064	1.1	<0.001	<0.1
4	7.866	6.854	87.1	0.272	3.5	0.171	2.2	0.006	<0.1	0.426	5.4	0.108	1.4	0.004	<0.1
7	1.500	0.053	3.5	0.205	13.7	0.217	14.4	0.002	<0.1	0.715	47.7	0.107	7.1	0.169	11.3
2	2.094	0.038	1.8	0.643	30.7	0.219	10.5	0.002	<0.1	0.929	44.4	0.156	7.4	0.076	3.7
3	2.990	0.107	3.6	0.741	24.8	0.847	28.3	0.003	0.1	0.675	56.0	0.155	5.2	0.004	0.2
5	2.810	0.142	5.1	0.893	31.8	0.360	12.8	0	0	1.286	45.8	0.178	6.3	0.025	0.9
10 June															
1	0.672	0.137	20.5	0.026	3.9	0.217	32.3	0.001	0.1	0.274	40.8	0	0	0	0
10	0.634	0.220	34.6	0.160	25.3	0.058	9.1	0.002	0.1	0.163	25.7	0.025	4.0	0	0
4	0.663	0.159	24.0	0.434	65.6	0.016	2.4	0.002	0.2	0.032	4.9	0.019	2.9	<0.001	<0.1
7	0.551	0.010	1.8	0.198	36.0	0.047	8.5	0.005	0.7	0.264	48.0	0.027	4.9	<0.001	<0.1
2	0.854	0.050	5.8	0.568	66.5	0.053	6.2	0.008	0.9	0.160	18.7	0.016	1.9	0	0
3	0.931	0.009	1.0	0.715	76.8	0.032	3.4	0.008	0.9	0.128	13.7	0.039	4.2	<0.001	<0.1
5	1.263	0.108	8.6	1.136	89.9	0.005	0.4	0.002	0.1	0.009	0.7	0.004	0.3	0	0
9 Sept															
1	4.142	2.371	57.2	0.059	1.4	0.531	12.8	0.003	<0.1	0.565	13.6	0.465	11.2	0.084	2.1
10	2.053	1.087	53.0	1.149	56.0	0.168	8.2	0.002	<0.1	0.617	30.1	0.111	5.4	0.005	0.2
4	2.474	1.162	47.0	0.076	3.1	0.164	6.6	0.003	0.1	0.843	34.1	0.154	6.2	0.055	2.2
7	0.576	0.006	1.1	0.345	59.9	0.023	4.0	0	0	0.154	26.7	0.004	0.8	0.044	7.6
2	1.373	0.011	0.8	0.324	23.6	0.090	6.6	0.003	0.2	0.827	60.2	0.054	4.0	0.064	4.7
3	2.575	0.115	4.5	0.178	6.9	0.920	35.7	0.001	<0.1	0.801	31.1	0.296	11.5	0.243	9.4
5	7.258	0.212	2.9	0.565	7.8	0.259	3.6	0	0	2.022	27.9	4.021	55.4	0.141	2.0
3 Dec															
1	3.235	2.310	71.4	0.009	0.3	0.328	10.1	<0.001	<0.1	0.548	16.9	0.039	1.2	0	0
10	1.309	0.698	53.3	0.048	3.7	0.206	15.7	<0.001	<0.1	0.313	23.9	0.042	3.2	0	0
4	1.281	0.542	42.3	0.082	6.4	0.251	19.6	<0.001	<0.1	0.357	27.9	0.047	3.7	0	0
7	2.065	0.015	0.7	0.185	9.0	0.321	15.6	0.003	0.2	0.723	35.0	0.817	39.6	0	0
2	0.185	0.046	24.7	0.153	82.9	0.011	6.2	0.005	2.7	0	0	0.015	8.3	0	0
3	1.999	0.029	1.5	0.126	6.3	0.200	10.0	0.004	0.2	0.905	45.3	0.736	36.8	0	0
5	0.770	0.008	1.1	0.011	1.4	0.015	2.0	0	0	0.017	2.2	0.718	93.3	0	0

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Table 5.3. Taxa which comprised 5% or more of the total phytoplankton density or biovolume of sampling locations near the Wolf Creek Generating Station, Burlington, Kansas, April, June, September and December 1975.

Taxon	John Redmond Reservoir (Location 1)				Neosho River (Locations 4 & 10)				Wolf Creek (Locations 2,3,5 & 7)			
	Apr	Jun	Sep	Dec	Apr	Jun	Sep	Dec	Apr	Jun	Sep	Dec
BACILLARIOPHYTA (Diatoms)												
Amphora ovalis v. *pediculus*	-[a]	-	-	-	-	-	-	-	-	-	-	X[b]
Cyclotella meneghiniana v. *plana*	-	-	X	X	-	-	X	X	-	-	-	-
Cymbella ventricosa	-	-	-	-	-	-	-	-	-	X	-	-
Cymbella sp.	-	-	-	-	-	X	-	-	-	-	-	-
Diploneis oblongella	-	-	-	-	-	-	-	-	-	-	-	X
Diploneis sp.	-	-	-	-	-	-	-	-	-	-	X	-
Gomphonema parvulum	-	-	-	-	-	X	-	-	-	X	-	-
Melosira varians	-	-	-	-	-	-	-	-	-	X	-	-
Navicula salinarum	-	-	-	-	-	-	-	-	-	X	-	-
Navicula tripunctata	-	-	-	-	-	-	-	-	-	X	-	-
Navicula sp.	-	-	-	-	-	X	-	-	-	X	X	X
Nitzschia linearis	-	-	-	-	-	X	-	-	X	-	-	-
Nitzschia palea	-	-	-	-	-	X	-	-	-	X	-	X
Nitzschia sp.	-	-	-	-	-	X	-	-	-	X	X	X
Stephanodiscus astraea	X	X	X	X	X	X	X	X	-	-	-	X
Stephanodiscus hantzschii	X	-	-	-	X	-	-	-	-	-	-	-
Stephanodiscus minutus	X	X	X	X	-	X	X	X	X	-	-	-
Stephanodiscus sp.	X	-	X	X	X	-	X	-	-	-	-	-
Surirella ovata	-	-	-	-	-	-	-	-	X	-	-	-
Synedra ulna	-	-	-	-	-	X	-	-	X	-	-	-
CHLOROPHYTA (Green Algae)												
Ankistrodesmus spiralis	-	-	-	-	-	-	-	-	-	-	-	X
Carteria sp.	-	-	X	-	-	-	-	-	-	-	X	-
Chlamydomonas sp.	-	X	-	X	-	X	-	X	X	-	X	X
Dictyosphaerium pulchellum	-	-	-	-	-	-	-	X	X	-	-	-
Oocystis borgei	-	X	-	-	-	-	-	-	-	-	-	-
Oocystis pusilla	-	-	-	-	-	-	-	X	-	-	-	-
CHRYSOPHYTA (Yellow-Brown Algae)												
Mallomonas sp.	-	-	-	-	-	-	-	-	X	-	X	-
Ochromonas sp.	-	-	-	-	-	-	-	-	-	-	X	-
Unidentified chrysophyte	-	-	-	-	-	-	-	-	X	-	-	-
CRYPTOPHYTA (Cryptomonads)												
Cryptomonas sp.	-	X	X	X	X	-	X	X	X	X	X	X
Rhodomonas minuta v. *nannoplanctica*	-	X	X	X	-	X	X	X	X	X	X	-
CYANOPHYTA (Blue-Green Algae)												
Aphanocapsa elachista	-	-	-	-	-	-	-	X	-	-	-	-
Merismopedia tenuissima	-	-	-	-	-	X	-	-	-	-	-	-
EUGLENOPHYTA (Euglenoids)												
Euglena acus	-	-	-	-	-	-	-	-	-	-	-	X
Euglena gracilis	-	-	-	-	-	-	-	-	-	-	-	X
Euglena polymorpha	-	-	-	-	-	-	-	-	-	-	X	-
Euglena sp.	-	-	-	-	-	-	-	-	X	-	-	X
Lepocinclis sp.	-	-	X	-	-	-	-	-	-	-	-	-
Phacus longicauda	-	-	-	-	-	-	-	-	-	-	-	X
Trachelemonas sp.	-	-	-	-	-	-	-	-	-	-	-	X

[a] <5%.
[b] 5% or more.

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Table 5.4. Shannon's species diversity indices[a] for phytoplankton collected in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, April, June, September and December 1975.

Sampling Date	Sampling Locations: John Redmond Reservoir 1	Neosho River 4	Neosho River 10	Wolf Creek 2	Wolf Creek 3	Wolf Creek 5	Wolf Creek 7
16 April	1.78[b]	1.65	1.52	2.78	1.88	2.19	2.78
10 June	2.56	3.06	3.07	3.37	3.24	2.96	3.24
9 September	2.67	2.42	2.39	2.68	2.56	3.19	2.63
3 December	2.32	2.57	2.51	2.33	2.00	2.36	1.79

a H values calculated to the base e.

b Mean of two replicates.

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Table 5.5. Summary of one-way ANOVA with Tukey's multiple comparisons showing significant differences among phytoplankton populations at sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 16 April 1975.

Taxon	One-way ANOVA F Among Locations	One-way ANOVA p[a]	Significant differences by Tukey's comparisons: Reservoir and River Locations (1, 10 & 4)	Creek Locations (7, 2, 3, & 5)	All Locations (1, 2, 3, 4, 5, 7 & 10)
Total Phytoplankton	135.4	<0.001	None	3 > 2, 7	1, 4, 10 > 2, 3, 5, 7 3 > 2, 7
Bacillariophyta	411.6	<0.001	None	None	1, 4, 10 > 2, 3, 5, 7
Chlorophyta	1.6	0.273	None	None	None
Cryptophyta	53.9	<0.001	None	3, 5 > 2, 7	3, 5 > 1, 2, 4, 7, 10 2 > 1, 10
Chrysophyta	53.4	<0.001	None	2, 7 > 3, 5 7 > 2	7 > 1, 2, 3, 4, 5, 10 2 > 1, 3, 5, 10 4 > 3
Cyanophyta	5.1	0.026	None	None	4 > 5
Euglenophyta	2.8	0.102	None	None	None
Pyrrhophyta	1.7	0.243	None	None	None

[a] Probability at 0.05 significance level.

Table 5.6. Summary of one-way ANOVA with Tukey's multiple comparisons showing significant differences among phytoplankton populations at sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 10 June 1975.

Taxon	One-way ANOVA F Among Locations	One-way ANOVA p[a]	Significant differences by Tukey's comparisons: Reservoir and River Locations (1, 10 & 4)	Creek Locations (7, 2, 3 & 5)	All Locations (1,2,3,4,5,7 & 10)
Total Phytoplankton	6.4	0.014	None	5 > 7	5 > 4,7,10
Bacillariophyta	17.5	<0.001	None	2,3,5 > 7	5 > 1,4,7,10 2 3,> 1,7
Chlorophyta	41.8	<0.001	1 > 4,10 10 > 4	2,7 > 4,5 3 > 5	1 > 2,3,4,5,7,10 2,7,10 > 4,5 3 > 5
Cryptophyta	39.8	<0.001	1 > 4,10 10 > 4	7 > 4,5 2 > 5	1 > 2,3,4,5,7,10 7 > 3,4,5 10 > 4,5 2 > 5
Cyanophyta	1.5	0.317	None	None	None
Euglenophyta	11.7	0.002	10 > 1	3,7 > 5	3,7 > 1,5 10 > 1

[a] Probability at 0.05 significance level.

Table 5.7. Summary of one-way ANOVA with Tukey's multiple comparisons showing significant differences among phytoplankton populations at sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 9 September 1975.

Taxon	One-way ANOVA F Among Locations	p[a]	Significant differences by Tukey's comparisons: Reservoir and River Locations (1, 10 & 4)	Creek Locations (7, 2, 3 & 5)	All Locations (1,2,3,4,5,7 & 10)
Total Phytoplankton	38.3	<0.001	None	3,5 > 2,7	1,3,4,5,10 > 2,7
Bacillariophyta	18.6	<0.001	None	5 > 2	1 > 2,3,7 4 > 2,7 5,10 > 2
Chlorophyta	61.8	<0.001	1 > 4,10	3 > 2,5,7 5 > 2,7	3 > 1,2,4,5,7,10 1 > 2,4,7,10 5 > 2,4,7 4,10 > 7
Cryptophyta	35.6	<0.001	4 > 1	3,5 > 2,7 2 > 7	3,4,5 > 1,2,7 1,2,10 > 7
Chrysophyta	46.1	<0.001	None	3 > 2,5,7	3 > 1,2,4,5,7,10 5 > 1,10 2 > 10
Cyanophyta	32.3	<0.001	None	None	4,10 > 2,3,5,7 1 > 2,5,7
Euglenophyta	28.9	<0.001	None	5 > 2,3,7 3 > 7	5 > 1,2,3,4,7,10 3 > 7

[a] Probability at 0.05 significance level.

NALCO ENVIRONMENTAL SCIENCES

Table 5.8. Summary of one-way ANOVA with Tukey's multiple comparisons showing significant differences among phytoplankton populations at sampling locations in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 3 December 1975.

Taxon	One-way ANOVA F Among Locations	p[a]	Significant differences by Tukey's comparisons: Reservoir and River Locations (1, 10 & 4)	Creek Locations (7, 2, 3 & 5)	All Locations (1,2,3,4,5,7 & 10)
Total Phytoplankton	29.7	<0.001	None	3,7>2,5	1>2,3,5,7 4,10>2,5
Bacillariophyta	36.8	<0.001	1>4,10	None	1>2,3,4,5,7,10 4,10>2,3,5,7
Chlorophyta	13.3	0.002	None	3,7>2,5	1,3,4,10>2,5
Cryptophyta	6.6	0.013	None	None	1>2,5
Cyanophyta	25.2	<0.001	None	None	1,4,10>2,3,5,7
Euglenophyta	37.1	<0.001	None	3,5,7>2	3,5,7>1,2,4,10

[a] Probability at 0.05 significance level.

NALCO ENVIRONMENTAL SCIENCES

Table 5.9. Mean carbon fixation rate and chlorophyll *a* concentration for phytoplankton samples collected in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1975.

	Sampling Location	16 April	10 June	9 September	3 December
Carbon fixation rate ($mg\ C/m^3$ per hr)					
John Redmond Reservoir	1	90.90	14.24	44.26	32.18
Neosho River	10	125.98	6.87	36.82	10.39
	4	130.65	2.54	24.66	10.38
Wolf Creek	7	11.03	5.15	9.23	25.49
	2	12.33	3.33	14.69	0.36
	3	33.82	2.36	-[a]	7.09
	5	27.72	1.61	93.34	2.50
Chlorophyll *a* concentration ($mg\ Chl\ a/m^3$)					
John Redmond Reservoir	1	34.97	3.67	10.97	21.67
Neosho River	10	33.33	1.84	10.34	6.57
	4	34.00	2.27	6.70	7.87
Wolf Creek	7	2.59	2.00	3.57	9.27
	2	6.30	2.07	6.17	1.75
	3	14.20	2.43	10.07	10.50
	5	12.43	2.54	30.00	3.29

[a] Contaminated samples.

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Chapter 6

PERIPHYTON STUDY

By

James R. Farrell

I. Introduction

Periphyton are generally referred to as the algal component of the aufwuchs community that are attached to, or live on, a substrate. Thus, periphyton may encompass epiphytic, epilithic, epipelic and epipsammic forms. Periphyton are important primary producers in lentic and lotic waters (Weber 1973a; Wetzel 1964) and are excellent indicators of water quality because of their sessile nature and quick response to environmental change (Weber 1973a; Lowe 1974). Thus, these algae have been used to assess the thermal effects of power plants on aquatic communities (Trembly 1960; Markowski 1960; Hickman 1974; Hickman and Klarer 1974, 1975).

The periphytic algae in the vicinity of the proposed Wolf Creek Generating Station have been monitored quarterly since 1973 (Kansas Gas and Electric Company 1974; Farrell 1975a). Past studies have revealed considerable temporal variation in dominant species composition at all sampled locations although diatoms (Bacillariophyta) were the dominant group of algae on most occasions. The intermittent flow of Wolf Creek in addition to other seasonal factors such as light and temperature contributed to the temporal variation of periphyton community structure in 1973 and 1974. In the past, water releases from John Redmond Reservoir usually prevented periphyton sampling in the Neosho River by submerging and scouring suitable substrate.

Objectives of this preconstruction study of the periphyton community in the vicinity of the proposed Wolf Creek Generating Station (WCGS) were:

1. To gather additional baseline information on the abundance, structure, and seasonal variability of the periphyton at locations below the John Redmond Reservoir Dam, in the Neosho River, and Wolf Creek; and

2. To use this information in the assessment and minimization of any potential effects of construction or operation of WCGS on the environment.

II. Field and Analytical Procedures

Sampling locations for periphyton are shown in Figure 6.1. Samples were collected on 16 April, 10 June, 9 September, and 2 December 1975. Eighteen samples delineated by a 0.1 dm^2 template were scraped from suitable natural substrates at Location 1P below John Redmond Dam and Locations 2, 3, 5, and 7 in Wolf Creek. Samples were not collected at Location 10 in the Neosho River because of lack of natural substrates suitable for quantitative sampling. Six samples from each location were placed in "M^3" preservative (Meyer 1971) for later identification and enumeration of diatom (3 samples) and non-diatom (3 samples) algal forms. Six more samples were kept on ice in the dark for chlorophyll analysis and the remaining six samples were placed in crucibles for biomass determinations in the laboratory.

Diatom samples were cleaned using a boiling concentrated nitric acid/potassium dichromate treatment (Hohn and Hellerman 1963). The samples were allowed to settle and the supernatant decanted and replaced at 24 hr intervals until a pH $\geq$ 6 was reached. After the concentration of the sample was adjusted

to a suitable volume, a subsample was mounted in Hyrax mounting medium. All volumes were kept consistent within each sampling period. A predetermined area (16.2 mm^2 per sample) of each mount was examined under phase contrast at 1250 X magnification. Each diatom frustule was counted as one unit.

Samples for non-diatom analysis were blended to insure uniformity and wet mounts were prepared with 0.1 ml subsamples. An area equal to that used for diatom analysis was examined under light field illumination at 500 X magnification. Filamentous algae were reported in units of 10 μm length and each cell of nonfilamentous algae was counted as one unit.

Algal abundance was expressed as number of units per square centimeter (no./cm^2). Biovolume of each algal taxon enumerated was determined using the methods of Cowell (1960) and Hohn (1969) and reported as microliters per square decimeter (μl/dm^2). Shannon's (1948) diversity index with log base 2 and evenness (Zar 1968) were calculated based on abundance data for each sampling period.

Taxonomic keys used for identification included Hustedt (1930), Smith (1950), Cleve-Euler (1951, 1952, 1953a, b, 1955), Tiffany and Britton (1952), Palmer (1962), Prescott (1962, 1970), Patrick and Reimer (1966), Drouet (1968), Weber (1971), and Whitford and Schumacher (1973).

Periphyton biomass and chlorophyll a samples were processed according to accepted methods (A.P.H.A. et al. 1971). Biomass standing crop was reported as milligrams of ash-free dry weight per square decimeter (mg/dm^2) and chlorophyll a standing crop was expressed as micrograms per square decimeter (μg/dm^2). A one-way analysis of variance (Steel and Torrie 1960) was performed on data from each sampling period to identify statistically significant differences ($p \leq 0.05$) in biomass or chlorophyll a standing crops among locations.

III. Results and Discussion

A composite list of all periphytic algae identified at locations in Wolf Creek and the Neosho River and quarterly data on species and biovolume composition are presented in Appendix E, Tables E.1-E.14.

A. Species Composition

Eighty-four periphytic algal taxa were identified from locations at John Redmond Dam and Wolf Creek in 1975 compared to 93 taxa in 1974 (Farrell 1975a and 113 taxa in 1973 (Kansas Gas and Electric Company 1974). Diatoms (Bacillariophyta) continued to dominate most locations on all collection dates averaging 65.1% of the density and 64.9% of the biovolume of periphyton sampled (Table 6.1). Diatoms averaged 66.5% of the density and 71.5% of the biovolume in 1974 and 58.6 and 56.9%, respectively, in 1973.

Dominant taxa (contributing 10% or more of density or biovolume) at Location 1P in the Neosho River below John Redmond Dam were different from those in Wolf Creek (Locations 7, 2, 3, and 5). Locations in Wolf Creek usually had similar species compositions on any sampling date (Table 6.2). Algal associations are usually variable (Blum 1956, 1960; Whitford 1960a; Patrick

1963, 1969, 1971a, b, 1973, 1974; Hynes 1970) even along the same reach of stream although Patrick (1968) found similar algal species compositions under comparable ecological conditions.

In September the periphyton at all sampling locations was dominated by various green or blue-green algae and diatoms (Table 6.2). Blue-green algae, particularly Oscillatoria sp., contributed from 31 to 39% of the density and from 16 to 36% of the biovolume of periphyton at Locations 7, 3, and 5 in Wolf Creek, while at Locations 2 (Wolf Creek) and 1P (Neosho River), only ≈10% of the density and <5% of the biovolume was contributed by blue-green algae (Table 6.1). The reason for the lower relative abundance of blue-green algae at Locations 1P and 2 is not clear. Intense shading at Location 2 may limit growth of all algae at this location, whereas the flow from John Redmond Dam may favor the growth of Cladophora glomerata at Location 1P and serve as a source of Stephanodiscus from the reservoir. High densities of these two algae would limit the relative importance of any blue-green algae. Diatoms comprised from 60 to 89% of the density and from 63 to 100% of the biovolume at all locations in September 1975. Species of Navicula were dominant at all locations. Species of Nitzschia, Gyrosigma, Pleurosigma, and Cymbella were also dominant at locations in Wolf Creek; however, Gomphonema parvulum and the planktonic alga Stephanodiscus sp. (Hustedt 1930; Stoermer and Yang 1970) were dominant only at Location 1P in the Neosho River. The abundance of Stephanodiscus at Location 1P was probably a result of discharge from John Redmond Reservoir. A similar occurrence of the planktonic alga Stephanodiscus contributing to the periphyton has been reported at a sampling location immediately downstream from Sutherland Reservoir, Nebraska (Farrell 1975b; Nalco Environmental Sciences 1976).

No taxa were observed in any of the samples collected for periphyton in December 1975. Ice covered pools existed at most creek sampling locations and flow in the river was low. Many periphytic algae have a definite flow requirement (Whitford 1960b; Whitford and Schumacher 1964; McIntire 1966; Hynes 1970; Reisen and Spencer 1970; Patrick 1971a) and the combination of unfavorable temperature, low light, and lack of flow prevented development of the periphyton in December.

B. Community Structure

Density, number of taxa, diversity, and evenness for each location and sampling date are presented in Table 6.3. Density decreased with each successive quarter at locations in Wolf Creek and was probably related to flow conditions. In April, current velocity in Wolf Creek ranged from 0.3 to 0.8 m/sec (Appendix E, Table E.1). In June, velocity ranged from 0.6 to 1.2 m/sec but this was accompanied by increased turbidities (Appendix E, Table E.2) from runoff which scoured and limited light available to the periphyton (McIntire 1973). Pools existed in Wolf Creek in September and December; however, in September they had not stagnated and were not ice-covered as in December. Downstream trends in density along Wolf Creek were not apparent except that density at Location 2 was approximately one-half that of Locations 7 (upstream) or 3 (downstream) on all sampling dates in 1975. Chlorophyll a and biovolume data also reflected this difference (Table 6.4). Periphyton densities and chlorophyll a standing crop were typically lower at Location 2 than at Location 3 in previous studies (Kansas Gas and Electric Company 1974; Farrell

1975a. Location 7 was not sampled until 1975. The dense canopy at Location 2, when compared to the other Wolf Creek locations, may be partially responsible for this pattern (Hansmann and Phinney 1972; McIntire 1973; Lyford and Gregory 1975; Naiman and Gerking 1975).

The number of taxa observed at each location in Wolf Creek also declined from April to December. No particular trend or pattern was evident in diversity or evenness data for Wolf Creek (Table 6.3). Density, number of taxa, diversity and evenness at Location 1P in previous years were generally higher in the warmer months of June or September than in March or December (Kansas Gas and Electric Company 1974; Farrell 1975a).

Species diversity is responsive to environmental changes within a given area; high diversity reflecting community, or more basically, environmental stability (Odum 1971; Pielou 1975). In 1975, diversity ranged from 0.00 to 3.36 at locations in Wolf Creek and from 0.00 to 3.42 at Location 1P in the Neosho River. Similar ranges were reported in 1973 and 1974 (Kansas Gas and Electric Company 1974; Farrell 1975a). Diversity of periphyton communities near Sutherland Reservoir, Nebraska, averaged 3.0-3.5 (Farrell 1975b). Patrick (1968) reported periphyton diversities between 2.29 and 3.45 in Darby Creek, Pennsylvania. Kehde and Wilhm (1972) reported diversity values between 1.0 and 1.5 for periphyton grown in laboratory streams and Cooper and Wilhm (1975) did not find diversities >2.0 at locations along Skeleton Creek, Oklahoma, a stream receiving domestic and oil refining effluents. All of these diversities were calculated by Shannon's (1948) formula with log base 2. The range of diversity reported by each of these investigators is considerably smaller than that observed in Wolf Creek or the Neosho River and may be related to the environmental instability during each study.

C. Standing Crop

Biomass and chlorophyll a standing crops, the autotrophic index, and biovolume are listed in Table 6.4. Mean differences between locations for biomass and chlorophyll a standing crop are presented in Table 6.6.

Maximum biomass standing crop at Locations 1P, 2, 3, and 5 occurred in June 1975 then declined in September and October. Biomass standing crop at Location 7 was highest in April and lower on each successive sampling date. However, chlorophyll a standing crop peaked in June at Location 7 and was highest in April at Locations 2, 3, and 5 (Table 6.4). Biovolume generally followed the same pattern as chlorophyll a. Biomass and chlorophyll a standing crops at locations in Wolf Creek during 1974 declined after the April collections; however, standing crops had increased on successive sampling dates during 1973. Spring floods and continued flow in the winter may have affected standing crop patterns in 1973.

In April 1975, biomass and chlorophyll a standing crops in Wolf Creek were significantly higher ($p \leq 0.05$) at Location 7 than the other locations in Wolf Creek. In June, biomass standing crop was significantly lower while chlorophyll a standing crop was significantly higher at Location 7 when compared to Locations 2, 3, and 5 for biomass and Locations 2 and 5 for chlorophyll a (Tables 6.4 and 6.5). In September, differences in standing crops occurred

between Location 1P in the Neosho River and Locations 7, 2, 3, and 5 in Wolf Creek and probably reflected the effect of pooling (no flow) on the periphyton in Wolf Creek. No significant differences were detected in December.

The autotrophic index was higher at most locations in June 1975 (Table 6.4). Location related trends in Wolf Creek were not noted in 1975 as in 1974 when the index decreased at successive downstream locations (Farrell 1975a.

IV. Summary and Conclusions

1. The species composition, density, biomass standing crop and chlorophyll a standing crop of periphyton varied temporally in the Neosho River and Wolf Creek in 1975.

2. Although measures of productivity at locations in Wolf Creek and the Neosho River were comparable, species compositions were different between the two water systems. However, species compositions among Wolf Creek locations were generally similar on a seasonal basis.

3. Diatoms were the dominant group of periphytic algae at most locations in 1975, e.g. in 1973 and 1974. Green and blue-green algae were more abundant in June and September than in April or December.

4. Lower density, biovolume, and chlorophyll a standing crop at Location 2 compared to the other locations in Wolf Creek may reflect greater shading at this location.

5. Periphyton communities in the Neosho River immediately below John Redmond Dam and at locations in Wolf Creek were highly variable between years. A major contributor to this variability, particularly in Wolf Creek, is intermittent flow. Periphyton in the Neosho River are influenced by the pattern of water releases from John Redmond Reservoir.

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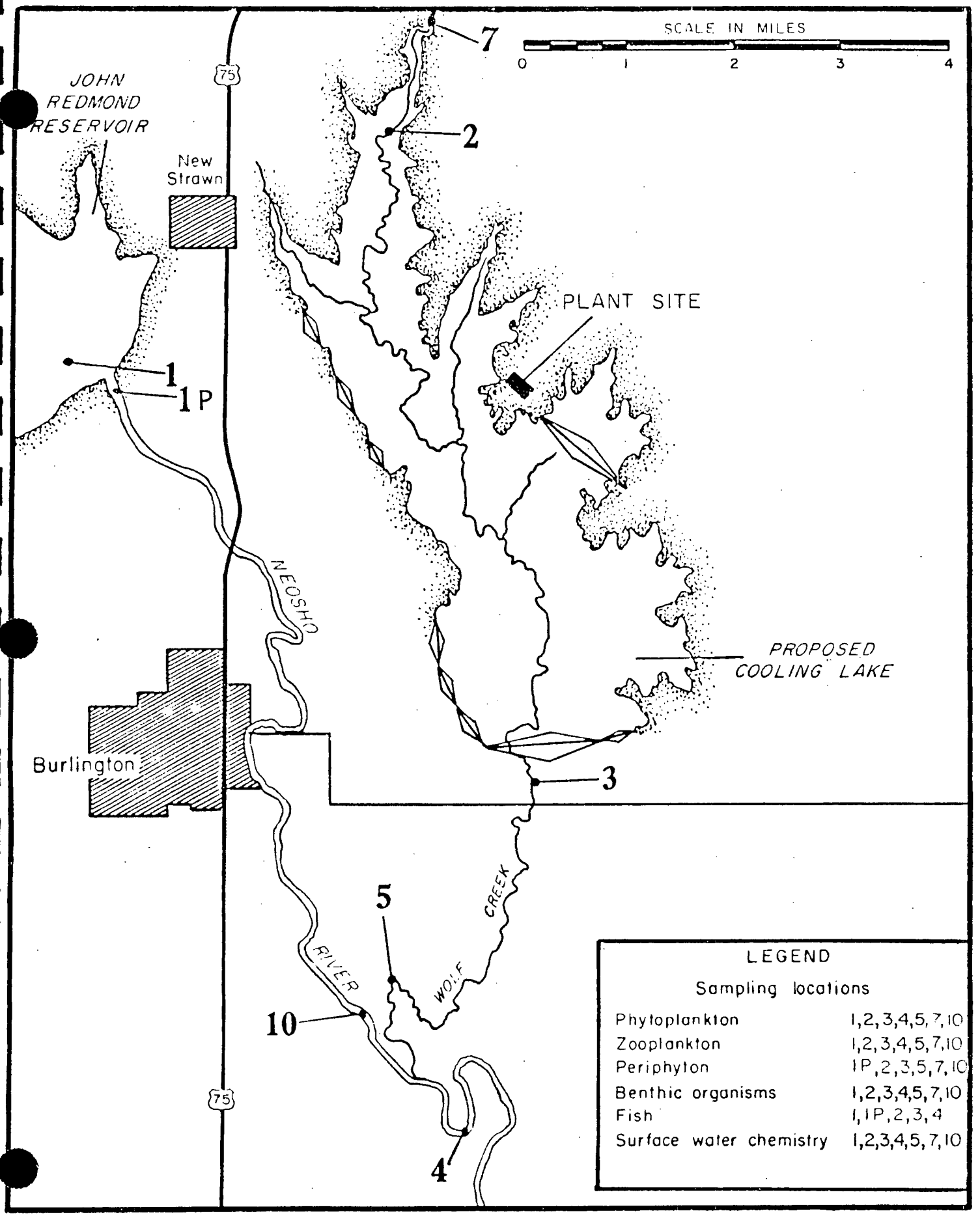

Figure 6.1. Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Table 6.1. Percent composition by algal division of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Collection Date		Sampling Location	Percent of Total Abundance			Percent of Total Biovolume		
			Bacillariophyta	Chlorophyta	Cyanophyta	Bacillariophyta	Chlorophyta	Cyanophyta
16 April	1975	1P	-[a]	-	-	-	-	-
		7	100.0	0.0	0.0	100.0	0.0	0.0
		2	100.0	0.0	0.0	100.0	0.0	0.0
		3	79.1	11.8	9.1	77.9	14.4	7.7
		5[b]	77.3	0.0	22.7	82.3	0.0	17.7
10 June	1975	1P	2.6	97.0	0.4	<1	100.0	<1
		7	68.5	30.2	1.2	14.4	85.6	0.1
		2	100.0	0.0	0.0	100.0	0.0	0.0
		3	27.2	0.0	72.8	48.6	0.0	51.4
		5[b]	0.0	0.0	0.0	0.0	0.0	0.0
9 September	1975	1P	73.7	16.0	10.2	67.7	27.8	4.6
		7	60.7	0.0	39.3	70.3	0.0	29.7
		2	89.2	0.0	10.8	99.7	0.0	0.3
		3	69.0	0.0	31.0	83.6	0.0	16.4
		5	64.3	0.0	35.7	63.8	0.0	36.2
2 December	1975	1P	0.0	0.0	0.0	0.0	0.0	0.0
		7	0.0	0.0	0.0	0.0	0.0	0.0
		2	0.0	0.0	0.0	0.0	0.0	0.0
		3	0.0	0.0	0.0	0.0	0.0	0.0
		5[b]	0.0	0.0	0.0	0.0	0.0	0.0
Mean			65.1	11.1	16.7	64.9	16.3	11.7

[a] Sample not collected because of high water releases from John Redmond Reservoir.
[b] Designated as "Location 4P" in the 1973 study.

NALCO ENVIRONMENTAL SCIENCES

Table 6.2 Periphytic algal taxa comprising 10% or more of the total density or biovolume of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Kansas, 1975.

Sampling Location	16 April	10 June	9 September	2 December
1P	-[a]	Cladophora glomerata	Cladophora sp. Navicula heufleri Navicula sp. Gomphonema parvulum Stephanodiscus sp.	No taxa observed
7	Gomphonema angustatum	Spirogyra sp. Navicula symmetrica Nitzschia dissipata	Oscillatoria sp. Navicula sp. Nitzschia sp. Navicula symmetrica	No taxa observed
2	Surirella ovata	Nitzschia frustulum var. perpusilla Achnanthes sp. Navicula symmetrica Surirella ovata	Nitzschia sp. Diploneis puella Navicula sp. Gyrosigma sp. Pleurosigma sp. Anabaena sp.	No taxa observed
3	Surirella ovata Nitzschia dissipata Navicula cryptocephala Cladophora sp.	Navicula symmetrica Phormidium sp. Oscillatoria sp.	Navicula sp. Gyrosigma sp. Oscillatoria sp.	No taxa observed
5[b]	Surirella ovata Nitzschia dissipata Navicula cryptocephala Nitzschia sp. Oscillatoria sp.	No taxa observed	Oscillatoria sp. Achnanthes lanceolata Nitzschia sp. Nitzschia longissima Cymbella ventricosa Navicula heufleri	No taxa observed

[a] Sample not collected because of high water releases from John Redmond Reservoir.
[b] Designated as "Location 4P" in the 1973 study.

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Table 6.3. Density (no./cm^2), number of taxa, diversity[a], and evenness[b] of periphytic algae collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Date	Location				
	1P	7	2	3	5[c]
Density (no./cm^2)					
16 April	-[d]	2306165	1187647	2725915	2370361
10 June	1323452	1224687	251850	572837	0
9 September	3037025	553081	229626	454315	34566
2 December	0	0	0	0	0
Number of taxa					
16 April	-[d]	27	31	31	28
10 June	11	30	16	21	0
9 September	23	15	14	17	8
2 December	0	0	0	0	0
Diversity					
16 April	-[d]	1.65	2.20	3.07	2.99
10 June	0.28	3.36	3.34	2.54	0.00
9 September	3.42	2.68	2.81	2.87	2.69
2 December	0.00	0.00	0.00	0.00	0.00
Evenness					
16 April	-[d]	0.35	0.45	0.62	0.62
10 June	0.08	0.68	0.84	0.58	0.00
9 September	0.76	0.69	0.74	0.70	0.90
2 December	0.00	0.00	0.00	0.00	0.00

[a] Shannon (1948).
[b] Zar (1968).
[c] Designated as "Location 4P" in the 1973 study.
[d] Sample not collected because of high water releases from John Redmond Reservoir.

Table 6.4. Biomass standing crop (mg/dm^2), chlorophyll a standing crop (µg/dm^2), autotrophic index[a], and biovolume (µl/dm^2) of periphytic algae collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Date	Location 1P	7	2	3	5[b]
Biomass standing crop (mg/dm^2)					
16 April	-[c]	305.99	117.82	554.83	618.97
10 June	455.35	263.52	1001.87	773.49	680.67
9 September	317.46	121.34	217.64	82.09	182.32
2 December	170.44	-[d]	28.78	71.97	89.04
Autotrophic index					
16 April	-[c]	582	277	288	364
10 June	1313	374	6229	2502	11071
9 September	336	769	3323	553	2862
2 December	-[e]	-[d]	-[e]	-[e]	-[e]
Chlorophyll a standing crop (µg/dm^2)					
16 April	-[c]	525.69	425.01	1925.89	1701.38
10 June	346.82	704.56	160.83	309.18	61.48
9 September	942.90	157.71	65.49	148.35	63.71
2 December	0.00	-[d]	0.00	0.00	0.00
Biovolume (µl/dm^2)					
16 April	-[c]	121.0	33.0	92.0	86.2
10 June	10085.9	212.5	3.5	10.3	0.0
9 September	148.1	14.4	7.0	16.8	0.7
2 December	0.0	0.0	0.0	0.0	0.0

[a] Weber (1973).
[b] Designated as "Location 4P" in the 1973 study.
[c] Sample not collected because of high water releases from John Redmond Reservoir.
[d] Sample not collected because of no visible growth.
[e] Infinity.

Table 6.5. Mean differences between locations for biomass and chlorophyll a standing crops from periphytic algae collected from natural substrates near the Wolf Creek Generating Station, Burlington Kansas, 1975.

		Biomass				
		1P	7	2	3	5[a]
16 April 1975	1P		-	-	-	-
	7	-		188.2	248.8[b]	313.0[b]
	2	-	100.7		437.0[b]	501.1[b]
Chlorophyll a	3	-	1400.2[b]	1500.9[b]		64.1
	5[a]	-	1175.7[b]	1276.4[b]	224.5	
10 June 1975	1P		191.8	546.5[b]	318.1	225.3
	7	357.7		738.3[b]	508.0[b]	417.1[b]
	2	186.0	543.7[b]		228.4	321.2
Chlorophyll a	3	37.6	395.4	148.4		92.8
	5[a]	285.3	643.1[b]	99.3	247.7	
9 September	1P		196.1[b]	99.9	235.4[b]	135.1[b]
	7	785.2[b]		96.3	39.2	61.0
	2	877.4[b]	92.2		135.5	35.3
Chlorophyll a	3	794.5[b]	9.4	82.9		100.2
	5[a]	879.2[b]	94.0	1.8	84.6	
2 December	1P		-	141.7	98.5	81.4
	7	0.0		-	-	-
	2	0.0	0.0		43.2	60.3
Chlorophyll a	3	0.0	0.0	0.0		17.1
	5[a]	0.0	0.0	0.0	0.0	

[a] Designated as "Location 4P" in 1973 study.
[b] Significant difference at $p \leq 0.05$.

Chapter 7

ZOOPLANKTON STUDY

By

Andrew J. Repsys

I. Introduction

Zooplankton are generally considered the second link in aquatic food chains (primary consumers). Planktonic fauna feeds on phytoplankton, bacteria, and organic detritus and in turn is utilized by other aquatic invertebrates and fish (secondary consumers). Zooplankton production is particularly important for young-of-the-year game fish which rely heavily on planktonic invertebrates for growth and survival and for small forage species (minnows, gizzard shad), the primary prey of piscivorous game fish (Russell-Hunter 1970).

Objectives of the present study were:

1. To gather further baseline data to determine natural seasonal and year-to-year variability in the zooplankton populations of John Redmond Reservoir, the Neosho River, and Wolf Creek; and

2. To provide a basis for the assessment of potential effects of construction and operation of the proposed Wolf Creek Generating Station upon the zooplankton of the area.

II. Field and Analytical Procedures

Sampling locations for zooplankton are indicated on Figure 7.1. Duplicate bottom to surface vertical tows were made at Location 1 (John Redmond Reservoir) with a no. 25 mesh (64 μm), 30 cm diameter, conical plankton net. Duplicate horizontal drift samples were collected at two locations (Locations 10 and 4) on the Neosho River downstream from John Redmond Reservoir and at four locations (Locations 7, 2, 3, and 5) on Wolf Creek using a no. 25 mesh plankton net with a 428 cm^2 aperature. Current velocity was measured with a General Oceanics flowmeter (Model 2031) to determine water volume sampled. When flow was absent in Wolf Creek during September and December 1975, the net was towed through a measured horizontal distance of 6 to 10 m. All samples were preserved at the time of collection in 5% formalin and stored in labeled containers.

In the laboratory, samples were concentrated or diluted to a workable density of organisms and then thoroughly mixed to obtain a representative subsample which was withdrawn and placed in a Bogorov counting chamber. Stratified counts of zooplankton in the subsample were obtained using a binocular dissection microscope at 50 X magnification. Subsampling was continued until a sufficient number of organisms was enumerated to estimate population densities, usually after counting at least 5% of the total sample. Microcrustacea were identified to species with the exception of taxonomically indistinct immature copepods and cladocerans which were identified to the lowest positive taxa. Rotifers were identified to genus, except certain littoral-benthic genera in the order Bdelloidea. Identifications were made with taxonomic keys by Pennak (1953), Brooks (1957, 1959), Edmondson (1959), Wilson and Yeatman (1959), Goulden (1968), Roberts (1970), and Ruttner-Kolisko (1974).

III. Results and Discussion

A. Current Study

Zooplankton taxa collected in the vicinity of the proposed Wolf Creek Generating Station during 1975 are listed in Table 7.1.

1. John Redmond Reservoir

Total zooplankton density at Location 1 (John Redmond Reservoir) in April was 419,475 organisms/m^3. Rotifers were the most abundant organisms collected in the reservoir and comprised 95% of the total zooplankton. Brachionus, Keratella, and Polyarthra were the dominant genera collected (Table 7.2). Microcrustacean populations in April were low and consisted primarily of copepod nauplii and cyclopoid copepodites which made up 4.5% of the total zooplankton. Adult limnetic copepods were present in densities of <50 organisms/m^3, whereas benthic harpacticoid copepods (juveniles and adults) were relatively abundant in April (825 organisms/m^3). Reservoir cladoceran populations were sparse, with the exception of Bosmina longirostris which occurred in moderate densities of 1066/m^3.

Total zooplankton declined 10% to 375,119 organisms/m^3 in June 1975 primarily due to sharp decreases in densities of the rotifer genera Brachionus and Keratella which constituted 60% of reservoir zooplankton in April. Brachionus and Keratella were replaced by the rotifer genera Polyarthra and Hexarthra as the most abundant zooplankton collected in June; the latter genera comprised 40% of the total zooplankton and were present as 100,209 and 65666/m^3, respectively. Reservoir zooplankton in June consisted of 18% copepods, 6% cladocerans and 76% rotifers (Table 7.3). Copepod densities increased 3-fold over April levels from 20003 to 65687 organisms/m^3 principally due to increases in numbers of copepod nauplii and copepodites. Densities of most adult copepods remained low, not exceeding 100 organisms/m^3, while those of Diaptomus siciloides increased from 38/m^3 in April to 1356/m^3 in June. Harpacticoid copepods were not collected in June and were absent from reservoir samples for the remainder of 1975. Cladocerans increased 17-fold over April densities primarily due to sharp increases in Bosmina longirostris (15090/m^3), Daphnia spp. (5010/m^3) and Diaphanosoma leuchtenbergianum (2830/m^3). Diaphanosoma was not present in April samples.

In September, zooplankton increased 31% over June levels to 490,590 organisms/m^3. This increase was due almost entirely to greater numbers of copepods and cladocerans present at Location 1 (Table 7.4). Rotifer densities increased only 1.5% during the same period. Zooplankton composition in September was 25% copepods, 16% cladocerans, and 59% rotifers. An increase of copepod nauplii densities from 37019 organisms/m^3 in June to 83892 organisms/m^3 combined with high densities of Diaphanosoma leuchtenbergianum (30841/m^3) and Moina micrura (22211/m^3) contributed to the microcrustacean increases in September. Other important cladocerans in September included Bosmina longirostris and Daphnia parvula. Hexarthra (123,740/m^3) and Conochiloides (60550/m^3) were the most abundant rotifer genera collected and together comprised 38% of total zooplankton.

Reservoir zooplankton declined 75% to 120,758 organisms/m^3 in December due to reduced densities of copepods, cladocerans, and particularly rotifers (Table 7.5). Rotifers decreased nearly 7-fold from September levels due primarily to the collapse of Hexarthra and Conochiloides populations. December samples were also characterized by the disappearance of the cladocerans Diaphanosoma leuchtenbergianum and Moina spp. which dominated in September. Bosmina longirostris and Diaptomus siciloides increased to densities of 16920 and 9563/m^3, respectively, in December which represented maximum densities for these microcrustacean species during 1975. Copepods were the most abundant reservoir zooplankton in December comprising 46% of the total population while rotifers and cladocerans represented 36 and 18%, respectively. Diaptomus siciloides was the only abundant adult copepod species, while Bosmina longirostris and Daphnia parvula comprised nearly 100% of the cladoceran community. Dominant rotifer genera included Keratella, Polyarthra, and Synchaeta in order of decreasing abundance.

2. Neosho River

Zooplankton abundance and species composition in the Neosho River should generally reflect populations present in John Redmond Reservoir since most of the river zooplankton collected at Locations 10 and 4 originate in reservoir discharges about 9 miles upstream. Zooplankton production between the dam and the river locations, particularly of microcrustaceans, appeared to be low due to currents which carried planktonic organisms downstream faster than they could complete their life cycles. Limited production of planktonic rotifers with shorter generation times may be possible in the Neosho River upstream of Location 10 during periods of low flow but no conclusive evidence for this has been obtained to date. Much of the pertinent literature indicates, moreover, that reservoir zooplankton discharged into rivers often show pronounced decreases due to river turbulence and turbidity (Chandler 1937; Rief 1939; Williams 1971). Particles of sand carried by currents exert a grinding action which destroys much zooplankton in turbid rivers while smaller particles of clay and silt may interfere with feeding and respiration.

The foregoing information suggests that any pronounced increases at Locations 10 and 4 (Neosho River) over reservoir Location 1 may be due to an underestimation of zooplankton actually being discharged from the reservoir. Zooplankton populations may show pronounced increases at the head of reservoir dams where outlets are located as compared to sampling sites further upstream (Hudson and Cowell 1966; Cowell 1967). As anticipated, dominant zooplankton species at Neosho River Locations 10 and 4 were the same as those collected at reservoir Location 1 for each sampling date during the current study. Total zooplankton densities (mean of Locations 10 and 4) ranged from 2939 organisms/m^3 in September 1975 to 216,692 organisms/m^3 in April 1975. Total zooplankton densities in the Neosho River ranged from 48 to 99% less than those collected at reservoir Location 1 from April to September 1975. In December 1975, zooplankton densities in the Neosho River were 9% higher than those at Location 1. This was due to higher numbers of rotifers collected at river locations on this sampling date, whereas microcrustacean densities were 38% less than reservoir populations following the trend of previous months (Table 7.6). The low zooplankton numbers present in river samples in June and September 1975 (38390 and 2939 organisms/m^3, respectively) relative to reservoir populations may have

been the result of low densities of plankton being actually discharged from the reservoir and/or be indicative of large losses of zooplankton that may have occurred between Location 1 and Locations 10 and 4. The magnitude of these decreases may in turn be related to season (temperature) and to volume of river flow. Sampling of reservoir discharges initiated in the 1976 study may help to clarify this problem in the future.

3. Wolf Creek

Total zooplankton standing crops in Wolf Creek during April ranged from 21324 organisms/m^3 at upstream Location 7 to 1417 organisms/m^3 at downstream Location 5 (Table 7.2). Mean total zooplankton for all four stations amounted to 9033 organisms/m^3. Rotifers formed 61% of total zooplankton with Synchaeta, Notholca, and Keratella being the dominant genera. Immature copepods were the next most common group collected and were most abundant at Location 7. Populations of adult copepods and cladocerans were low, averaging <100 organisms/m^3. Tropocyclops prasinus mexicanus, Chydorus sphaericus and Bosmina longirostris were representative species in April.

Mean zooplankton densities in Wolf Creek increased to 62650 organisms/m^3 in June 1975. The pattern of downstream decrease in zooplankton observed in April was also evident in June with maximum densities occurring at Location 7 (110,411 organisms/m^3) and minimum populations present at Location 5 (28221 organisms/m^3) (Table 7.3). Dominant taxa collected in June included immature copepods, Bosmina longirostris, Ceriodaphnia lacustris, and rotifers Polyarthra, Keratella, and Brachionus.

Flow was absent in Wolf Creek during September and the creek was reduced to a series of isolated pools. Zooplankton densities were high in pools at all creek locations. Populations ranged from 294,774 organisms/m^3 at Location 3 to 691,111 organisms/m^3 at Location 2 (Table 7.4). Mean zooplankton density for all creek locations (461,109 organisms/m^3) was comparable to the density present in John Redmond Reservoir (490,590 organisms/m^3) during September. Both microcrustaceans and rotifers showed a positive response to the cessation of flow. Pool zooplankton consisted of 37% copepods, 5% cladocerans, and 57% rotifers. Upstream pools (Locations 7 and 2) contained densities of copepods and rotifers similar to those in downstream pools (Locations 3 and 5), whereas cladocerans were nine times more abundant in upstream pools (Table 7.4). Tropocyclops prasinus mexicanus, Diaphanosoma leuchtenbergianum, and Daphnia parvula were the most frequently collected microcrustaceans and Keratella, Conochiloides, and Polyarthra represented dominant rotifer taxa in Wolf Creek during September.

Stagnant, isolated pools similar to those sampled in September were also present during December. Evidently little or no flow had occurred between sampling dates. Zooplankton was reduced to low densities at Locations 7, 3, and 5 (Table 7.5), but populations at Location 2 remained high (142,231 organisms/m^3). Cladocerans comprised 62% of total zooplankton at Location 2 with Chydorus sphaericus and Daphnia ambigua representing the most abundant zooplankters collected (38163 and 22876/m^3, respectively).

B. Comparison with Previous Studies

Comparisons of mean zooplankton densities collected in 1974 and 1975 are presented in Table 7.6. Considerable variation in microcrustacean and rotifer densities was observed between studies at all sampling locations. Early spring samples were collected on 26 March in 1974, whereas in 1975, samples were taken on 17 April. Spring is frequently a period of rapid population increase for zooplankton (Pennak 1953) and sampling in 1974 may have preceded the spring zooplankton pulse that was evident in April 1975 samples. Variations in zooplankton densities at reservoir Location 1 between years may be attributed to natural year-to-year variability reported for many lakes that are influenced by a complex of environmental factors difficult to isolate (Welch 1952; Hutchinson 1967). Moreover, estimates of reservoir population densities on the basis of one sampling location can be considered, at best, as only rough approximations, given the great variability in temporal and spatial distributions of zooplankton in lakes of any size.

Seasonal and yearly variations of zooplankton densities at Neosho River Locations 10 and 4 in 1974 and 1975 may have been more closely related to densities of zooplankton actually being discharged from the reservoir (not sampled in studies to date) than to populations sampled at Location 1 and to volume of river flow (reservoir water releases). Total zooplankton populations in the Neosho River were considerably higher relative to those in John Redmond Reservoir in spring and winter than in summer and fall during both 1974 and 1975 (Table 7.6).

Higher mean zooplankton populations in Wolf Creek in 1975 during April and June compared to previous studies were primarily due to the inclusion of upstream Location 7 which contained higher zooplankton densities than any of the previously sampled downstream locations (Tables 7.2 and 7.3). The higher densities observed in Wolf Creek in September and December 1975 compared to the same months in 1974, was the result of cessation of flow which was not observed during 1974 (Table 7.5). Flow was also absent in September 1973 and similarly high densities of zooplankton were collected in standing pools at Locations 2 and 3 (Kansas Gas and Electric Company 1974).

Comparisons of major microcrustacean taxa collected at Location 1 during 1973, 1974 and 1975 indicate that mean yearly densities of nine categories of zooplankton were highest during 1975 (Table 7.7). The greatest increases were observed for *Moina* spp. which increased from 205/m^3 in 1974 to 7848/m^3 in 1975. *Diaphanosoma leuchtenbergianum* increased over 3-fold from 2795/m^3 to 8418/m^3 during the same period. Three taxa were found at lower densities in 1975 than in previous studies. Yearly densities of *Ceriodaphnia* spp. (mainly *C. lacustris*) declined from 2483/m^3 in 1974 to 103/m^3 in 1975 and those of *Daphnia* (juveniles and adults) decreased over 3-fold from 1973 densities (Table 7.7). *Diaptomus pallidus* populations declined from 1006/m^3 in 1974 to 48/m^3 in 1975. The above changes may represent long term trends or short term fluctuations.

During periods of measurable flow, adult microcrustacean densities in Wolf Creek were usually too low to effectively establish significant changes in community structure between years. Flow within the creek tends to obscure seasonal and other environmental effects by differentially reducing zooplankton

populations available for analysis. The magnitude of zooplankton depletion in flowing water is related in a complex way to velocity of flow, variation of velocity characteristics with time, turbidity, turbulance, and creek bed morphology.

No major changes were observed in Wolf Creek zooplankton populations between years that could be termed lasting during periods of flow (March and June). Cessation of flow in September 1973 and in September and December 1975 produced spectacular increases in densities of major zooplankton taxa (Table 7.6). The most abundant microcrustacean species collected in Wolf Creek from 1973 to 1975 were Bosmina longirostris ($4644/m^3$) and Tropocyclops prasinus mexicanus ($4107/m^3$). Less abundant were Daphnia spp. (D. parvula and D. ambigua), Chydorus sphaericus and Ceriodaphnia lacustris. Keratella, Polyarthra, Synchaeta, Brachionus, and Conochiloides generally were dominant rotifer genera collected in Wolf Creek in 1974 and 1975 (Repsys 1975).

C. Relationship of Zooplankton to Environment

1. John Redmond Reservoir and the Neosho River

John Redmond Reservoir is a very shallow, hard water, eutrophic body of water characterized by high turbidity, widely fluctuating water levels and high summer water temperatures which may exceed 31 C (Prophet 1966). These conditions can be expected to influence community structure in determining which zooplankton species become dominant. Copepod species collected in John Redmond Reservoir were predominantly warm-water forms (e.g. Diaptomus siciloides, Cyclops vernalis) which appeared to reach maximum densities (mainly in the form of nauplii and copepodites) in late summer (Tables 7.5 and 7.6). Relatively large populations of adult Diaptomus siciloides then persisted through early December 1975 while immature copepod densities declined (Table 7.5) which suggests decreased reproduction of warm-water copepods in late fall. Only two taxa that could be termed "cold-water" organisms, Cyclops bicuspidatus thomasi and benthic harpacticoid copepods, were present in the reservoir in measurable numbers, but they formed only a small part of total annual microcrustacean populations. Those organisms appeared in low densities primarily in March and April.

The foregoing also applies to the cladoceran community in John Redmond Reservoir. Brooks (1956) found that the optimum temperature range for cladocerans in Kansas was from 22 C to 32 C. This may apply to reservoir populations of Bosmina longirostris and Daphnia parvula that build up relatively large populations from June through September that may persist until early December.

Two major reservoir taxa, Diaphanosoma leuchtenbergianum and Moina spp., prefer high temperatures (Ruttner 1953; Hutchinson 1967) and a third major taxon, Ceriodaphnia lacustris, may have similar temperature requirements. The high maximum densities attained by Ceriodaphnia in September 1974 relative to more eurythermic species (e.g. Bosmina, Daphnia parvula) suggested that population structure in John Redmond Reservoir may be shifted toward strictly thermophilic organisms which are indicative of shallow, warm temperate environments.

Dominant rotifers in John Redmond Reservoir, Keratella, Polyarthra, Synchaeta, and Brachionus, are cosmopolitan genera widely distributed throughout North America (Williams 1966) and therefore apparently are adapted to a wide

range of environmental conditions. In addition, a warm-water form, Hexarthra, was abundant in the reservoir in June and September. The nature of the zooplankton in the Neosho River and its dependence upon the reservoir have been discussed previously.

2. Wolf Creek

Microcrustacean zooplankton species composition in Wolf Creek was generally similar to that in John Redmond Reservoir although lower densities occurred in the creek during normal flow. Moreover, a greater variety of littoral microcrustaceans and benthic-littoral rotifers was often collected in Wolf Creek. The relatively shallow depth of the creek, close proximity of bottom substrates, and penetration of light to the bottom of shallow areas, simulate littoral zones of lakes that provide suitable habitat for a variety of littoral crustaceans and rotifers. One copepod species Tropocyclops prasinus mexicanus and one cladoceran Chydorus sphaericus were generally more abundant in Wolf Creek than in John Redmond Reservoir or the Neosho River from 1973 to 1975. Most of the zooplankton collected in Wolf Creek probably was produced in relatively static backwaters and small pools of the creek itself; there being no lentic source of zooplankton apparent. Upstream Locations 7 and 2 usually contained larger standing crops of zooplankton than downstream locations. The downstream locations may be less productive or currents may be stronger causing more rapid depletion of zooplankton. Chandler (1937) demonstrated that zooplankton normally do not accumulate downstream as currents sweep organisms out of successive pools and backwaters and transport them downstream. Chandler reported downstream zooplankton losses ranging from 40 to 99% in a five-mile stretch of the Huron River, a small stream in Michigan.

Cessation of flow in Wolf Creek during September and December 1975 produced dramatic increases in zooplankton densities (Table 7.5). Zooplankton numbers at all Wolf Creek locations in September and at Location 2 in December 1975 were comparable or exceeded zooplankton densities in John Redmond Reservoir. These results suggest that zooplankton can flourish only in standing water.

IV. Summary

1. Total zooplankton densities in John Redmond Reservoir were highest in September (490,590 organisms/m^3) and lowest during December (120,758 organisms/m^3). Maximum and minimum densities in the Neosho River were observed in April and September, respectively. Total mean zooplankton density in Wolf Creek was highest in September (461,109 organisms/m^3) and lowest in April (9283 organisms/m^3). High densities in September 1975 were attributed to cessation of flow in Wolf Creek.

2. Downstream decreases in total zooplankton densities were observed in Wolf Creek between upstream Locations 7 and 2 and downstream Locations 3 and 5 during April and June. Zooplankton decreases were attributed to current and turbidity.

3. The influence of Wolf Creek on Neosho River zooplankton was minor in April due to the small water volume of the creek and generally sparse zooplankton densities at downstream locations.

4. Dominant microcrustacean taxa in John Redmond Reservoir during 1975 were Bosmina longirostris, Diaphanosoma leuchtenbergianum, Daphnia parvula, Moina micrura, and Diaptomus siciloides. Abundant rotifer general were Polyarthra, Keratella, Synchaeta, Brachionus, and Hexarthra.

5. Wolf Creek zooplankton were primarily composed of Tropocyclops prasinus mexicanus, Daphnia parvula, Daphnia ambigua, Chydorus sphaericus, and Bosmina longirostris during the present study. Most frequently collected rotifer genera were Keratella, Polyarthra, Conochiloides, and Filinia.

6. Population densities in the Neosho River (Locations 10 and 4) appear to be related to volume of reservoir water releases in addition to seasonal factors.

7. Population densities in Wolf Creek are primarily governed by creek flow characteristics and season.

8. No major trends were discerned in total zooplankton populations between years due to natural year-to-year variability in zooplankton, change in sampling techniques and equipment, and infrequency of sampling. However, nine major zooplankton taxa were found at greater densities in John Redmond Reservoir in 1975 than in previous studies.

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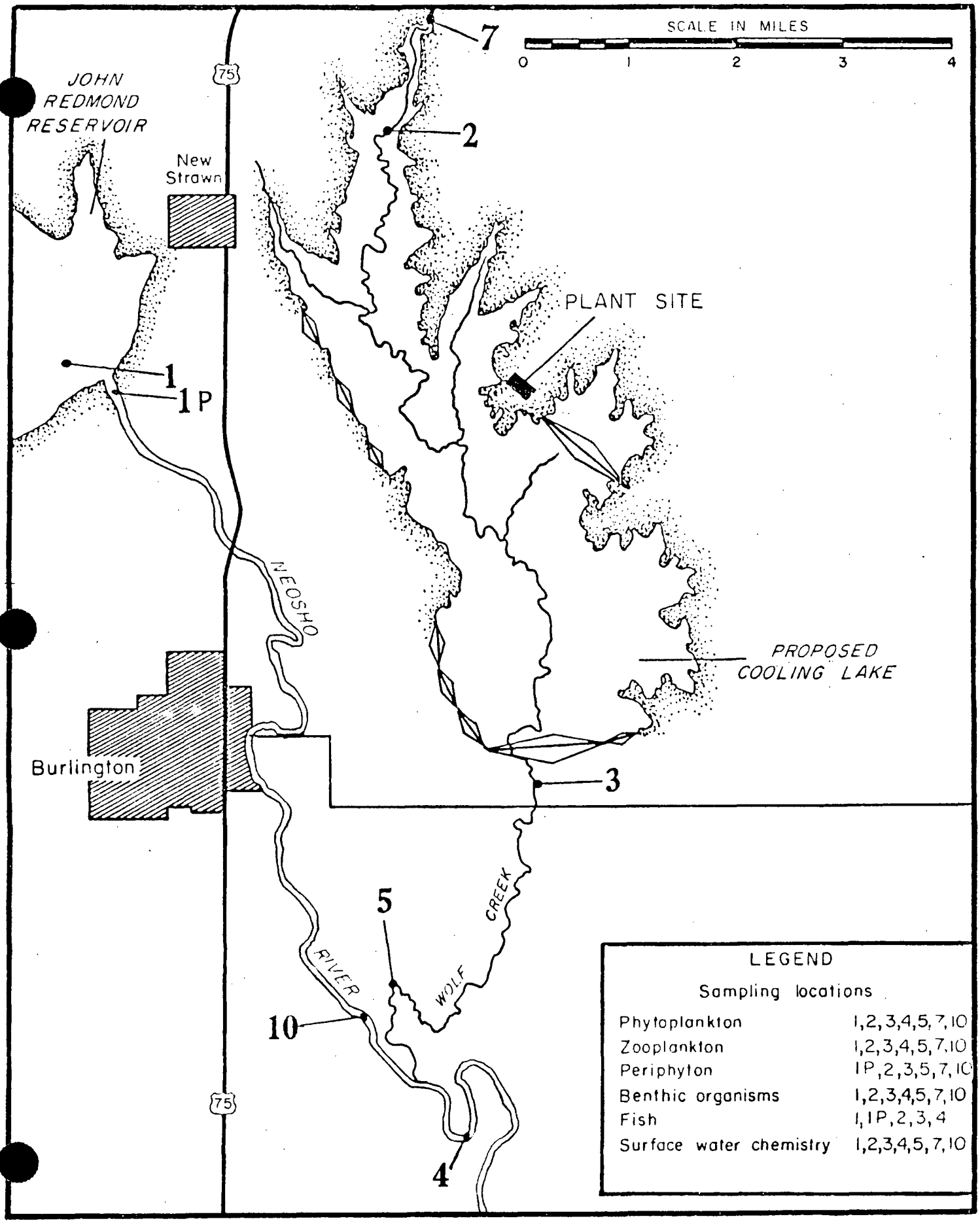

Figure 7.1. Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Table 7.1. Zooplankton taxa collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

COPEPODA

Cyclops bicuspidatus thomasi S. A. Forbes
Cyclops varicans rubellus Lilljeborg
Cyclops vernalis Fischer
Diaptomus clavipes Schaeht
Diaptomus pallidus Herrick
Diaptomus siciloides Lilljeborg
Ergasilus chautauquaensis Fellows
Ergasilus megaceros Wilson
Ergasilus versicolor Wilson
Eucyclops agilis (Koch)
Eucyclops agilis montanus (Brady)
Eucyclops prionophorus Kiefer
Eucyclops speratus (Lilljeborg)
Macrocyclops albidus (Turine)
Mesocyclops edax (S. A. Forbes)
Orthocyclops modestus (Herrick)
Paracyclops fimbriatus poppei (Rehberg)
Tropocyclops prasinus mexicanus Kiefer
Harpacticoida

CLADOCERA

Alona circumfimbriata (Meegard)
Alona gutatta Sars
Alona pulchella King
Bosmina longirostris (O. F. Muller)
Camptocercus rectirostris (Schodler)
Ceriodaphnia lacustris Birge
Ceriodaphnia quadrangula (O. F. Muller)
Chydorus globosus Baird
Chydorus sphaericus (O. F. Muller)
Daphnia ambigua Scourfield
Daphnia catawba Coker
Daphnia galeata mendotae Birge
Daphnia parvula Fordyce
Diaphanosoma leuchtenbergianum Fischer
Ilyocryptus sordidus (Lieven)
Kurzia latissima (Kurz)
Leydigia acanthocercoides (Fisher)
Leydigia leydigi (Schoedler)
Macrothrix laticornis (Jurine)
Moina affinis Birge
Moina micrura Kurz
Pleuroxus denticulatus Birge
Pleuroxus hamulatus Birge
Scapholeberis kingi Sars
Simocephalus serrulatus (Koch)

Table 7.1. Continued.

ROTIFERA

Anuraeopsis sp. Lauterborn
Asplanchna sp. Gosse
Bdelloid rotifers
Brachionus spp. Pallas
Cephalodella spp. Bory St. Vincent
Collotheca sp. Harring
Colurella sp. Bory St. Vincent
Conochiloides sp. Hlava
Dicranophorus spp. Nitzsch
Eosphora spp. Ehrenberg
Euchlanis spp. Ehrenberg
Filinia spp. Bory St. Vincent
Hexarthra spp. Schmarda
Horaella spp. Donner
Kellicottia sp. Ahlstrom
Keratella spp. Bory St. Vincent
Lecane spp. Nitzsch
Lepadella spp. Bory St. Vincent
Lophocharis sp. Ehrenberg
Monostyla sp. Ehrenberg
Mytilina sp. Bory St. Vincent
Notholca spp. Gosse
Notommata sp. Ehrenberg
Notommatid rotifers
Platyias sp. Harring
Pleurotrocha spp. Ehrenberg
Ploesoma sp. Herrick
Polyarthra spp. Ehrenberg
Pompholyx sp. Gosse
Rotaria sp. Scopoli
Synchaeta spp. Ehrenberg
Testudinella sp. Bory St. Vincent
Trichocerca spp. Lamarck
Trichotria sp. Bory St. Vincent
Wolga sp. Skorikov

Table 7.2. Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 17 April 1975.

	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1		10		4		7		2		3		5	
Taxa	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
COPEPODA														
Nauplii	15090[a]	3.60	5760	3.17	5898	2.34	15440	72.41	2552	40.53	822	11.58	195	13.76
Calanoid copepodites	94	0.02	83	0.04	96	0.04	3	0.01	6	0.10	4	0.06	3	0.21
Cyclopoid copepodites	3838	0.91	1978	1.09	2002	0.80	428	2.01	35	0.56	61	0.86	39	2.75
Cyclops bicuspidatus thomasi	47	0.01	42	0.02	62	0.02	0		0		<1	0.00	<1	0.03
Cyclops varicans rubellus	0		0		0		1	0.00	0		<1	0.00	0	
Cyclops vernalis	28	0.01	17	0.01	16	0.01	3	0.01	1	0.02	0		0	
Diaptomus clavipes	5	0.00	2	0.00	0		0		0		<1	0.00	0	
Diaptomus pallidus	9	0.00	2	0.00	5	0.00	0		0		<1	0.00	1	0.07
Diaptomus siciloides	38	0.01	7	0.00	18	0.01	1	0.00	0		1	0.01	1	0.07
Ergasilus chautauquaensis	5	0.00	0		0		0		0		0		0	
Eucyclops agilis	24	0.01	7	0.00	13	0.01	19	0.09	1	0.02	2	0.03	2	0.14
Eucyclops prionophorus	0		0		0		0		0		<1	0.00	0	
Eucyclops speratus	0		3	0.00	5	0.00	2	0.01	1	0.02	1	0.01	<1	0.03
Mesocyclops edax	0		2	0.00	16	0.01	0		0		0		0	
Paracyclops fimbriatus poppei	0		2	0.00	2	0.00	3	0.01	2	0.03	0		<1	0.03
Tropocyclops prasinus mexicanus	0		3	0.00	2	0.00	3	0.01	2	0.03	5	0.07	1	0.07
Harpacticoida	825	0.20	239	0.13	467	0.18	65	0.30	8	0.13	3	0.04	2	0.14
TOTAL COPEPODA	20003	4.77	8147	4.48	8622	3.42	15968	74.88	2608	41.42	899	12.67	245	17.29
CLADOCERA														
Alona circumfimbriata	9	0.00	3	0.00	10	0.00	2	0.01	1	0.02	1	0.01	1	0.07
Alona guttata	0		2	0.00	2	0.00	0		0		<1	0.00	<1	0.03
Alona pulchella	0		0		0		1	0.00	0		<1	0.00	<1	0.03
Alona spp.	0		0		2	0.00	0		0		1	0.01	0	
Bosmina longirostris	1066	0.25	291	0.16	312	0.12	14	0.06	21	0.33	25	0.35	26	1.83
Camptocercus rectirostris	0		0		0		0		0		<1	0.00	1	0.07
Ceriodaphnia quadrangula	5	0.00	2	0.00	0		0		0		0		1	0.03
Ceriodaphnia spp. (Immature)	0		0		0		0		0		1	0.01	<1	0.03
Chydorus sphaericus	198	0.05	123	0.07	176	0.07	103	0.48	52	0.82	81	1.14	74	5.22
Daphnia galeata mendotae	5	0.00	2	0.00	0		0		0		0		0	
Daphnia parvula	38	0.01	14	0.01	10	0.00	0		0		4	0.06	1	0.07
Daphnia spp. (Immature)	28	0.01	28		21	0.01	0		1	0.02	10	0.14	2	0.14
Ilyocryptus sordidus	0		2	0.00	2	0.00	0		0		0		0	
Ilyocryptus spp. (Immature)	0		10	0.01	13	0.01	0		0		0		0	
Kurzia latissima	0		0		0		1	0.00	0		<1	0.00	0	
Leydigia quadrangularis	0		2	0.00	2	0.00	0		0		0		0	
Pleuroxus denticulatus	0		0		0		1	0.00	0		<1	0.00	0	
TOTAL CLADOCERA	1349	0.32	479	0.26	550	0.22	122	0.57	75	1.19	121	1.70	107	7.55

Table 7.2. Continued.

Taxa	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1		10		4		7		2		3		5	
	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
ROTIFERA														
Asplanchna spp.	354	0.08	173	0.10	260	0.10	0		0		12	0.17	0	
Bdelloid rotifers	589	0.14	433	0.24	908	0.36	22	0.10	7	0.11	111	1.56	45	3.18
brachionus spp.	160216	38.19	78834	43.41	107996	42.89	56	0.26	0		161	2.27	80	5.64
Cephalodella spp.	0		0		0		28	0.13	49	0.78	86	1.21	24	1.69
Colurella spp.	0		0		0		0		0		6	0.08	0	
Conochiloides spp.	589	0.14	173	0.10	260	0.10	0		0		0		0	
Euchlanis spp.	0		0		0		5	0.02	0		3	0.04	0	
Filinia spp.	19099	4.55	10298	5.67	9086	3.61	434	2.04	90	1.43	34	0.48	14	0.99
Keratella spp.	93017	22.17	38585	21.25	53349	21.19	807	3.78	222	3.53	1860	26.21	208	14.68
Lecane spp.	0		0		0		0		7	0.11	12	0.17	7	0.49
Lepadella spp.	0		0		0		22	0.10	14	0.22	124	1.75	11	0.78
Lophocharis spp.	0		0		0		11	0.05	7	0.11	16	0.22	0	
Monostyla spp.	0		0		0		0		0		6	0.08	3	0.21
Notholca spp.	2476	0.59	1211	0.67	1168	0.46	913	4.28	1376	21.86	606	8.54	149	10.52
Notommatid rotifers	0		0		0		0		0		6	0.08	0	
Pleurotrocha spp.	0		0		0		0		932	14.80	148	2.08	97	6.84
Ploesoma spp.	0		0		0		0		7	0.11	3	0.04	0	
Polyarthra spp.	73683	17.56	25787	14.20	40239	15.98	317	1.49	41	0.65	6	0.08	0	
Rotaria spp.	0		0		0		5	0.02	7	0.11	6	0.08	14	0.99
Synchaeta spp.	47982	11.44	17480	9.62	29335	11.65	2470	11.58	688	10.93	2769	39.02	372	26.25
Testudinella spp.	118	0.03	0		0		0		0		12	0.17	3	0.21
Trichocerca spp.	0		0		0		0		14	0.22	12	0.17	0	
Trichotria spp.	0		0		0		83	0.39	7	0.11	9	0.13	3	0.21
Wolga spp.	0		0		0		0		7	0.11	6	0.08	0	
Unidentified rotifers	0		0		0		61	0.29	138	2.19	62	0.87	35	2.47
TOTAL ROTIFERA	398123	94.91	172984	95.25	242601	96.36	5234	24.54	3613	57.38	7076	85.62	1065	75.16
TOTAL ZOOPLANKTON	419475		181610		251773		21324		6296		7096		1417	

[a] Mean of two replicates.

Table 7.3. Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 10 June 1975.

	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1		10		4		7		2		3		5	
Taxa	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
COPEPODA														
Nauplii	37019[a]	9.87	8126	16.42	4843	17.75	29556	26.77	16394	21.27	7204	20.66	5812	20.59
Calanoid copepodites	14265	3.80	1166	2.36	444	1.63	762	0.69	414	0.54	143	0.41	114	0.40
Cyclopoid copepodites	12850	3.43	6809	13.76	1707	6.26	2278	2.06	1558	2.02	696	2.00	649	2.30
Cyclops vernalis	99	0.03	1212	2.45	705	2.58	6	0.00	3	0.00	0		6	0.02
Diaptomus pallidus	0		0		11	0.04	39	0.03	6	0.00	39	0.11	3	0.01
Diaptomus siciloides	1356	0.35	736	1.49	455	1.67	228	0.21	33	0.04	43	0.12	25	0.09
Ergasilus chautauquaensis	0		0		11	0.04	49	0.04	6	0.00	0		0	
Eucyclops agilis	0		66	0.12	0		17	0.01	29	0.04	42	0.12	36	0.12
Eucyclops agilis montanus	0		33	0.06	0		84	0.08	26	0.03	0		0	
Eucyclops speratus	0		11	0.02	0		20	0.01	29	0.04	6	0.02	6	0.02
Mesocyclops edax	0		0		11	0.04	36	0.03	36	0.05	13	0.04	6	0.02
Paracyclops fimbriatus poppei	0		0		0		35	0.03	0		3	0.00	8	0.03
Tropocyclops prasinus mexicanus	98	0.03	98	0.20	55	0.20	244	0.22	61	0.08	71	0.20	198	0.70
Harpacticoida	0		0		0		3	0.00	3	0.00	0		0	
TOTAL COPEPODA	65687	17.51	18257	36.88	8242	30.21	33357	30.21	18598	24.13	8260	23.68	6863	24.32
CLADOCERA														
Alona circumfimbriata	0		0		0		10	0,00	23	0.03	7	0.02	0	
Alona guttata	0		0		0		3	0.00	0		0		3	0.01
Alona spp.	0		0		11	0.04	0		6	0.00	0		3	0.01
Bosmina longirostris	15090	4.02	844	1.71	920	3.37	3661	3.32	4089	5.30	812	2.33	589	2.09
Ceriodaphnia lacustris	59	0.02	0		43	0.16	4595	4.16	1255	1.63	143	0.41	84	0.30
Ceriodaphnia quadrangula	0		33	0.06	22	0.08	16	0.01	68	0.08	7	0.02	3	0.01
Chydorus sphaericus	0		87	0.18	76	0.28	307	0.28	579	0.75	146	0.42	90	0.32
Daphnia spp. (Immature)	4460	1.19	768	1.55	368	1.35	78	0.07	85	0.11	98	0.28	30	0.11
Daphnia ambigua	0		11	0.02	596	2.18	0		10	0.01	101	0.29	33	0.12
Daphnia catawba	0		0		0		0		0		3	0.00	0	
Daphnia parvula	550	0.15	87	0.17	227	0.83	52	0.05	10	0.01	10	0.03	8	0.03
Diaphanosoma leuchtenbergianum	2830	0.75	76	0.15	44	0.16	501	0.45	192	0.25	26	0.07	8	0.03
Kurzia latissima	0		0		0		0		10	0.01	0		0	
Leydigia quadrangularis	0		0		0		10	0.00	42	0.05	0		3	0.01
Moina affinis	0		0		0		3	0.00	3	0.00	3	0.00	3	0.01
Moina micrura	0		0		0		7	0.00	7	0.01	0		0	
Moina spp.	315	0.08	33	0.06	33	0.12	7	0.00	26	0.03	16	0.05	17	0.06
Pleuroxus denticulatus	0		11	0.02	11	0.04	0		39	0.05	32	0.10	14	0.05
Pleuroxus hamulatus	0		0		11	0.04	7	0.00	10	0.01	0		3	0.01
Scapholeberis kingi	0		0		0		3	0.00	0		36	0.10	22	0.07
Simocephalus serrulatus	0		0		33	0.12	0		10	0.01	6	0.02	3	0.01
TOTAL CLADOCERA	23304	6.21	1950	3.94	2395	8.78	9260	8.39	6464	8.39	1446	4.15	916	3.25

Table 7.3. Continued.

Taxa	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1		10		4		7		2		3		5	
	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
ROTIFERA														
Asplanchna spp.	5541	1.48	37	0.07	186	0.68	73	0.06	117	0.15	128	0.37	14	0.05
Bdelloid Rotifera	0		334	0.67	538	1.97	467	0.42	234	0.30	573	1.64	390	1.38
Brachionus spp.	6013	1.60	1225	2.47	482	1.77	8314	7.53	4946	6.42	2551	7.31	2192	7.77
Cephalodella spp.	0		37	0.07	19	0.07	50	0.05	17	0.02	17	0.05	37	0.13
Colurella spp.	0		0		0		11	0.01	6	0.00	22	0.06	14	0.05
Conochiloides spp.	48690	12.98	483	0.98	279	1.02	1299	1.18	1324	1.72	2726	7.82	218	0.77
Collotheca spp.	118	0.03	0		0		0		0		6	0.02	0	
Eosphora spp.	0		0		0		11	0.01	6	0.00	45	0.13	23	0.08
Euchlanis spp.	0		19	0.04	37	0.14	140	0.13	62	0.08	50	0.14	28	0.09
Filinia spp.	2004	0.53	1169	2.36	650	2.38	2123	1.92	1869	2.42	273	0.78	241	0.85
Hexarthra spp.	65666	17.51	3117	6.30	1076	3.94	882	0.80	1052	1.36	312	0.89	306	1.08
Kellicottia spp.	0		19	0.04	0		0		6	0.00	50	0.14	5	0.02
Keratella spp.	2712	0.72	2746	5.55	3581	13.13	15129	13.70	16920	21.95	6425	18.42	6266	22.20
Lecane spp.	0		19	0.04	167	0.61	134	0.12	206	0.27	184	0.53	79	0.28
Lepadella spp.	0		93	0.19	130	0.48	262	0.24	351	0.46	217	0.62	130	0.46
Lophocharis spp.	0		0		56	0.21	39	0.04	45	0.06	50	0.14	42	0.15
Monostyla spp.	0		19	0.04	0		234	0.21	151	0.20	89	0.26	112	0.40
Mytilina spp.	0		0		0		17	0.02	0		0		0	
Notommata spp.	0		0		19	0.07	29	0.03	28	0.04	45	0.13	19	0.06
Platyias spp.	0		0		56	0.21	6	0.01	51	0.06	17	0.05	10	0.04
Pleurotrocha spp.	0		0		0		0		0		0		5	0.02
Ploesoma spp.	0		0		0		0		6	0.00	6	0.02	0	
Polyarthra spp.	100209	26.71	17208	34.77	7551	27.68	36916	33.44	21009	27.25	9385	26.91	8929	31.64
Pompholyx spp.	2005	0.53	167	0.34	74	0.27	545	0.49	2356	3.06	345	0.99	204	0.72
Rotaria spp.	0		0		130	0.48	11	0.01	173	0.22	774	2.22	680	2.41
Synchaeta spp.	52698	14.05	2468	4.99	1188	4.35	484	0.44	273	0.35	240	0.69	139	0.49
Testudinella spp.	0		19	0.04	130	0.48	156	0.14	545	0.71	367	1.05	186	0.66
Trichocerca spp.	472	0.13	74	0.15	74	0.27	256	0.23	195	0.25	56	0.16	33	0.12
Trichotria spp.	0		19	0.04	0		0		0		11	0.03	0	
Wolga spp.	0		19	0.04	37	0.14	106	0.09	45	0.06	101	0.29	65	0.23
Unidentified Rotifera	0		0		186	0.68	100	0.09	34	0.04	106	0.30	75	0.27
TOTAL ROTIFERA	286128	76.28	29291	59.18	16646	61.01	67794	61.40	52027	67.49	25171	72.17	20442	72.44
TOTAL ZOOPLANKTON	375119		49498		27283		110411		77089		34877		28221	

[a] Mean of two replicates.

Table 7.4. Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 9 September 1975.

	Sampling locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1		10		4		7		2		3		5	
Taxa	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
COPEPODA														
Nauplii	83892	17.10[a]	946	18.75	191	22.96	80997	27.12	91277	13.21	94860	32.18	75234	13.44
Calanoid copepodites	17306	3.53	151	2.99	51	6.13	17952	6.01	30685	4.44	8645	2.93	1121	0.20
Cyclopoid copepodites	14242	2.90	174	3.45	90	10.82	19509	6.53	58684	8.49	18614	6.31	19782	3.54
Cyclops vernalis	1282	0.26	27	0.54	2	0.24	47	0.02	62	0.01	39	0.01	8	0.00
Diaptomus clavipes	0		0		0		0		8	0.00	0		0	
Diaptomus pallidus	47	0.01	0		0		7905	2.65	7788	1.13	8528	2.89	2235	0.40
Diaptomus siciloides	2876	0.59	61	1.21	16	1.92	1308	0.44	93	0.01	218	0.07	78	0.01
Ergasilus chautauquaensis	3018	0.62	107	2.12	19	2.28	86	0.03	16	0.00	156	0.05	779	0.14
Ergasilus versicolor	19	0.01	2	0.04	0		0		16	0.00	31	0.01	0	
Eucyclops agilis	0		0		0		0		218	0.03	47	0.02	54	0.01
Eucyclops agilis montanus	0		0		0		8	0.00	16	0.00	8	0.00	16	0.00
Eucyclops prionophorus	0		0		0		0		0		8	0.00	0	
Eucyclops speratus	0		0		0		272	0.09	62	0.01	249	0.08	140	0.02
Macrocyclops albidus	0		0		0		0		0		8	0.00	0	
Mesocyclops edax	75	0.02	0		0		257	0.09	1830	0.26	16	0.00	54	0.01
Paracyclops fimbriatus poppei	0		0		0		0		8	0.00	0		0	
Tropocyclops prasinus mexicanus	38	0.01	0		2	0.24	13747	4.51	28115	4.07	20911	7.09	6192	1.11
Argulus spp.	0		1	0.02	0		0		0		0		0	
Harpacticoida	0		0		0		54	0.02	54	0.01	0		0	
TOTAL COPEPODA	122795	25.03	1469	29.11	371	44.59	141869	47.50	218932	31.68	152338	51.68	105693	18.89
CLADOCERA														
Alona circumfimbriata	0		0		0		0		0		23	0.01	0	
Alona spp.	0		0		4	0.48	0		23	0.00	23	0.01	16	0.00
Bosmina longirostris	9243	1.88	53	1.05	35	4.21	3427	1.15	1752	0.25	650	0.22	265	0.05
Ceriodaphnia lacustris	349	0.07	6	0.12	2	0.24	1674	0.56	11332	1.64	202	0.07	171	0.03
Chydorus sphaericus	0		0		0		0		62	0.01	109	0.04	39	0.01
Daphnia ambigua	0		0		0		3053	1.02	164	0.02	0		8	0.00
Daphnia parvula	5800	1.18	21	0.42	4	0.48	10125	3.39	17017	2.46	218	0.07	397	0.07
Diaphanosoma leuchtenbergianum	30841	6.29	18	0.36	2	0.24	20716	6.94	5646	0.82	3544	1.20	1402	0.25
Ilyocryptus sordidus	0		1	0.02	4	0.48	0		47	0.01	460	0.16	86	0.02

Table 7.4.Continued.

Taxa	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1		10		4		7		2		3		5	
	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
Kurzia latissima	0		0		0		62	0.02	23	0.00	54	0.02	31	0.00
Leydigia acanthocercoides	0		0		0		54	0.02	0		16	0.00	16	0.00
Leydigia leydigi	0		0		6	0.72	350	0.12	413	0.06	148	0.05	47	0.01
Macrothrix laticornis	0		0		8	0.96	0		16	0.00	54	0.02	125	0.02
Moina spp. (immature)	4527	0.92	1	0.02	0		0		0		0		0	
Moina affinis	4338	0.88	0		0		0		0		0		0	
Moina micrura	22211	4.53	4	0.08	2	0.24	0		226	0.03	31	0.01	125	0.02
Pleuroxus denticulatus	0		0		0		23	0.01	70	0.01	8	0.00	0	
Pleuroxus hamulatus	0		0		2	0.24	0		16	0.00	125	0.04	31	0.00
Scapholeberis kingi	0		0		0		0		23	0.00	8	0.00	0	
Simocephalus serrulatus	0		0		0		16	0.01	0		0		0	
TOTAL CLADOCERA	77309	15.76	105	2.08	69	8.29	39500	13.22	36861	5.33	5673	1.92	2759	0.49
ROTIFERA														
Anuraeopsis spp.	0		0		0		0		0		0		272	0.05
Asplanchna spp.	17070	3.48	100	1.98	16	1.92	0		0		312	0.11	1402	0.19
Bdelloid Rotifers	0		22	0.44	8	0.96	584	0.20	2375	0.34	1713	0.58	350	0.06
Brachionus spp.	46120	9.40	345	6.84	74	8.89	2687	0.90	2687	0.39	1558	0.53	10981	1.96
Cephalodella spp.	0		22	0.44	4	0.48	234	0.08	506	0.07	156	0.05	0	
Collotheca spp.	2499	0.51	89	1.76	12	1.44	0		0		0		272	0.05
Conochiloides spp.	60550	12.34	256	5.07	45	5.41	23598	7.90	395327	57.20	16433	5.57	3154	0.56
Euchlanis spp.	0		0		0		0		78	0.01	0		39	0.01
Filinia spp.	613	0.12	0		2	0.24	28076	9.40	3582	0.52	662	0.22	39681	7.09
Hexarthra spp.	123740	25.22	1024	20.29	97	11.66	0		545	0.08	1480	0.50	4322	0.77
Horaella spp.	0		0		0		0		0		0		2103	0.38
Kellicottia spp.	0		0		0		0		156	0.02	0		0	
Keratella spp.	236	0.05	11	0.22	4	0.48	53505	17.92	7360	1.06	96495	32.74	185981	33.24
Lecane spp.	0		0		0		195	0.06	506	0.07	312	0.11	0	
Lepadella spp.	0		0		2	0.24	623	0.21	818	0.12	312	0.11	818	0.15
Lophocharis spp.	0		0		0		195	0.06	428	0.06	156	0.05	78	0.01
Monostyla spp.	0		0		0		39	0.01	5062	0.73	312	0.11	234	0.04
Mytilina spp.	0		0		0		0		195	0.03	0		0	
Notommata spp.	0		0		0		0		0		78	0.03	0	
Platyias spp.	0		0		0		0		350	0.05	0		0	
Polyarthra spp.	26360	5.37	434	5.07	31	3.72	2882	0.96	4128	0.60	11098	3.76	187383	33.49
Pompholyx spp.	0		0		0		896	0.30	428	0.06	117	0.04	467	0.08
Rotaria spp.	0		0		0		3660	1.22	10047	1.45	2570	0.87	1324	0.24

Table 7.4. Continued.

Taxa	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1		10		4		7		2		3		5	
	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%
Synchaeta spp.	6790	1.38	312	6.18	31	3.72	0		0		0		5880	1.05
Testudinella spp.	0		0		0		78	0.03	78	0.01	78	0.03	78	0.01
Trichocerca spp.	6366	1.30	768	15.22	56	6.73	39	0.01	0		1986	0.67	3271	0.58
Trichotria spp.	0		0		0		0		39	0.00	78	0.03	0	
Wolga spp.	0		0		2	0.24	0		0		39	0.01	117	0.02
Dicranophorus spp.	0		0		0		0		0		0		1324	0.24
Unidentified Rotifera	142	0.03	89	1.76	8	0.96	0		623	0.09	818	0.28	1908	0.34
TOTAL ROTIFERA	290486	59.21	3472	68.81	392	47.12	117291	39.27	435318	62.99	136763	46.40	451439	80.62
TOTAL ZOOPLANKTON	490590		5046		832		298660		691111		294774		559891	

[a] Mean of two replicates.

Table 7.5. Zooplankton collected in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 3-4 December 1975.

	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1		10		4		7		2		3		5	
Taxa	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
COPEPODA														
Nauplii	35820[a]	29.66	26376	16.61	17290	16.60	6859	65.59	26108	18.36	317	34.42	729	25.54
Calanoid copepodites	4188	3.47	2674	1.68	2005	1.92	0		8	0.00	0		0	
Cyclopoid copepodites	5093	4.22	3141	1.98	2044	1.96	900	8.60	3104	2.18	77	8.36	120	4.20
Cyclops bicuspidatus thomasi	11	0.01	10	0.01	8	0.01	0		0		0		0	
Cyclops vernalis	362	0.30	358	0.22	117	0.11	103	0.98	480	0.34	0		0	
Diaptomus clavipes	0		0		4	0.00	0		0		0		0	
Diaptomus pallidus	136	0.11	483	0.30	171	0.16	0		94	0.07	0		0	
Diaptomus siciloides	9563	7.92	6360	4.00	2998	2.88	0		26	0.02	0		0	
Ergasilus chautauquaensis	0		21	0.01	8	0.01	0		0		0		0	
Ergasilus megaceros	45	0.04	42	0.03	23	0.02	0		0		0		0	
Eucyclops agilis	0		0		4	0.00	0		266	0.19	0		0	
Eucyclops agilis montanus	0		0		0		0		77	0.05	0		0	
Eucyclops speratus	0		5	0.00	0		43	0.41	874	0.61	17	1.84	0	
Macrocyclops albidus	0		0		0		0		154	0.11	0		0	
Mesocyclops edax	0		0		0		0		0		17	1.84	0	
Orthocyclops modestus	0		0		0		0		26	0.02	0		0	
Paracyclops fimbriatus poppei	0		0		0		8	0.08	26	0.02	8	0.87	17	0.60
Tropocyclops prasinus mexicanus	0		5	0.00	0		129	1.23	4681	3.29	0		0	
Harpacticoida	0		0		0		1766	16.89	480	0.34	8	0.87	77	2.70
TOTAL COPEPODA	55218	45.73	39472	24.86	24672	23.69	9808	73.78	36404	25.59	444	48.21	943	33.04
CLADOCERA														
Alona circumfimbriata	0		5	0.00	4	0.00	0		6276	4.41	0		0	
Alona pulchella	0		0		0		0		8	0.00	0		0	
Alona spp. (Imm.)	0		5	0.00	0		0		1440	1.01	68	7.38	0	
Bosmina longirostris	16920	14.01	16381	10.32	11371	10.92	0		10418	7.32	34	3.69	0	
Ceriodaphnia lacustris	0		0		0		0		163	0.11	0		0	
Chydorus globosus	0		0		0		0		266	0.19	26	2.82	0	
Chydorus sphaericus	0		0		8	0.01	0		38163	26.83	77	8.36	0	
Daphnia ambigua	0		0		0		0		22876	16.08	8	0.87	0	
Daphnia parvula	5093	4.22	592	0.37	420	0.40	0		0		0		0	
Ilyocryptus sordidus	0		0		4	0.00	0		0		0		0	
Kurzia latissima	0		0		0		0		6748	4.74	26	2.82	0	
Leydigia leydigi	0		0		0		0		1440	1.01	34	3.69	0	
Macrothrix laticornis	0		5	0.00	8	0.01	0		51	0.04	0		8	0.28
Pleuroxus denticulatus	11	0.01	0		0		0		257	0.18	0		0	
Pleuroxus hamulatus	0		0		0		0		43	0.03	0		0	
Simocephalus serrulatus	0		0		8	0.01	0		86	0.06	0		0	
TOTAL CLADOCERA	22024	18.24	16988	10.70	11823	11.35	0		88235	62.04	273	29.64	8	0.28

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Table 7.5. Continued.

Taxa	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1		10		4		7		2		3		5	
	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
ROTIFERA														
Asplanchna spp.	102	0.08	62	0.04	31	0.03	0		0		0		0	
Bdelloid Rotifera spp.	0		150	0.09	66	0.06	60	0.57	3044	2.14	103	11.18	68	2.38
Brachionus spp.	6338	5.25	4906	3.09	4634	4.45	26	0.25	369	0.26	0		1398	48.98
Cephalodella spp.	11	0.01	42	0.03	8	0.01	17	0.16	60	0.04	0		103	3.61
Conochiloides	0		5	0.00	0		0		0		0		0	
Euchlanis spp.	0		5	0.00	8	0.01	0		94	0.07	0		0	
Filinia spp.	0		5	0.00	4	0.00	0		0		0		0	
Keratella spp.	18278	15.14	41044	25.85	25000	24.01	0		8	0.00	8	0.87	0	
Lecane spp.	0		0		0		0		17	0.01	0		0	
Lepadella spp.	0		21	0.01	0		60	0.57	1355	0.95	8	0.87	26	0.91
Lophocharis spp.	0		0		0		34	0.32	8994	6.32	0		0	
Monostyla spp.	0		5	0.00	4	0.00	0		26	0.02	0		0	
Notholca spp.	0		0		4	0.00	0		0		0		0	
Platylas spp.	0		0		4	0.00	0		223	0.16	0		0	
Polyarthra spp.	10469	8.67	45768	28.82	30530	29.32	0		0		0		0	
Rotaria spp.	0		0		0		111	1.06	77	0.05	34	3.69	223	7.81
Synchaeta spp.	8318	6.89	10280	6.47	7321	7.03	317	3.03	8	0.00	0		34	1.19
Testudinella spp.	0		0		0		8	0.08	660	0.46	8	0.87	8	0.28
Trichocerca spp.	0		5	0.00	4	0.00	17	0.16	2426	1.70	43	4.67	17	0.60
Trichotria spp.	0		0		4	0.00	0		60	0.04	0		0	
Wolga spp.	0		0		0		0		103	0.07	0		0	
Unidentified Rotifera	0		36	0.02	16	0.02	0		68	0.05	0		26	0.91
TOTAL ROTIFERA	43516	36.04	102334	64.44	67638	64.95	650	6.22	17592	12.37	204	22.15	1903	66.68
TOTAL ZOOPLANKTON	120758		158797		104133		10458		142231		921		2854	

[a] Mean of two replicates.

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Table 7.6. Mean density of major zooplankton groups collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, March 1974 to December 1975.

Taxa and Location	March	April	June		September		December	
	No./m^3 (1974)	No./m^3 (1975)	No./m^3 (1974)	No./m^3 (1975)	No./m^3 (1974)	No./m^3 (1975)	No./m^3 (1974)	No./m^3 (1975)
COPEPODA								
John Redmond Reservoir	8809	20003	38649	65687	111975	122795	23673	55218
Neosho River	25366	8384	20414	13250	35524	920	26410	32072
Wolf Creek	991	4930	17003	16770	11562	154708	101	11900
CLADOCERA								
John Redmond Reservoir	307	1349	26690	23304	27333	77309	2065	22024
Neosho River	1059	514	14926	2127	17777	87	1657	14406
Wolf Creek	222	106	3299	4522	393	21198	25	22129
ROTIFERA								
John Redmond Reservoir	43038	398123	264471	286128	45158	290486	11091	43516
Neosho River	165245	207792	110076	22968	13496	1932	35605	84986
Wolf Creek	1120	4247	16587	41358	11243	285203	27	5087
TOTAL ZOOPLANKTON								
John Redmond Reservoir	52154	419475	329810	375119	184466	490590	36829	120758
Neosho River	191670	216692	145416	38390	66797	2939	63672	131465
Wolf Creek	2333	9283	36889	62650	23198	461109	153	39116

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Table 7.7. Yearly mean densities (No./m^3) of selected major microcrustacean taxa from John Redmond Reservoir (Location 1) March 1973 to December 1975.

	1973	1974	1975
COPEPODA			
Calanoid (*Diaptomus*) copepodites	2634	6948	8963
Cyclopoid copepodites	2546	6558	9006
Cyclops vernalis	284	597	443
Diaptomus pallidus	17[a]	1006	48
Diaptomus siciloides	1418[a]	1171	3458
All adult *Diaptomus* spp.	2591	2177	3508
Ergasilus chautauquaensis	133	39	756
CLADOCERA			
Bosmina longirostris	4509	4247	10580
Ceriodaphnia spp.[b]	1022	2483	103
Daphnia parvula	1271	2095	2870
All *Daphnia* spp.[c] (juveniles and adults)	14413	5089	3994
Diaphanosoma leuchtenbergianum	3032	2759	8418
Moina spp.[d]	163	205	7848

[a] Males only. Females not identified to species in 1973.
[b] Mainly *C. lacustris*
[c] Mainly juveniles and adults of *D. parvula*
[d] Mainly *M. micrura*

Chapter 8

BENTHOS STUDY

By

Darell L. Andersen

I. Introduction

Benthic macroinvertebrates occupy important positions in aquatic food webs and many have displayed sensitivity to various environmental perturbations (Weber 1973). The accumulation of background information to be used for the assessment and minimization of construction and operational effects near the proposed Wolf Creek Generating Station (WCGS) has therefore included monitoring the benthic macroinvertebrate communities of the site and immediate environs. Species composition and relative abundance data on the benthic fauna from John Redmond Reservoir, the Neosho River, and Wolf Creek have been collected quarterly since March 1973 (Kansas Gas and Electric Company 1974; Nulty 1975). Objectives of the study discussed herein were:

1. To provide additional baseline data on the benthic macroinvertebrate fauna of the proposed WCGS site and immediate environs; and

2. To document the naturally occurring temporal and spatial variability of benthic populations for assessing potential environmental impacts from construction and operation of WCGS.

II. Field and Analytical Procedures

Duplicate Ponar dredge samples were collected on 17 April, 10 June, 9 September, and 3 December 1975 from John Redmond Reservoir (Location 1), the Neosho River (Locations 10 and 4), and Wolf Creek (Locations 7, 2, 3, and 5) (Figure 8.1). Single qualitative samples were also collected at these locations on the same dates. The collection of each qualitative sample involved one-half man hour of effort in hand-picking, dip netting, or seining.

All samples were sieved in the field using U. S. Standard no. 30 mesh (0.595 mm) screen. The retained material was transferred to appropriately labeled containers and fixed with a rose bengal staining solution of 10% formalin (Mason and Yevich 1967). After exposure to the staining solution for a minimum of 24 hr, samples were rewashed at the laboratory in a no. 60 mesh (0.250 mm) sieve and preserved in 70% ethanol. Organisms were hand-picked from debris with the aid of a stereozoom microscope, identified to the lowest positive taxonomic level, and enumerated. Taxonomic keys used in identifications included Andersen (1973), Beck and Beck (1966), Beck and Beck (1969), Borror and DeLong (1964), Brinkhurst (1964, 1968), Burch (1972), Burks (1953), Cook (1956), Edmondson (1959), Flint (1964), Hamilton and Saether (1970), Harden and Michel (1952), Hilsenhoff (1970), Hiltunen (1973), Hobbs (1972), Holsinger (1972), Klemm (1972), Leonard and Leonard (1962), Lewis (1969, 1974), Needham et al. (1935), Needham and Westfall (1955), Pennak (1953), Roback (1957, 1962, 1969, 1971, 1974), Ross (1944), Sperber (1950), Usinger (1971), and Williams (1972).

Diversity indices for all quantitative samples were calculated using the log base 2 in Shannon's (1948) equation as discussed by Wilhm and Dorris (1968). A one-way analysis of variance was used to test for differences in diversity values among sampling dates and locations (Steel and Torrie 1960).

III. Results and Discussion

A. Habitat Characterization

This study was concerned with the macrobenthic fauna of three distinctly different aquatic environments typical of east central Kansas. John Redmond Reservoir was built by the U. S. Army Corps of Engineers in 1965 to provide flood control and steamflow regulation for the upper Neosho (Grand) River. At conservation level (elevation 1036 msl) the impoundment has a surface area of 3157 hectares (about 7800 acres) and gross storage capacity of 69.70 x 10^6 m^3 (about 56500 acre ft) with approximately 75% of the basin being less than 3 m deep (Prophet 1966; Funk 1973). Because of its shallow depth and exposure to winds, summer thermal stratification seldom occurs and turbidity usually remains high (Funk 1973).

The Neosho River is a relatively sluggish meandering stream which rarely exceeds a 1 m/km gradient (Prophet 1966). River flow in the study area depends primarily upon discharge from John Redmond Dam and is therefore subject to extreme fluctuations according to flood control priorities of the U. S. Army Corps of Engineers, Tulsa District. The substrates at the study locations varied from a mixture of sand, clay, and organic debris in deeper pools to gravel and rubble in shallower riffle areas.

Wolf Creek is a small intermittent tributary to the Neosho River. The creek is subject to brief periods of high flow from snow melt and rainfall runoff as well as extended periods of pooling without flow during drought. Substrates sampled along the creek were generally gravel bottoms of riffles or pools at Locations 7, 2, and 3 and hard clay at Location 5 (Figure 8.1).

B. Benthic Macroinvertebrate Communities

1. John Redmond Reservoir

Benthic samples collected from John Redmond Reservoir (Location 1) during 1975 contained a total of 26 taxa of which 8 were oligochaetes and 11 were chironomids (Table 8.1). Taxa consistently common during all sampling periods included only immature tubificids without capilliform chaetae (probably *Limnodrilus*) and the midge genus *Coelotanypus*. However, periodically abundant taxa (representing >10% of total benthic abundance) included *Chironomus* and *Procladius* (*Psilotanypus*) in April, *Tanypus stellatus* in June and September, and *Hexagenia limbata* and *Chironomus* in December (Tables 8.2-8.5). This macroinvertebrate assemblage is similar to those previously reported from John Redmond and is typical of reservoirs with ooze substrates receiving substantial organic enrichment (Reid 1961; Funk 1973; Neel 1963; Kansas Gas and Electric Company 1974; Nulty 1975).

A total of 13 taxa was collected in the reservoir benthos samples during April (Table 8.2). Six worm taxa (62.2%), five midge taxa (31.1%), and the phantom midge, *Chaoborus punctipennis*, (6.7%) contributed to the mean total benthic density of 1276 organisms/m^2 (Table 8.2). The most abundant genera present were *Limnodrilus*, *Chironomus*, and *Procladius* (*Psilotanypus*).

Totals of 15 taxa were present in both the June and September benthos collections with mean densities of 1488 and 1181 organisms/m^2, respectively (Tables 8.3 and 8.4). Chironomidae numerically dominated the community comprising 75.4 and 68.8% of the total collections in June and September. Tanypus stellatus, a species which prefers ooze substrates (Roback 1969), represented about 61% of the total benthos in collections from both sampling periods. The worm family Tubificidae accounted for 21.5 and 19.2% of the benthic population in June and September, respectively.

Benthic samples collected from the reservoir in December yielded 12 taxa with a mean total density of 992 organisms/m^2 (Table 8.5). Chironomidae, as a whole, represented 60.0% of the total benthic population with the genus Chironomus comprising 71.4% of that family total. Tubificidae accounted for only 10.5% of total benthic population sampled. Branchiura sowerbyi was the only worm identified to species, but immature specimens of other taxa were present in low densities (Table 8.5). The fossorial mayfly Hexagenia limbata comprised 19.0% of the mean total benthic population and was the second most abundant taxa collected in December. Hunt (1953), Fremling (1970), and Hudson and Swanson (1972) have reported migration of these nymphs in rivers, lakes, and reservoirs. However, the presence of this population does indicate that favorable substrates and dissolved oxygen concentrations were available within the reservoir throughout the year.

Qualitative samples collected from the riprap along the shoreline of the reservoir near the launching ramp during 1975 yielded nine additional taxa (Table 8.1). These included bryozoan, scud, crayfish, mayfly, damselfly, water boatman, and midge taxa. Although these data are not sufficient to warrant detailed discussion, they do indicate that the shoreline areas provide habitats suitable for populations which are not otherwise supported by the open reservoir habitats.

Diversity indices ranged from 1.33 to 2.95 among individual samples and averaged 2.12 for the year (Table 8.6). No statistical differences ($p \geq 0.05$) in diversity were found among sampling periods.

2. Neosho River

Ponar grab samples collected upstream (Location 10) and downstream (Location 4) of the confluence of Wolf Creek and the Neosho River yielded a total of 72 taxa during 1975 (Table 8.1). Individual samples contained from 2 to 31 taxa (Tables 8.2-8.5). Total densities ranged from 319 to 2438 organisms/m^2 during 1975 and no taxon or group of taxa were consistently present in abundance. Such variation of composition and abundance in assemblages between locations and among sampling periods exemplifies the dynamic nature of benthic communities typical to lotic environments where fluctuating flow rates and varied substrates provide a variety of habitats.

Samples collected in April contained a mean density of 319 organisms/m^2 and a total of 10 taxa at Location 10, while a mean of 402 organisms/m^2, representing 14 taxa, was found at Location 4 (Table 8.2). Tubificidae (67.7%) and Chironomidae (26.3%) numerically dominated the fauna found in the mud and leaf litter at Location 10 where Limnodrilus udekemianus

and Chironomus were the most abundant taxa. The muddy gravel collected at Location 4 supported a fauna containing 28.1% Rhyocophila lobifera, 25.6% Chironomidae, and 23.4% Enchytraeidae.

The reduction of outflow from John Redmond Dam on 8 and 9 June decreased flow in the river and exposed much of the previously available habitat (Figure 8.2). Active migration of organisms with the receding water was observed during collection of samples on 10 June. Samples were collected from gravel substrstes in riffles and the circumstances are apparent in the data (Table 8.3). The unusually low density and diversity in the B replicate at Location 10 could not be explained (Tables 8.3 and 8.6). Mean densities exceeded 2000 organisms/m^2 at Locations 10 and 4. Hydropsychidae, rheophilic net-spinning caddis larvae (Dodds and Hisaw 1925; Ross 1944), comprised about half of the benthic population. Abundant taxa included the mayflies, Ephoron album and Caenis; the caddisflies, Cheumatopsyche and Potamyia flava; and several lotic midges (Table 8.3).

River flow was low during the September sampling period which permitted collection from riffle habitats at Locations 10 and 4. Hydropsychidae, primarily Potamyia flava, comprised 84.5% of the 973 organisms/m^2 collected at Location 10 (Table 8.4). Hydropsychids made up 41.3% of the 1257 organisms/m^2 collected from Location 4 and the stonefly Neoperla clymene comprised 36.1% of that density (Table 8.4).

Water level in the river was lowest during December and the riffle fauna at Location 10 had begun to show signs of stress. Benthic density at this location dropped to 567 organisms/m^2 and was composed of 43.3% Chironomidae and 21.7% Sphaeriidae (Table 8.5). Location 4, a gravel bar, supported populations totaling 2438 organisms/m^2 but was primarily Chironomidae (68.2%) (Table 8.5).

Qualitative samples collected at the Neosho River locations yielded a total of 65 taxa, 38 of which were not collected in the quantitative Ponar samples (Table 8.1). Receding water during June sampling allowed collection of many mollusc specimens (Table 8.7) which had previously been unreported in studies of the river (Kansas Gas and Electric Company 1974; Nulty 1975).

Diversity indices calculated from the 1975 river benthos data varied from 0.50 to 3.75 and averaged 2.08 at Location 10 and 2.70 at Location 4 (Table 8.6). Fluctuations in diversity were greater at Location 10, because the substrate is more variable than at Location 4, where a uniform gravel bar was sampled each time. The annual average values approximated the summer mean diversity (2.64) determined for a riffle in the upper reaches of the Neosho River near Emporia, Kansas, by Nulty (1974). No statistical differences ($p \geq 0.05$) were found in benthic diversities between Locations 10 and 4 or among samples collected over the four sampling periods.

Table 8.6 shows that the numbers of taxa collected from the Neosho River during 1975 were generally larger than those of previous studies (Kansas Gas and Electric Company 1974; Nulty 1975). This increase was primarily due to the lower river levels which allowed better sampling of the more productive

riffle habitats. These habitats had been obscured by high water during previous investigations. Thus, any further interpretation of this apparent change in fauna should acknowledge the improved sampling conditions and not assume major changes in the quality of the Neosho River water.

3. Wolf Creek

It is pertinent to point out that the creek was flowing only during the April and June collections and that the September and December samples were taken from isolated pools or puddles in the creek bed. The intermittent flow of the creek during the two latter sampling periods limits discussion of temporal and spatial variability.

Samples collected with a Ponar dredge from Wolf Creek (Locations 7, 2, 3, 5) during 1975 yielded a total of 84 macroinvertebrate taxa which included 34 chironomid and eight tubificid taxa (Table 8.1). Chironomidae and Tubificidae consistently were the most abundant families found, and comprised more than 10% of the total benthic population in over two-thirds of the Ponar samples collected from the creek. Other families which sporadically represented major portions of the benthic fauna included Naididae, Caenidae, Hydropsychidae, Simuliidae, Physidae, and Sphaeriidae. The mean density of benthos collected at creek locations under flowing conditions (April and June) was about 1600 organisms/m^2 (Tables 8.2 and 8.3) and the mean from the isolated pools sampled during September and December was about 900 organisms/m^2 (Tables 8.4 and 8.5). However, the minimum and maximum values recorded were from samples collected while the creek was flowing: 18 organisms/m^2 at Location 5 in June (Table 8.3) and 6488 organisms/m^2 at Location 3 in April (Table 8.2).

Creek samples collected in April contained a low of 4 taxa at Location 5 and a high of 18 taxa at Location 3 (Table 8.2). Densities ranged from 227 organisms/m^2 at Location 5 to 6766 organisms/m^2 at Location 3 (Table 8.2). The macroinvertebrate communities sampled along the creek were numerically dominated by Chironomidae, especially Orthocladius (ss), except at Location 5 where Simuliidae represented 84.0% of the population (Table 8.2).

During the June sampling, the creek was carrying runoff water and the increased current and turbidity had apparently caused some scouring at downstream Locations 3 and 5. The number of taxa reported per location ranged from 2 at Location 5 to 25 at Location 2 (Table 8.8). The density of benthos ranged from 19 organisms/m^2 at Location 5 to 3062 organisms/m^2 at Location 2 (Table 8.3). Midges of the genus Stictochironomus predominated at Locations 7 and 2, tubificids and hydropsychids were prevalent at Location 3, and only two organisms were found in the scoured clay at Location 5 (Table 8.3).

Although heavy rains occurred during the second and fourth weeks of August (Figure 8.3), water in the creek bed during the September sampling was restricted to pools and puddles. The pools sampled at Locations 2 and 3 were larger and deeper than those at Locations 7 and 5. The numbers of taxa collected and the density of the benthos populations were also larger at Locations 2 and 3 (23 taxa and 1200 organisms/m^2) than at Locations 7 and 5 (11 and 6 taxa, and 123 and 217 organisms/m^2, respectively) (Table 8.4). The percentage of total benthos represented by tubificids ranged from 23.1% at Location 7 to 87.0% at Location 5 (Table 8.4). This relative increase in the

percentage of worms was probably promoted by summer emergences of insects and the resultant reduction of total benthic densities.

December collections also were made in isolated pools and puddles and precipitation records indicate that water flow between locations had probably not occurred since September. Substantial amounts of leaf litter had accumulated in the water resulting in an increased oxygen demand at all locations. When accumulations of organic matter reduce oxygen concentrations, changes in the resident fauna occur (Hynes 1966). Locations 2 and 3 were sampled through the ice on 3 December and such reduced oxygen levels were evident (Chapter 4). The presence of Tubifera at Locations 2, 3, and 5 suggests that low oxygen concentrations had probably existed previously (Tables 8.5 and 8.7). However, the continued existence of other macroinvertebrate populations at these locations indicates that the oxygen stress had not persisted for extended periods of time. Under prolonged oxygen stress conditions, Tubifera would have dominated the fauna (Larimore et al. 1959; Hynes 1966). The favorable effect of the larger water bodies at Locations 2 and 3 was reflected by the larger density of benthos. These findings were similar to those of September. Sphaeriidae were found in appreciable numbers at Locations 3 and 5 (Table 8.5). Baker (1928) and Ingram (1940) have reported sphaeriids surviving in temporarily dry habitats but neither offered explanations of this behavior. Snails (Physa) were numerous in one sample from Location 7 (Table 8.5). Ingram (1940) also discussed this genus in his paper on survival during drought. Stehr and Branson (1938) also reported Physa as being fairly abundant and widespread in their study of an intermittent Ohio stream. Other major populations (Table 8.5) indicative of the degraded conditions found in the puddles along Wolf Creek's streambed included tubificids, Limnodrilus hoffmeisteri and Branchiuria sowerbyi, and Procladius (Psilotanypus) midges (Kennedy 1965; Schaefer et al. 1965; Roback 1971). Qualitative samples collected from the creek during December contained 26 taxa but Physa was the only taxa found at all locations (Table 8.7).

Diversity indices were calculated for all benthic samples collected in Wolf Creek and ranged from 0.61 to 3.79 (Table 8.6). However, the data were subjected to a one-way analysis of variance to test for differences among locations during April and June and no significant ($p \geq 0.05$) differences in diversity values were found. The apparent reduction of diversity at Location 5 was promoted by the hard clay substrate not offering as many microhabitats as the gravel bottoms of other locations (Table 8.6).

C. Relationships to the Environment

The benthic fauna in John Redmond Reservoir during 1975 was similar to assemblages found during previous studies (Funk 1973; Kansas Gas and Electric Company 1974; Nulty 1975). The data showing numerical dominance of Tubificidae and Chironomidae approximated that reported from other reservoirs in the Dakotas, Nebraska, and Oklahoma (Peterka 1972; Ransom and Dorris 1972; Andersen 1975; Benson and Hudson 1975). Although the major midge genera in John Redmond, Coelotanypus and Tanypus, do not develop large populations in the investigations cited above, Roback (1969, 1974) and Sublette (1955, 1957) report their cohabitation of ooze substrates in Lake Texoma, Oklahoma-Texas.

The presence of Hexagenia limbata indicated that favorable dissolved oxygen concentrations existed throughout the year in the reservoir and the

increased abundance of this insect larvae at Location 1 during December was probably due to a winter migration into shallower areas as reported by Hudson and Swanson (1972). Diversity indices determined from 1975 benthic data at Location 1 approximated those reported earlier by Funk (1973) and those found at similar depths in Keystone Reservoir, Oklahoma (Ransom and Dorris 1972) and Sutherland Reservoir, Nebraska (Andersen 1975). The benthic community of John Redmond Reservoir continues to be determined primarily by the shallow depth of much of the basin, the fluctuating quantity and quality of the incoming water, and the exposure to persistent winds which promotes its generally turbid condition (Prophet et al. 1970; Funk 1973).

The temporal and spatial variability in the benthos data from the Neosho River is primarily due to the fluctuations in the water levels over past years. These fluctuations are caused by natural runoff and drought complicated by the artificial manipulations created at the John Redmond Dam. Tubificids and chironomids have generally been the most numerous organisms collected, but caddisflies, mayflies, and fingernail clams have occasionally been abundant (Kansas Gas and Electric Company 1974; Nulty 1975). During extended periods of low water, the study areas of the river closely resemble upstream riffle areas near Emporia, Kansas (Nulty 1974) and allow sampling of more productive habitats which may be easily overlooked during periods of high water. The increased sampling efficiency afforded by lower water levels was reflected by an increase in the number of taxa reported during 1975 over previous years (Kansas Gas and Electric Company 1974; Nulty 1975).

The characteristics of the benthic community of Wolf Creek varied considerably during 1975. Flow was sporadically increased by heavy rains in June and August but was reduced to zero during dryer periods when only isolated pools could be found in the creek bed. This intermittent character is common to many creeks in the central United States (Carlander et al. 1966). Many of the major taxa inhabiting Wolf Creek have short life cycles (midges and blackflies) or are tolerant of crowding and low dissolved oxygen concentrations (worms, snails, and fingernail clams). These adaptations are characteristic of intermittent stream faunas (Stehr and Branson 1938; Starrett 1950; Larimore et al. 1959). Repopulation by insects after extended periods of drought is usually accomplished rapidly by ovaposition of aerial adults which fly in from nearby bodies of water but active migration upstream may contribute near the confluence with more permanent streams (Stehr and Branson 1938; Larimore et al. 1959). In spite of the precarious nature of the fauna in intermittent streams they continue to make an important contribution to the aquatic ecology of the mid-continent states.

IV. Summary and Conclusions

1. Benthic samples from John Redmond Reservoir, the Neosho River, and Wolf Creek by both qualitative and quantitative means yielded 75, 110, and 115 macroinvertebrate taxa, respectively, during 1975.

2. Although the species composition found in 1975 was similar to that of previous years, low water in the river and creek did allow collection of several previously unreported taxa.

3. Similar to the findings of previous studies, the benthic fauna in Wolf Creek was the most diverse with that of John Redmond Reservoir being the least diverse.

4. Tubificidae and Chironomidae were the most numerous groups present in all three systems. Other groups that were occasionally abundant included mayflies, caddisflies, blackflies, and fingernail clams.

5. The benthic fauna in Wolf Creek, John Redmond Reservoir, and the Neosho River is characteristic of that reported from similar habitats throughout the mid-continent states.

6. Temporal fluctuation in fauna is large and due primarily to natural and artificial changes in water level.

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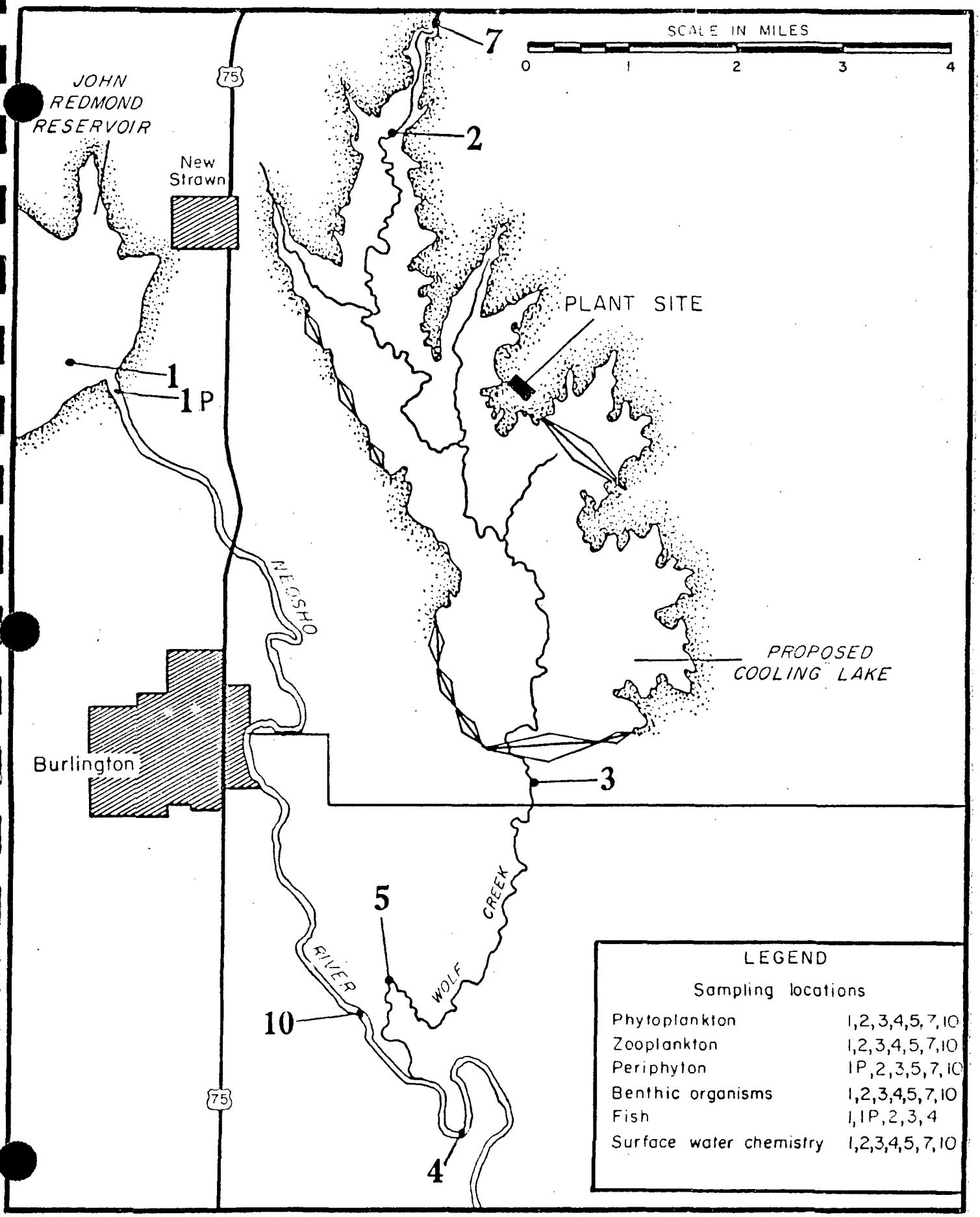

Figure 8.1. Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

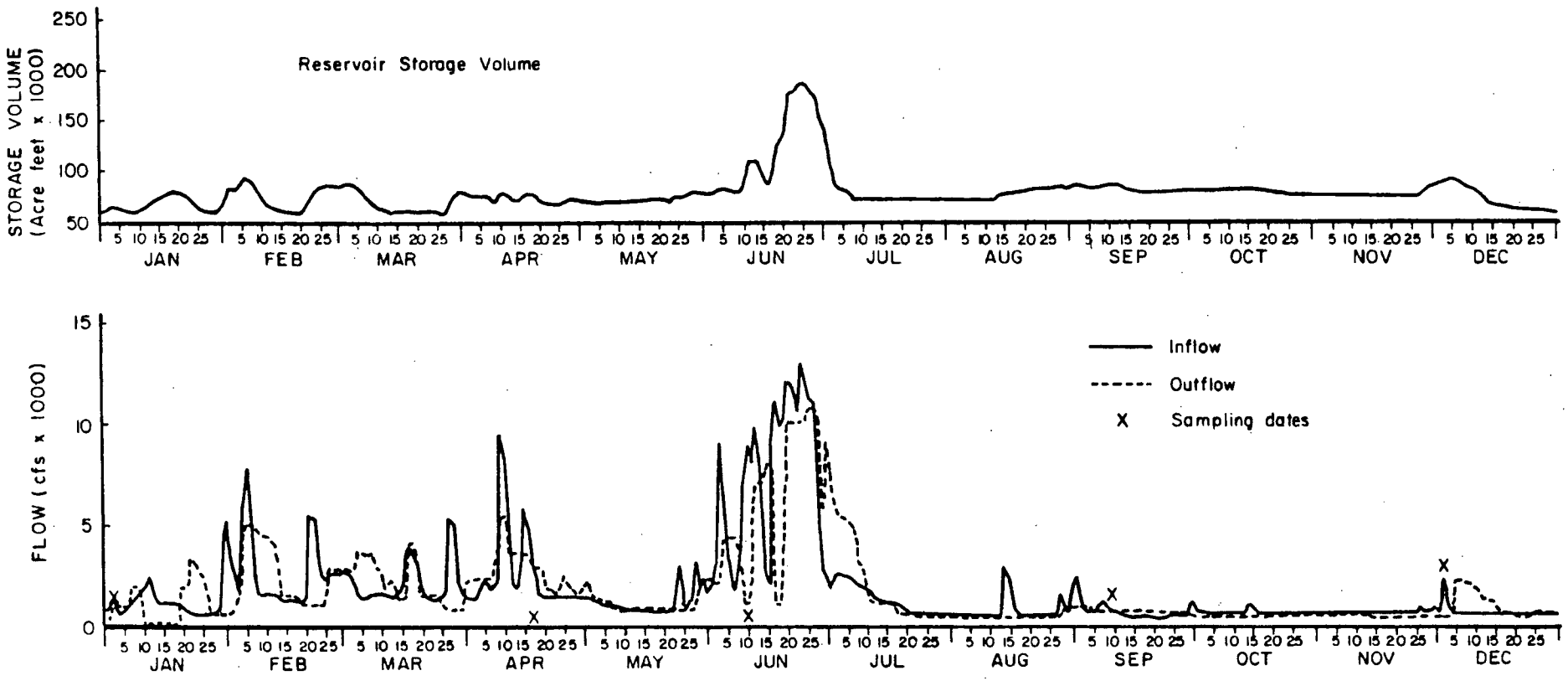

Figure 8.2. Hydrological conditions including reservoir storage volume, reservoir inflow and outflow for John Redmond Reservoir, 1975 (U. S. Army, Corps of Engineers 1975).

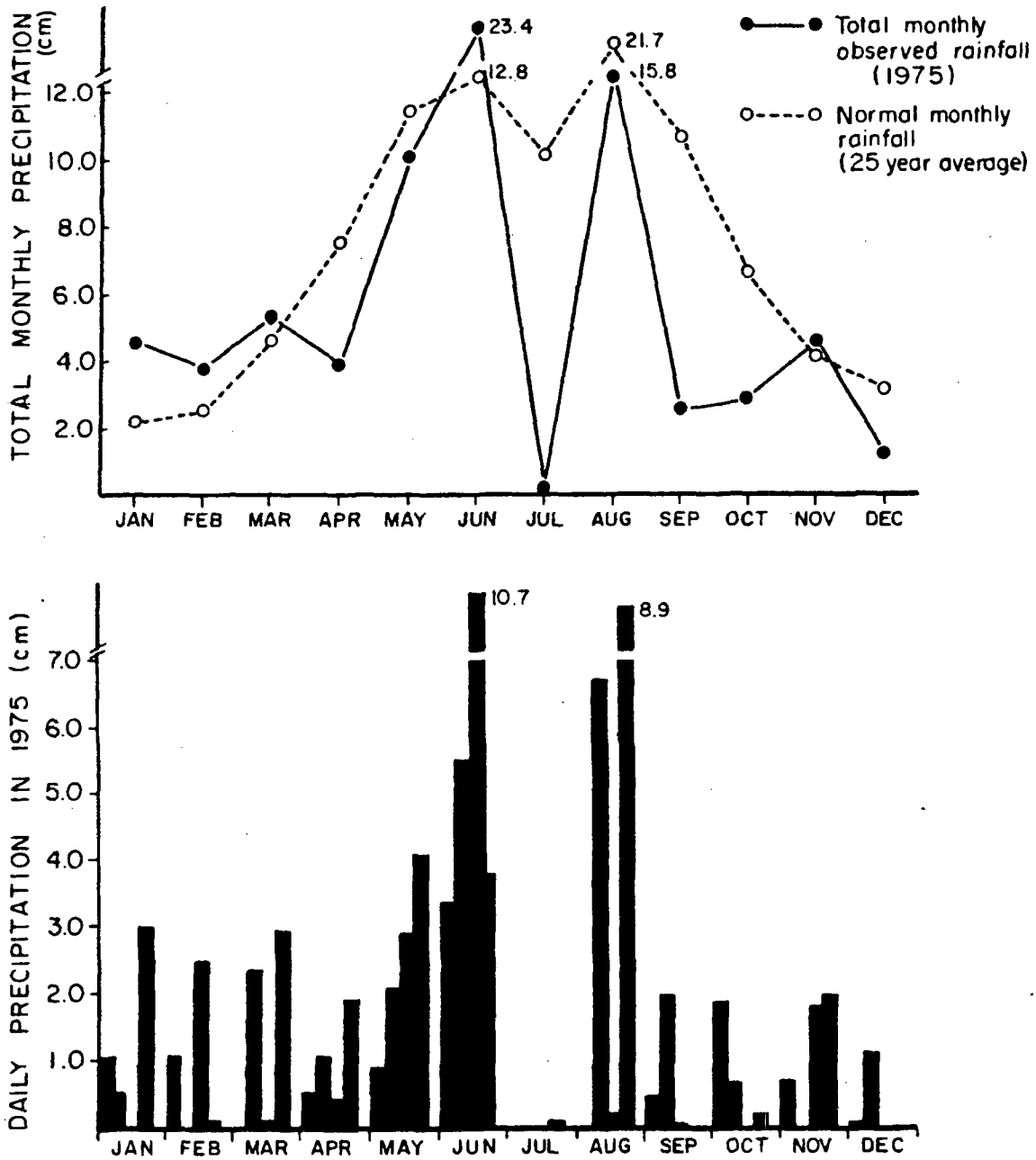

Figure 8.3. Precipitation recorded at the John Redmond Dam, 1975 (U. S. Army, Corps of Engineers 1975).

Table 8.1. Occurrence of macroinvertebrates collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Taxa	John Redmond Reservoir		Neosho River		Wolf Creek	
	Ponar	Qual.	Ponar	Qual.	Ponar	Qual.
Cnidaria						
Hydrozoa						
Hydroidea						
Hydridae						
Hydra sp.			+	+		
Platyhelminthes						
Turbellaria						
Tricladida						
Planaridae						
Dugesia sp.			+	+	+	
Nematoda						
Unidentified Nematoda					+	+
Ectoprocta						
Phylactolaemata						
Plumatellina						
Plumatellidae						
Fredericella sultana		+	+			
Annelida						
Oligochaeta						
Plesiopora						
Enchytraeidae						
Unidentified Enchytraeidae			+		+	
Naididae						
Dero digitata	+		+		+	+
Nais bretscheri				+		
N. elinguis			+		+	+
Tubificidae						
Branchiura sowerbyi	+		+		+	+
Ilyodrilus templetoni	+		+		+	
Limnodrilus cervix	+				+	+
L. claparedianus	+				+	
L. hoffmeisteri	+		+		+	+
L. spiralis			+			
L. udekemianus			+		+	
Immature w/cap. chaetae	+		+		+	
Immature w/o cap. chaetae	+		+		+	+
Prosopora						
Branchiobdellidae						
Branchiobdella americana				+		+
Cambarincola macrodonta					+	
Hirudinea						
Pharyngobdellida						
Erpobdellidae						
Dina sp.	+		+			
D. microstoma				+	+	+
Arthropoda						
Crustacea						
Amphipoda						
Talitridae						
Hyalella azteca		+			+	+
Decapoda						
Astacidae						
Unidentified Astacidae		+		+	+	+
Orconectes sp.					+	+
O. nais		+				+
Arachnida						
Araneae						
Unidentified Araneae					+	
Acarina						
Unidentified Hydracarina					+	
Insecta						
Ephemeroptera						
Ephemeridae						
Ephoron album			+	+		
Hexagenia sp.					+	
H. limbata	+		+	+	+	+
Pentagenia sp.			+			
Potamanthus sp.			+	+		
Caenidae						
Caenis sp.			+	+	+	+
Tricorythodes sp.		+	+	+	+	

Table 8.1. Continued.

Taxa	John Redmond Reservoir		Neosho River		Wolf Creek	
	Ponar	Qual.	Ponar	Qual.	Ponar	Qual.
Heptageniidae						
Stenonema sp.			+		+	+
S. bipunctatum			+		+	
S. femoratum			+			+
S. heterotarsale						+
S. interpunctatum				+		
S. scitulum						+
S. tripunctatum		+		+	+	+
Baetidae						
Unidentified Baetidae						+
Baetis sp.						+
Isonychia sp.				+		
Odonata						
Coenagrionidae						
Argia sp.		+		+		+
Gomphidae						
Gomphus sp.				+		
Libellulidae						
Macromia sp.						+
Plecoptera						
Nemouridae						
Brachyptera fasciata						+
Perlodidae						
Isoperla sp.	+		+		+	
Perlidae						
Unidentified Perlidae						+
Neoperla clymene						+
Perlesta placida						+
Hemiptera						
Corixidae						
Unidentified Corixidae		+	+	+	+	
Gerridae						
Gerris remigis				+		+
Rheumatobates sp.				+		
Trepobates sp.				+		
Belostomatidae						
Belostoma sp.						+
Megaloptera						
Sialidae						
Sialis sp.						+
Trichoptera						
Rhyacophilidae						
Rhyacophila lobifera			+			+
Psychomyiidae						
Cyrnellus sp.				+		
Hydropsychidae						
Unidentified Hydropsychidae			+	+		
Cheumatopsyche sp.			+	+	+	+
Hydropsyche sp.			+			
H. frisoni			+	+		
H. orris			+	+	+	+
H. simulans			+	+	+	
Potamyia flava			+	+	+	+
Hydroptilidae						
Agraylea sp.						+
Leptoceridae						
Leptocella sp.				+		
Oecetis sp.			+		+	
O. avara			+			
Coleoptera						
Dytiscidae						
Unidentified Dytiscidae						+
Noteridae						
Unidentified Noteridae						+
Hydrophilidae						
Laccobius sp.						+
Gyrinidae						
Dineutus sp.				+		+
Gyrinus sp.						+
Elmidae						
Dubiraphia sp.			+		+	

Table 8.1. Continued.

Taxa	John Redmond Reservoir		Neosho River		Wolf Creek	
	Ponar	Qual.	Ponar	Qual.	Ponar	Qual.
Stenelmis sp.			+	+	+	+
Diptera						
Psychodidae						
Psychoda sp.					+	
Chaoboridae						
Chaoborus punctipennis	+				+	+
Simuliidae						
Unidentified Simuliidae			+	+	+	+
Chironomidae						
Ablabesmyia (*A.*) *janta*				+		
A. (*A.*) *mallochi*					+	
A. (*A.*) *monilis*	+					
Cardiocladius sp.					+	
Chironomus sp.	+		+		+	+
C. (*ss*) *p.* var. *ferrugineovittatus*	+					
C. (*ss*) *tentans*					+	
Cladotanytarsus sp.			+			
Clinotanypus (*ss*) *pinguis*					+	
Coelotanypus concinnus type	+					
C. scapularis type	+					
C. tricolor type	+					
Cricotopus sp.					+	
Cryptochironomus blarina			+			
C. digitatus			+	+	+	+
C. fulvus			+			
C. ponderosus			+			
Dicrotendipes sp.			+	+	+	+
near *Demicryptochironomus monstrosus*					+	
Endochironomus sp.				+		+
Eukiefferiella sp.						+
E. claripennis					+	
Glyptotendipes sp.					+	
G. (*Phytotendipes*) sp.				+	+	
Kiefferulus dux					+	
Larsia sp.			+		+	
Leptochironomus sp.					+	
Microcricotopus sp.			+		+	+
Micropsectra sp.			+		+	+
Microtendipes sp.		+			+	
M. pedellus type					+	
Orthocladius (*ss*) sp.	+		+		+	+
Parakiefferiella sp.			+		+	+
Parametriocnemus lundbecki					+	
Paratanytarsus sp.			+		+	
Paratendipes sp.			+			
P. albimanus type					+	
Polypedilum (*ss*) *convictum* type	+		+	+	+	+
P. (*ss*) *fallax* group						+
P. (*ss*) *illinoense* type						+
P. (*ss*) *scalaenum* type			+			
P. (*ss*) *simulans* type	+		+	+	+	
Procladius (*ss*) sp.					+	
P. (*Psilotanypus*) sp.	+				+	
Psectrocladius sp.				+		+
Pseudochironomus sp.			+		+	+
Rheotanytarsus sp.			+	+	+	+
Stenochironomus sp.			+	+		
Stictochironomus sp.			+	+	+	+
Tanypus stellatus	+				+	+
Tanytarsus sp.			+		+	+
Thienemanniella sp.			+			
Thienemannimyia Group			+	+	+	+
Trissocladius sp.					+	
Xenochironomus (*A.*) *taenionotus*			+			
Ceratopogonidae						
Unidentified Ceratopogonidae	+		+		+	
Syrphidae						
Tubifera sp.						+
Empididae						
Unidentified Empididae			+		+	
Hemerodromia sp.				+		+

Table 8.1. Continued.

Taxa	John Redmond Reservoir		Neosho River		Wolf Creek	
	Ponar	Qual.	Ponar	Qual.	Ponar	Qual.
Tipulidae						
Unidentified Tipulidae			+	+	+	
Tipula sp.			+		+	
Mollusca						
Gastropoda						
Pulmonata						
Physidae						
Physa sp.				+	+	+
Planorbidae						
Gyraulus parvus					+	
Heliosoma trivolvis					+	+
H. truncata					+	+
Ancylidae						
Ferrissia fragilis					+	
F. rivularis			+	+	+	
Pelecypoda						
Heterodonta						
Spaeriidae						
Sphaerium sp.						+
S. striatinum					+	
S. transversum	+		+		+	+
Eulamellibranchia						
Unionidae						
Unidentified Unionidae			+			
Actinonais carinata				+		
Amblema peruviana				*		
Anodonta grandis			+	+		
Elliptio dilatatus				*		
Fusconaia flava				+		
Lampsilis anodontoides				*		
L. ovata				*		
Leptodea fragilis				+		
Obliqueria reflexa				+		
Pleurobema cordatum tatillus				*		
P. c. pyramidatum				*		
Proptera alata				*		
P. purpurata				*		
Quadrula metanerva				+		
Q. pustulosa				+		
Q. quadrula				+		
Total number of taxa	26	9	72	65	84	68

* Nonliving specimens collected.

Table 8.2. Benthic macroinvertebrate densities (no./m^2) in Ponar grab samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 17 April 1975.

	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
Taxa	1A	1B	10A	10B	4A	4B	7A	7B	2A	2B	3A	3B	5A	5B
Nematoda														
Unidentified Nematoda								38	38	38				
Platyhelminthes														
Turbellaria														
Tricladida														
Planariidae														
Dugesia sp.					19									
Annelida														
Oligochaeta														
Plesiopora														
Enchytraeidae														
Unidentified Enchytraeidae				38	38	151		19		19	94	132		
Naididae														
Nais elingius					19				19		19	38		
Tubificidae														
Branchiura sowerbyi		76	19											
Ilyodrilus templetoni	19	113												
Limnodrilus cervix	76	76						19	19	57				
L. claparedianus	19													
L. hoffmeisteri		170	38		38		94	19		38	397	680	19	38
L. spiralis			19											
L. udekemianus			170								57	19		
Immature w/o cap. chaetae	321	718	113	76	19		38	19		76	151	775	38	
Immature w/cap. chaetae	38	57											19	19
Arthropoda														
Insecta														
Ephemeroptera														
Caenidae														
Caenis sp.												57		
Heptageniidae														
Stenonema femoratum					38									
Plecoptera														
Perlidae														
Unidentified Perlidae									38			19		
Trichoptera														
Rhyacophilidae														
Rhyacophila lobifera					227									
Coleoptera														
Elmidae														
Dubiraphia sp.					19									
Stenelmis sp.													19	
Diptera														
Chaoboridae														

NALCO ENVIRONMENTAL SCIENCES

Table 8.2. Continued.

Taxa	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1A	1B	10A	10B	4A	4B	7A	7B	2A	2B	3A	3B	5A	5B
Chaoborus punctipennis	113	57												
Simuliidae														
Unidentified Simuliidae					19						38	1588	132	2230
Chironomidae														
Ablabesmyia mallochi							19							
Chironomus sp.	113	189	76	19							19			
Coelotanypus concinnus	94	19												
C. scapularis	38	19												
C. tricolor	19	19												
Cricotopus sp.									19	19		19		
Cryptochironomus digitatus					19	38					38	94		
Dicrotendipes sp.											38	76	57	94
Eukiefferiella claripennis										19	113	57		
Larsia sp.								76				19		
Micropsectra sp.							19						19	
Orthocladius (ss) sp.					38	19	265	94	340	718	3402	4630	38	38
Parakiefferiella sp.									19	38	19			
Paratendipes sp.			19											
Paratendipes albimanis							19		76	284				
Polypedilum (ss) "*convictum*" gr.				19	57	19					19			
Procladius (*Psilotanypus*) sp.	113	170												
Pseudochironomus sp.														19
Rheotanytarsus sp.							19							
Stictochironomus sp.			38				19	19						38
Tanytarsus sp.					19		19				19	38		
Thienemannimyia group									19	19	19			
Trissocladius sp.							76		170	94	19	19		
Ceratopoganidae														
Unidentified Ceratopogonidae					19		19				94	76		
Mollusca														
Gastropoda														
Pulmonata														
Physidae														
Physa sp.														19
Pelecypoda														
Heterodonta														
Sphaeriidae														
Sphaerium striatinum							38			19	76	19	19	
Total number/m^2	964	1682	529	151	699	76	643	246	756	1436	4593	6766	227	302
Total number of taxa	10	11	9	4	14	4	12	8	10	13	18	18	8	8

NALCO ENVIRONMENTAL SCIENCES

Table 8.3. Benthic macroinvertebrate densities (no./m^2) in Ponar grab samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 10 June 1975.

	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
Taxa	1A	1B	10A	10B	4A	4B	7A	7B	2A	2B	3A	3B	5A	5B
Cnidaria														
Hydrozoa														
Hydroidea														
Hydridae														
Hydra sp.						19								
Nematoda														
Unidentified Nematoda							19							
Annelida														
Oligochaeta														
Plesiopora														
Enchytraeidae														
Unidentified Enchytraeidae			38			19			19					
Naididae														
Dero digitata									19					
Nais elinguis			57				19							
Tubificidae														
Limnodrilus cervix	38	189						19	38					
L. claparedianus									19					
L. hoffmeisteri		19						19	19			19		
L. udekemianus												132		
Immature w/cap. chaetae	19				19				19			19		
Immature w/o cap. chaetae	227	151					19	340	643	302	76	284		
Hirudinea														
Pharyngobdellida														
Erpobdellidae														
Dina sp.		19												
Arthropoda														
Crustacea														
Amphipoda														
Talitridae														
Hyalella azteca									19					
Decapoda														
Astacidae														
Unidentified Astacidae									19					
Insecta														
Ephemeroptera														
Ephemeridae														
Ephoron album			170		321	605								
Hexagenia limbata		38												
H. rigida	19													

NALCO ENVIRONMENTAL SCIENCES

Table 8.3. Continued.

Taxa	Sampling Locations: John Redmond Reservoir 1A	1B	Neosho River 10A	10B	4A	4B	Wolf Creek 7A	7B	2A	2B	3A	3B	5A	5B
Caenidae														
Caenis sp.			189	151	19	132	19			19				
Tricorythodes sp.			19		57									
Heptageniidae														
Stenonema sp.							19							
Plecoptera														
Perlodidae														
Isoperla sp.			38									19		
Trichoptera														
Hydropsychidae														
Unidentified Hydropsychidae			132											
Cheumatopsyche sp.			454		397	227	189	38						
Hydropsyche orris			57		57	38			19					
H. frisoni			57											
H. simulans			19								94	76		
Potamyia flava			1682		813	794					19			
Coleoptera														
Elmidae														
Stenelmis sp.					19									
Diptera														
Simuliidae														
Unidentified Simuliidae			19	19		38								
Chironomidae														
Ablabesmyia mallochi									19					
Chironomus sp.						19								
C. (ss) p. var. *ferrugineovittatus*		19												
C. (ss) tentans									38					
Coelotanypus concinnus	94	38												
C. scapularis	57													
C. tricolor	151	38												
Cricotopus sp.							19				19			
Cryptochironomus digitatus			76		76	57	38	19				19		
Dicrotendipes sp.						38	94		19					
Glyptotendipes (*Phytotendipes*) sp.									19					
Larsia sp.			38			19								
Microcricotopus sp.			19											
Micropsectra sp.			19											
Microtendipes sp.										38				
M. pedellus							113	94						
Parametriocnemus lundbecki							19							

NALCO ENVIRONMENTAL SCIENCES

Table 8.3. Continued.

Taxa	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1A	1B	10A	10B	4A	4B	7A	7B	2A	2B	3A	3B	5A	5B
Paratanytarsus sp.			151		19	19	38	19	38	19				
Paratendipes nr. *albimanus*											19			
Polypedilum (*ss*) *convictum* type			699		321	94	113			38	19			
P. (*ss*) *acalaenum* type			19		19	19								
P. (*ss*) *simulans* type		19	57			19			19					
Procladius (*Psilotanypus*) sp.	19								19					
Pseudochironomus sp.			227											
Rheotanytarsus sp.			284			19	94							
Stenochironomus sp.			284											
Stictochironomus sp.							94	2230	1833	1984		38		
Tanypus stellatus	1002	813					19							
Thienemanniella sp.			38											
Thienemannimyia group			113				38			19	19			
Ceratopogonidae														
Unidentified Ceratopogonidae		19	19		19			38		19				
Empididae														
Unidentified Empididae			132										19	
Tipulidae														
Unidentified Tipulidae					19									
Mollusca														
Gastropoda														
Pulmonata														
Physidae														
Physa sp.							38							
Planorbidae														
Helisoma truncata							57		19					
Pelecypoda														
Heterodonta														
Sphaeridae														
Sphaerium transversum			19				132	189	208	19				19
Total number/m^2	1625	1361	5122	170	2174	2174	1191	3005	3062	2457	265	605	19	19
Total number of taxa	9	11	29	2	14	17	20	10	20	9	7	8	1	1

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Table 8.4. Benthic macroinvertebrate densities (no./m^2) in Ponar grab samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 9 September 1975.

	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
Taxa	1A	1B	10A	10B	4A	4B	7A	7B	2A	2B	3A	3B	5A	5B
Nematoda														
Unidentified Nematoda													19	
Annelida														
Oligochaeta														
Plesiopora														
Naididae														
Dero digitata		38						38						
Tubificidae														
Branchiura sowebyi	19		38			38					38	265		
Ilyodrilus templetoni	38	38												
Limnodrilus cervix		38						19		19	19	170		
L. hoffmeisteri		38							38					
L. udekemianus									38	19		76	19	19
Immature w/cap. chaetae	38	38					19		38	19	76	529	19	19
Immature w/o cap. chaetae	94	113				19	19		794	794	38	170	208	94
Prosopora														
Branchiobdellidae														
Cambarincola macrodonta							19							
Hirudinea														
Pharyngobdellida														
Erpobdellidae														
Dinn microstoma									19					
Arthropoda														
Crustacea														
Amphipoda														
Talitridae														
Hyalella azteca									19					
Decapoda														
Astacidae														
Unidentified Astacidae							19							
Arachnida														
Araneae														
Unidentified Araneae											19			
Acarina														
Unidentified Hydracarina												38		

NALCO ENVIRONMENTAL SCIENCES

Table 8.4. Continued.

Taxa	Sampling Locations													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1A	1B	10A	10B	4A	4B	7A	7B	2A	2B	3A	3B	5A	5B
Insecta														
Ephemeroptera														
Ephemeridae														
Hexagenia sp.												38		
H. limbata								19						
Potomanthus sp.						57								
Caenidae														
Caenis sp.					19	19		19	38		38	265		
Tricorythodes sp.				19	19	19				19				
Heptageniidae														
Stenonema sp.			19			19								
S. tripunctatum														19
Plecoptera														
Perlodidae														
Isoperla sp.		38							38	19				
Perlidae														
Neoperla clymene			113		227	680								
Hemiptera														
Corixidae														
Unidentified Corixidae									19		19			
Trichoptera														
Hydropsychidae														
Unidentified Hydropsychidae			19		19									
Cheumatopsyche sp.			19		57	94								
Hydropsyche orris						19								
H. frisoni						19								
Potamyia flava			1077	529	321	510				38				
Leptoceridae														
Oecetis sp.											19	19		
O. avara				19										
Coleoptera														
Elmidae														
Dubiraphia sp.											19	94		
Stenelmis sp.				57	57	170								
Diptera														
Chaoboridae														
Chaoborus punctipennis	113	94					19							
Chironomidae														
Cardiocladius sp.														19
Coelotanypus scapularis	94													
C. tricolor	19													
Cryptochironomus digitatus					19				19			94		

NALCO ENVIRONMENTAL SCIENCES

Table 8.4. Continued.

Taxa	Sampling Locations: John Redmond Reservoir 1A	1B	Neosho River 10A	10B	4A	4B	Wolf Creek 7A	7B	2A	2B	3A	3B	5A	5B
Glyptotendipes (*Phytotendipes*) sp.									57					
Larsia sp.									19					
Leptochironomus sp.												151		
Micropsectra sp.					19							19		
Orthocladius (*ss*) sp.	19													
Polypedilum (*ss*) *convictum* type		19												
P. (*ss*) *scalaenum type*				19										
P. (*ss*) *simulans type*									19					
Procladius (*ss*) sp.												19		
P. (*Psilotanypus*) sp.	19											76		
Pseudochironomus sp.						57								
Rheotanytarsus sp.						19				19				
Stictochironomus sp.							19		19			19		
Tanypus stellatus	359	1096					38							
Tanytarsus sp.									57			19		
Ceratopogonidae														
Unidentified Ceratopogonidae									57	38		113		
Mollusca														
Gastropoda														
Pulmonata														
Physidae														
Physa sp.									94	113				
Ancylidae														
Ferrisia fragilis										38	113	38		
Pelecypoda														
Heterodonta														
Sphaeriidae														
Sphaerium transversum									57	19	76	94		
Eulamellibranchia														
Unionidae														
Unidentified Unionidae						19								
Anodonta grandis			19											
Total number/m^2	813	1550	1304	643	756	1758	151	94	1436	1153	472	2325	265	170
Total number of taxa	10	10	7	5	9	15	7	4	18	12	11	21	4	5

NALCO ENVIRONMENTAL SCIENCES

Table 8.5. Benthic macroinvertebrate densities (no./m^2) in Ponar grab samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 3 December 1975.

	Sampling Location													
	John Redmond Reservoir		Neosho River				Wolf Creek							
Taxa	1A	1B	10A	10B	4A	4B	7A	7B	2A	2B	3A	3B	5A	5B
Cnidaria														
Hydrozoa														
Hydroidea														
Hydridae														
Hydra sp.					38	76								
Platyhelminthes														
Turbellaria														
Tricladida														
Planariidae														
Dugesia sp.						19							19	
Nematoda														
Unidentified Nematoda									94	57				
Ectoprocta														
Phylactolaemata														
Plumatellina														
Plumatellidae														
Fredericella sultana						+[a]								
Annelida														
Oligochaeta														
Plesiopora														
Naididae														
Dero digitata						19		76		57				
Nais elinguis			38		38	57		19	38	57				
Tubificidae														
Branchiura sowerbyi	19		19		19	19					340	548		
Ilyodrilus templetoni						19	19							
Limnodrilus cervix									19	94		19		
L. claparedianus										132	57	19		
L. hoffmeisteri			19		19	57		19	19	680		38		
L. udekemianus									76	151	76	19	19	38
Immature w/ cap. chaetae	19	38			76	76	38	38	246	227	19			
Immature w/o cap. chaetae	19	113			38	38	38	170	284	926	227	113	38	284
Prosopora														
Branchiobdellidae														
Cambarincola macrodonta										19				
Hirudinea														
Pharyngodellida														
Erpobdellidae														
Dina sp.						19								
D. microstoma								38	38		19			
Arthropoda														
Crustacea														

NALCO ENVIRONMENTAL SCIENCES

Table 8.5. Continued.

Taxa	Sampling Location													
	John Redmond Reservoir		Neosho River				Wolf Creek							
	1A	1B	10A	10B	4A	4B	7A	7B	2A	2B	3A	3B	5A	5B
Decapoda														
Astacidae														
Orconectes sp.										19				
Insecta														
Ephemeroptera														
Ephemeridae														
Hexagenia limbata	189	189		19										
Pentagenia sp.				19										
Potamanthus sp.						94								
Caenidae														
Caenis sp.						19	19		113	57				
Tricorythodes sp.			19		38	19								
Heptageniidae														
Stenonema sp.			38		38	246								
S. bipunctatum			19										19	
Plecoptera														
Perlodidae														
Isoperla sp.				19		19								
Hemiptera														
Corixidae														
Unidentified Corixidae					19						76	57		
Trichoptera														
Hydropsychidae														
Hydropsyche sp.					19									
H. orris			19	19	57									
Leptoceridae														
Oecetis sp.					19	19								
Coleoptera														
Elmidae														
Stenelmis sp.			57	76	208	38								
Diptera														
Psychodidae														
Psychoda sp.									38	151				
Chaoboridae														
Chaoborus punctipennis	94						19		38			19		
Chironomidae														
Ablabesmyia monilis	38													
Chironomus sp.	378	472	38	57	397	284	19		19		76	38		
Cladotanytarsus sp.						19								
Clinotanypus (ss) *pinguis*										38				
Coelotanypus concinnus	57	38												
C. scapularis	76	57												
C. tricolor	38	38												

NALCO ENVIRONMENTAL SCIENCES

Table 8.5. Continued.

Taxa	Sampling Location: John Redmond Reservoir 1A	1B	Neosho River 10A	10B	4A	4B	Wolf Creek 7A	7B	2A	2B	3A	3B	5A	5B
Cryptochironomus blarina					19	19								
C. fulvus			38			38								
C. ponderosus						57								
Dicrotendipes sp.					76	132			19	38				
near *Demicryptochironomus monstrosus*														19
Glyptotendipes sp.							19							
Kiefferulus dux										19				
Larsia sp.						19								
Orthocladius (*ss*) sp.					19									
Parakiefferiella sp.			19		57	132								
Polypedilum (*ss*) *simulans* type					19									
Procladius (*ss*) sp.											19			
P. (*Psilotanypus*) sp.								151		19	227	19		
Pseudochironomus sp.			57	57	472	624								
Stictochironomus sp.			57	19	302	605								
Tanytarsus sp.					19	19								
Xenochironomus (*Anceus*) *taenionotus*			38	113										
Ceratopogonidae														
Unidentified Ceratopogonidae						19			151	113	38			
Syrphidae														
Tubifera sp.													19	
Tipulidae														
Unidentified Tipulidae				19									19	
Tipula sp.	38								38				38	
Mollusca														
Gastropoda														
Pulmonata														
Physidae														
Physa sp.								208						
Planorbidae														
Gyraulus parvus										19				
Helisoma trivolvis								19						
Ancylidae														
Ferrissia rivularis						57			132	189		38		
Pelecypoda														
Heterodonta														
Sphaeriidae														
Sphaerium transversum	38	57	76	170			19		38	19	151	397	94	
Total number/m^2	983	1002	548	586	2003	2873	189	737	1361	3024	1323	1323	284	321
Total number of taxa	12	3	15	11	22	31	8	9	16	20	12	12	9	2

[a] Present as colonies.

NALCO ENVIRONMENTAL SCIENCES

Table 8.6. Diversity indices calculated from Ponar dredge samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

		Sampling Locations						
		John Redmond Reservoir	Neosho River		Wolf Creek			
Sampling Date	Replicate	1	10	4	7	2	3	5
17 April	A	2.87	2.30	3.05	2.66	2.43	1.57	2.35
	B	2.95	1.50	1.42	2.47	2.27	1.84	0.70
	Mean	2.91	1.90	2.23	2.56	2.35	1.71	1.52
10 June	A	1.45	3.60	2.60	3.83	1.60	2.16	*
	B	1.74	0.50	2.75	1.03	0.61	2.15	*
	Mean	1.60	2.05	2.67	2.43	1.11	2.15	*
9 September	A	2.12	1.04	2.27	2.25	3.79	2.80	*
	B	1.33	0.99	2.54	1.92	2.97	3.73	1.58
	Mean	1.72	1.01	2.41	2.09	3.38	3.27	1.58
3 December	A	2.64	3.75	3.28	2.58	3.44	2.80	2.65
	B	1.87	2.96	3.66	2.23	3.27	2.19	*
	Mean	2.26	3.36	3.47	2.41	3.36	2.50	2.65
1975 Mean		2.12	2.08	2.70	2.37	2.55	2.40	1.82

* Insufficient data.

NALCO ENVIRONMENTAL SCIENCES

Table 8.7. Macroinvertebrates collected qualitatively in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Taxa	April							June							September							December						
	1	10	4	7	2	3	5	1	10	4	7	2	3	5	1	10	4	7	2	3	5	1	10	4	7	2	3	5
Cyndaria																												
Hydrozoa																												
Hydroidea																												
Hydridae																												
Hydra sp.									O[a]															R[b]				
Platyhelminthes																												
Turbellaria																												
Tricladida																												
Planaridae																												
Dugesia sp.									O	R						O	R											
Nematoda																												
Unidentified Nematoda													R															
Ectoprocta																												
Phylactolaemata																												
Plumatellina																												
Plumatellidae																												
Fredericella sultana															R													
Annelida																												
Oligochaeta																												
Plesiopora																												
Naididae																												
Dero digitata											R																	
Nais bretscheri																								R				
N. elinguis				R		R																						
Tubificidae																												
Branchiura sowerbyi													R															
Limnodrilus cervix													R															
L. hoffmeisteri													R															
Immature w/o cap. chaetae													R															
Prosopora																												
Branchiobdellidae																												
Branchiobdella americana						O				R																		
Hirudinea																												
Pharyngobdellida																												
Erpobdellidae																												
Dina (*M.*) *microstoma*												R	R			R												
Arthropoda																												
Crustacea																												
Amphipoda																												
Talitridae																												
Hyallella azteca	R										R																	
Decapoda																												
Astacidae																												
Unidentified Astacidae								R	R	C[c]	O	O	O				R					R				R		
Orconectes sp.						R																						R
O. nais							R	R					R															

NALCO ENVIRONMENTAL SCIENCES

Table 8.7. Continued.

Taxa	April							June							September							December						
	1	10	4	7	2	3	5	1	10	4	7	2	3	5	1	10	4	7	2	3	5	1	10	4	7	2	3	5
Insecta																												
Ephemeroptera																												
Ephemeridae																												
Ephoron album									C																			
Hexagenia limbata									R	R						R		R								R	R	
H. rigida									R	O																		
Potamanthus sp.									O	R																		
Caenidae																												
Caenis sp.						R			C	A[d]						R	R											
Tricorythodes sp.									R	A					R	R	R											
Heptageniidae																												
Unidentified Heptageniidae														R														
Stenonema sp.														R														
S. femoratum							R																					
S. heterotarsale						R	R																					
S. interpunctatum										R														R				
S. scitulum						R																						
S. tripunctatum							R				R	R			O	R	R	R	R					R				
Baetidae																												
Unidentified Baetidae														R														
Baetis sp.												R																
Isonychia sp.									O																			
Odonata																												
Coenagrionidae																												
Argia sp.	R			R	R	R			O	R					R									R				
Gomphidae																												
Gomphus sp.									R	R																		
Libellulidae																												
Macromia sp.																											R	
Plecoptera																												
Nemouridae																												
Brachyptera fasciata							O																					
Perlidae																												
Neoperla clymene										O																		
Perlesta placida											O		O															
Hemiptera																												
Corixidae																												
Unidentified Corixidae								R		C							R											
Gerridae																												
Gerris remigis				O	R	R				R								R	R									
Rheumatobates sp.										R																		
Trepobates sp.										O																		
Belostomatidae																												
Belostoma sp.																		R										
Megaloptera																												
Sialidae																												
Sialis sp.																										R		
Trichoptera																												
Rhyacophilidae																												
Rhyacophila lobifera						O	O																					

NALCO ENVIRONMENTAL SCIENCES

Table 8.7. Continued.

Taxa	April							June							September							December						
	1	10	4	7	2	3	5	1	10	4	7	2	3	5	1	10	4	7	2	3	5	1	10	4	7	2	3	5
Psychomyiidae																												
Cyrnellus sp.																								R				
Hydropsychidae																												
Unidentified Hydropsychidae									A																			
Cheumatopsyche sp.						O			A	C	O	C		R														
Hydropsyche frisoni									O	O						O												
H. orris									A	O			R			A												
H. simulans									R	R																		
Potamyia flava									A	A	R					O												
Hydroptilidae																												
Agraylea sp.												R																
Leptoceridae																												
Leptocella sp.																								R				
Coleoptera																												
Dytiscidae																												
Unidentified Dytiscidae																												R
Noteridae																												
Unidentified Noteridae																											R	
Hydrophilidae																												
Laccobius sp.											R		R															
Gyrinidae																												
Dineutus sp.						R							R	R			C											
Gyrinus sp.				R																								
Elmidae																												
Stenelmis sp.						O				R	R		O	R														
Diptera																												
Chaoboridae																												
Chaoborus punctipennis														R														
Simuliidae																												
Unidentified Simuliidae				O	O	A	C		O	O			O															
Chironomidae																												
Ablabesmyia (*A.*) *janta*																								R				
Chironomus sp.																										R		
Cryptochironomus digitatus													R															
Dicrotendipes sp.							R			R	R													R				
Endochironomus sp.											R													R				
Eukiefferiella sp.						R	R																					
Glyptotendipes (*Phytotendipes*) sp.																								R				
Microcricotopus sp.						R																						
Micropsectra sp.						R																						
Microtendipes sp.								R																				
Orthocladius (*ss*) sp.				O	O	O	R																					
Parakiefferiella sp.						R					R																	
Polypedilum (*ss*) *convictum* type						R			R	O	R	O	R															
P. (*ss*) *fallax* group											R																	
P. (*ss*) *illinoense* type												R																
P. (*ss*) *simulans* type									R																			
Psectrocladius sp.						R																		R				
Pseudochironomus sp.											O		R															
Rheotanytarsus sp.										R	R																	
Stenochironomus sp.																								R				
Stictochironomus sp.										R		O												O				

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Table 8.7. Continued.

Taxa	April 1	April 10	April 4	April 7	April 2	April 3	April 5	June 1	June 10	June 4	June 7	June 2	June 3	June 5	September 1	September 10	September 4	September 7	September 2	September 3	September 5	December 1	December 10	December 4	December 7	December 2	December 3	December 5
Tanypus stellatus													R															
Tanytarsus sp.							R				R			R														
Thienemannimyia group							R							R										R				
Syrphidae																												
Tubifera sp.																										R	R	
Empididae																												
Hemerodromia sp.												R	R	R			R											
Tipulidae																												
Unidentified Tipulidae										R																		
Mollusca																												
Gastropoda																												
Pulmonata																												
Physidae																												
Physa sp.										R	O	O	R					R	R					R	O	O	O	R
Planorbidae																												
Helisoma trivolvis																			R						O	R		
H. truncata											O																	
Ancylidae																												
Ferrissia rivularis										R																		
Pelecypoda																												
Heterodonta																												
Sphaeriidae																												
Sphaerium sp.																		R										
S. transversum											O	O																
Eulamellibranchia																												
Unionidae																												
Actinonaias carinata									R																			
Amblema peruviana									+	e																		
Anodonta grandis																R												
Elliptio dilatatus									+																			
Fusconaia flava									R																			
Lampsilis anodontoides									+																			
L. ovata									+																			
Leptodea fragilis										+																		
Obliqueria reflexa																R												
Pleurobema cordatum catillus										+																		
P. c. pyramidatum										+																		
Proptera alata									+																			
P. purpurata									+																			
Quadrula metanerva									R	+																		
Q. pustulosa									+	R																		
Q. quadrula									R																			

[a] O = Occasional (5-25).
[b] R = Rare (1-4).
[c] C = Common (26-99).
[d] A = Abundant (100 +).
[e] + = Nonliving specimens collected.

NALCO ENVIRONMENTAL SCIENCES

Table 8.8. Numbers of benthic macroinvertebrate taxa in Ponar dredge samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-75.

	John Redmond Reservoir			Neosho River						Wolf Creek											
	1			10			4			7			2			3			5		
Sampling Dates	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975	1973	1974	1975
March/April																					
Tubificidae	3	7	7	-[a]	-	5	-	-	2	-	-	3	5	4	3	5	6	3	-	6	2
Hydropsychidae	0	0	0	-	-	0	-	-	0	-	-	0	0	0	0	0	0	0	-	0	0
Chironomidae	4	4	5	-	-	4	-	-	4	-	-	9	7	10	7	5	8	12	-	2	5
Other	2	2	1	-	-	1	-	-	8	-	-	4	14	7	4	12	12	7	-	1	4
Total	9	13	13	-	-	10	-	-	14	-	-	16	26	21	14	22	26	22	-	9	11
June																					
Tubificidae	3	1	4	-	1	0	-	0	1	-	-	3	5	5	5	7	6	4	-	2	0
Hydropsychidae	0	0	0	-	0	6	-	0	3	-	-	1	2	1	1	0	1	2	-	1	0
Chironomidae	3	3	7	-	1	13	-	1	9	-	-	11	12	4	11	2	7	6	-	2	0
Other	1	4	4	-	2	10	-	5	9	-	-	8	16	6	9	9	4	1	-	2	2
Total	7	8	15	-	4	29	-	6	22	-	-	23	35	16	25	18	18	13	-	7	2
September																					
Tubificidae	1	1	6	-	0	1	4	4	2	-	-	3	4	3	5	3	1	4	-	1	3
Hydropsychidae	0	0	0	-	1	3	0	0	5	-	-	0	0	0	1	0	0	0	-	0	0
Chironomidae	3	3	6	-	2	1	7	2	4	-	-	2	3	4	7	3	0	7	-	0	1
Other	1	5	3	-	7	6	8	1	7	-	-	6	6	5	10	3	2	12	-	0	2
Total	5	9	15	-	10	11	19	7	18	-	-	11	13	12	23	9	3	23	-	1	6
December																					
Tubificidae	4	4	3	-	1	2		6	5	-	-	4	4	7	6	2	4	6	-	3	2
Hydropsychidae	0	0	0	-	2	1	3	1	3	-	-	0	1	0	0	1	1	0	-	0	0
Chironomidae	6	7	5	-	3	6	4	7	13	-	-	3	6	8	5	3	15	3	-	4	1
Other	3	5	4	-	6	10	2	5	15	-	-	8	11	7	14	6	14	7	-	4	6
Total	13	16	12	-	12	19	9	19	36	-	-	15	22	22	25	12	34	16	-	11	9

[a] Not sampled.

NALCO ENVIRONMENTAL SCIENCES

Chapter 9

FISHERIES STUDY

By

Donald C. Szmania

I. Introduction

Baseline information of the Neosho River basin fishery near the proposed Wolf Creek Generating Station (WCGS) was obtained during 1973 and 1974 (Kansas Gas and Electric Company 1974; Szmania and Johnson 1975). This report contains the results of investigations conducted in 1975 to provide additional preconstruction data on the area which may be affected by construction and operation of WCGS. Specific objectives of the study were to obtain information regarding:

1. Species composition, relative abundance, and seasonal distribution of fish inhabiting John Redmond Reservoir, the Neosho River, and Wolf Creek near the proposed site of WCGS;

2. The food habits and age distribution of selected species; and

3. The occurrence and identification of larval fish in John Redmond Reservoir and immediately downstream of the dam near the proposed WCGS make-up water intake structure.

II. Field and Analytical Procedures

A. Sampling Locations

Four locations were utilized for fish sampling within the three water systems (Figure 9.1):

1. John Redmond Reservoir (Location 1) was sampled near the boat launch and off the dam face. Current in both areas was negligible and the bottom was composed primarily of ooze with occasional rock and gravel deposits near shore. Maximum depth was approximately 3 m.

2. The Neosho River was sampled at a location approximately one mile downstream from its confluence with Wolf Creek (Location 4). The sampling area included a shallow gravel bar and deep holes.

3. Locations 2 and 3 were located in Wolf Creek, a shallow intermittent stream characterized by pool and riffle areas. When stream flow was discontinuous, sampling was conducted in stagnant pools. The bottom substrate consisted of gravel with occasional deposits of silt and clay. Water depth was usually less than 1 m.

B. Sampling Methods

Fish samples were collected once per month during April, June, September, and December 1975 by the following methods:

1. Seining

A seine, 15 ft long and 6 ft deep with 0.25 in Ace mesh, was used to collect forage-size fish from the shallow areas at all locations. A sample consisted of two to four hauls at each location. Samples were preserved in 10% formalin and analyzed in the laboratory.

2. Gill Netting

Two experimental mesh monofilament gill nets were employed at the deeper areas of Location 1. Each net consisted of a 90 ft x 6 ft panel of 2 in stretch mesh and a 180 ft x 6 ft panel of 4 in stretch mesh. During each sampling period one net was set near the dam face and another near the boat launch, northwest of the dam. Nets were set perpendicular to the shoreline in 2-3 m of water with the small mesh nearest the shore. An overnight sampling effort of approximately 12-14 hr was expended during each sampling period.

3. Hoop Netting

Hoop nets were used to collect fish from Location 4. Two hoop nets of 1 in square mesh, 8 ft long by 2.5 ft in diameter with 6 ft wings, were set overnight during each sampling period. Sampling effort averaged 18 hr per set.

4. Larval Fish Sampling

Larval fish were sampled in John Redmond Reservoir (Location 1) and below the dam (Location 1P) during April and June 1975. Two 0.5 m diameter, no. 0 mesh Nitex plankton nets were towed simultaneously for 3 min at the water surface. Each net was equipped with a General Oceanics flow meter (Model 2030) and the volume of water sampled by each net was computed. Samples were preserved separately in 10% formalin and analyzed in the laboratory.

C. Data Collections

Fish collected by gill netting and hoop netting were identified, measured (total length in mm), and weighed (g) in the field. Forage-size fish collected by seining were identified and measured in the laboratory. Fish identifications were made with the aid of keys by Eddy (1953), Cross (1967), and Pfleiger (1971). Larval fish were identified to the lowest positive taxonomic level using Fish (1932), Mansueti and Hardy (1967), and May and Gasaway (1967). Larval fish densities were expressed as the number of larvae per cubic meter (no./m^3).

Stomach samples were obtained from selected game fish and preserved in 95% ethanol for laboratory analyses. The contents of each stomach were examined using appropriate microscopic techniques. Food items were identified to the lowest positive taxonomic level, enumerated, and measured to the nearest 0.1 ml by water displacement. The following taxonomic keys were used to identify food organisms: Burks (1953), Pennak (1953), Needham and Needham (1962), Hilsenhoff (1970), and Usinger (1971).

Scale samples were collected from selected game fish, impressed on cellulose acetate slides, and examined with the aid of a slide microprojector. Age was determined for individual fish and mean lengths were calculated for each age group represented.

Water temperatures were recorded in conjunction with each fish collection using a Whitney TC-5A thermometer.

III. Results and Discussion

A. Physical Parameters

In general, surface water temperatures were similar among all locations during each sampling period in 1975 (Table 9.1). Water temperatures ranged from 2.2C (35.9F) in Wolf Creek on 3 December to 26.2C (79.2F) in the Neosho River on 10 June.

Water levels were similar at John Redmond Reservoir during three of the sampling periods. The reservoir level was higher in June than during April, September, and December (Figure 9.2). The flow rate and water level of the Neosho River were primarily dependent upon outflow from the reservoir (Figure 9.2). Moderate flow was observed during the April sampling period; consequently, the gravel bar habitat at Location 4 was inundated. The river level was low on 10 June, exposing the gravel bar. River flow was minimal from mid-July through December (Figure 9.2). Wolf Creek exhibited lotic characteristics (pool and riffle habitats) in April and June, whereas in September and December flow ceased, resulting in a series of isolated pools. Water levels were generally lower than during previous studies (Kansas Gas and Electric Company 1974; Szmania and Johnson 1975).

B. Species Composition and Relative Abundance

1. General

Scientific and common names of fish collected during the 1975 and previous studies (1973-74) are listed according to Bailey (1970) in Table 9.2.

Total catch during 1975 consisted of 2608 individuals representing 30 species. Seining was the most successful method in terms of numbers collected. Total catch was numerically dominated by red shiner. Ghost shiner and mosquitofish were also abundant in the seine collections. Larger individuals of commercial and game species were taken in limited numbers by gill netting and hoop netting. Adult gizzard shad, river carpsucker, channel catfish, white bass, and freshwater drum were the predominant species collected in terms of biomass. No endemic or endangered species were collected during the 1975 study.

A total of 40 species has been collected in the study area since 1973 (Table 9.2) with species composition being similar each year. The slenderhead darter was collected for the first time during the 1975 study. Redfin shiner, golden redhorse, flathead catfish, brook silversides, spotted bass, orangethroat darter, bluntnose darter, and walleye were collected in 1973 and/or 1974 but not during 1975. The red shiner was the predominant species collected during each study.

2. John Redmond Reservoir

a. Seining

Results of seine collections are presented in Appendix F, Tables F.1-F.4.

A total of 89 individuals of 11 species was collected from the reservoir by seining (Table 9.3). Ghost shiner and red shiner were the predominant species collected and comprised 39 and 23% of the total catch, respectively. Both species are considered very abundant in the Neosho River drainage (Cross 1967). Young-of-the-year (YOY) carpsucker (Carpiodes sp.) and white bass were collected by seining during the June sampling period.

Although fewer fish were collected during 1975 than in previous years, the number of species collected was similar among years. No fish were collected by seining during September 1975. Young-of-the-year gizzard shad were abundant during the previous two years, but were not present in the 1975 collections. Numbers of YOY white bass and bluegill also diminished in the 1975 collections. Fewer juvenile fish in the 1975 collection may indicate reduced spawning success of several species, or that the young of these species were not accessible to seining.

b. Gill Netting

Results of gill net collections are presented in Appendix F, Table F.5.

Total catch by gill netting consisted of 110 individuals of 8 species (Table 9.3). River carpsucker and freshwater drum were the predominant species collected, whereas adult gizzard shad, channel catfish, and white bass were common.

The number of species collected by gill netting remained similar from 1973-75 (Table 9.3). The flathead catfish was collected in previous studies but was not found in 1975. Although total catch in 1975 was greater than that of the two previous years, the greater success was due in part to the increase in effort from one to two gill net sets. Freshwater drum exhibited the greatest increase in total catch. Forty percent of the freshwater drum collected were yearlings, indicating that the reservoir may have produced a strong year class in 1974. The number of white crappie, although collected during all three years, decreased during 1975.

3. Neosho River

a. Seining

A total of 1920 individuals of 16 species was collected by seining at Location 4 (Table 9.4). Channel catfish, largemouth bass, and slenderhead darter were collected for the first time at this location. Red shiner dominated the collections and comprised 81% of the total catch, whereas mosquitofish, ghost shiner, and slim minnow were common. The abundance of the red shiner in 1975 was primariy due to the preponderance of juvenile individuals (based on length-frequency) in the September and December collections (Appendix F, Tables F.3 and F.4). Similar results were also reported in 1974 (Szmania and Johnson 1975). Cross and Collins (1975) stated that the red shiner is a prolific and ubiquitous species and that its populations frequently consist of mainly one-year-old individuals. Mosquitofish were most abundant in September of 1974 and 1975. Cross (1967) reported that in the spring this

species is scarce due to high winter mortality, but it rapidly becomes abundant in autumn after producing several successive generations. The ghost shiner and slim minnow are both considered common in the Neosho River (Deacon 1961) and were routinely collected during 1975.

Young-of-the-year white bass and freshwater drum were present in June. Limited numbers of juvenile carpsucker, buffalo, channel catfish, bluegill, longear sunfish, orangespotted sunfish, and largemouth bass were also taken during 1975.

The greater total catch during 1975 over the two previous years was primarily due to the increased catch of red shiner in December. Other species which increased in total numbers were ghost shiner, slim minnow, and mosquitofish. Reduced river flow and stable water levels during 1975 provided more favorable seining conditions than in either of the previous yeras. During 1973, fewer fish and fewer species were collected than in 1974 or 1975 with the predominant species being the bullhead minnow, red shiner, and ghost shiner. Species composition and relative abundance were generally similar during 1974 and 1975 with the red shiner, ghost shiner, and mosquitofish being predominant during each study period. The changes in species composition after 1973 probably can be attributed to the relocation of the seining site from a steep muddy bank to a gravel bar in 1974.

b. Hoop Netting

The total hoop netting catch in 1975 consisted of 10 individuals of four species (Table 9.4). White crappie accounted for over half of the total catch. The channel catfish was collected for the first time by this method. Total catch and species composition were similar among years.

4. Wolf Creek

A total of 482 individuals of 18 species was collected by seining in Wolf Creek (Table 9.5). Fish that were collected primarily consisted of small forage species (minnows and juvenile centrarchids). Species composition at Locations 2 and 3 was similar. The red shiner was numerically dominant at both locations while green sunfish, blackstripe topminnow, and oragnespotted sunfish were common. Four species were collected at Location 2 and six species at Location 3.

The rosyface shiner was collected exclusively at Location 2 during 1974 and 1975 (Table 9.5). Deacon (1961) reported that the rosyface shiner is found in tributary streams of the Neosho River but rarely in the mainstream.

Species collected during the two previous years but not during 1975 included carp, redfin shiner, fathead minnow, bullhead minnow, golden redhorse, shorthead redhorse, channel catfish, mosquitofish, bluntnose darter, and orangethroat darter. Total catch and number of species were similar between years even though drought conditions were prevalent in the Wolf Creek area during the September and December sampling periods; discontinuous flow reduced the aquatic habitat to a few isolated pools at Locations 2 and 3. Red shiner

was the predominant species during each year. Cross and Collins (1975) stated that red shiners are abundant especially where conditions are unstable due to irregular flow or high turbidity.

C. Age Analyses

A total of 50 individuals (represented by white crappie, white bass, and freshwater drum) was aged by scale analysis (Table 9.6). White bass from John Redmond Reservoir were represented by Age Groups 0, II, III, and IV with Age Group III being predominant. Yearlings (Age Group I) were predominant among the white crappie and freshwater drum. Freshwater drum were represented by Age Groups I through VI.

The mean total lengths of various age groups of white bass from John Redmond Reservoir were similar to white bass from Arkansas and Oklahoma reservoirs (Ruelle 1971). Szmania and Johnson (1975) reported white bass from the 1972 year class (Age Group II in 1974 study and Age Group III in the present study) were predominant, indicating that it was a dominant year class for this species. Several age groups of freshwater drum from the reservoir exhibited greater mean lengths than drum from Lewis and Clark Lake, Nebraska and South Dakota (Swedberg 1968). Mean lengths of white bass and freshwater drum were generally similar between the 1974 (Szmania and Johnson 1975) and 1975 studies.

Data from the Neosho River and Wolf Creek were too limited for meaningful comparisons.

D. Food Habits

Detailed results of monthly stomach analyses are presented in Appendix F, Table F.6. The number of stomach samples was limited; consequently, only general food habits could be determined. Channel catfish, white bass, and white crappie from John Redmond Reservoir were primarily piscivorous (Table 9.7). Catfish also consumed crayfish and terrestrial insects. Freshwater drum utilized both fish and aquatic insects as major food items.

Although the data were limited from Wolf Creek and Neosho River, the food habits of selected species were similar to those species in the reservoir.

E. Larval Fish

There were no fish eggs or larvae collected from the reservoir (Location 1) or from below the dam (Location 1P) on 17 April 1975. On 9 June the densities of larval gizzard shad and minnows (Cyprinidae) were 0.43 and $0.01/m^3$, respectively, in the reservoir samples, whereas none were collected at Location 1P (Table 9.8). The absence of larvae below the dam in June may have been due to the minimal flow which existed in the tailwaters.

Gizzard shad comprised 96% of the total number of larvae collected from the reservoir during each year, but were most abundant on 10 June 1974 when its density was $21.11/m^3$ (Szmania and Johnson 1975). Fish larvae collected during June 1974 but not during the present study included carpsuckers (Catostomidae) and freshwater drum.

IV. Summary and Conclusions

1. A total of 2608 individuals representing 30 species was collected during 1975. No endemic or endangered species were found.

2. Total seining catch in John Redmond Reservoir was smaller in 1975 than in 1973 or 1974. The absence of YOY gizzard shad and reduced frequency of juvenile white bass and bluegill in 1975 collections may indicate reduced spawning success or that young fish were using rearing areas other than those seined in the reservoir.

3. The gill netting catch from the reservoir increased during 1975, primarily due to increased sampling effort. However, relative abundance of freshwater drum increased and white crappie decreased from 1974.

4. Reduced flow and stable water levels in the Neosho River during 1975 created conditions that were more favorable for seining than in 1973 or 1974. Channel catfish, largemouth bass, and slenderhead darter were collected from the river for the first time.

5. The total hoop net catch from the river during 1975 included 10 fish representing four species. The abundance and composition of fish collected were similar to previous studies.

6. Seining in Wolf Creek yielded a total catch and species composition similar between locations and to previous years despite the intermittent flow during 1975. Red shiner, green sunfish, blackstripe topminnow, and orange-spotted sunfish were prevalent in the collections of small forage species.

7. A total of 50 individuals representing three species was aged by scale analysis during 1975. As in 1974, white bass from John Redmond Reservoir exhibited good growth and the 1972 year class was predominant. The growth rate of freshwater drum from the reservoir and river compared favorably with that of Lewis and Clark Lake, Nebraska and South Dakota. Data on growth rates of fish collected in Wolf Creek were insufficient for meaningful comparisons.

8. Limited stomach analysis data from the reservoir suggest that channel catfish, white bass, and white crappie were piscivorous, whereas freshwater drum fed on both fish and aquatic insects.

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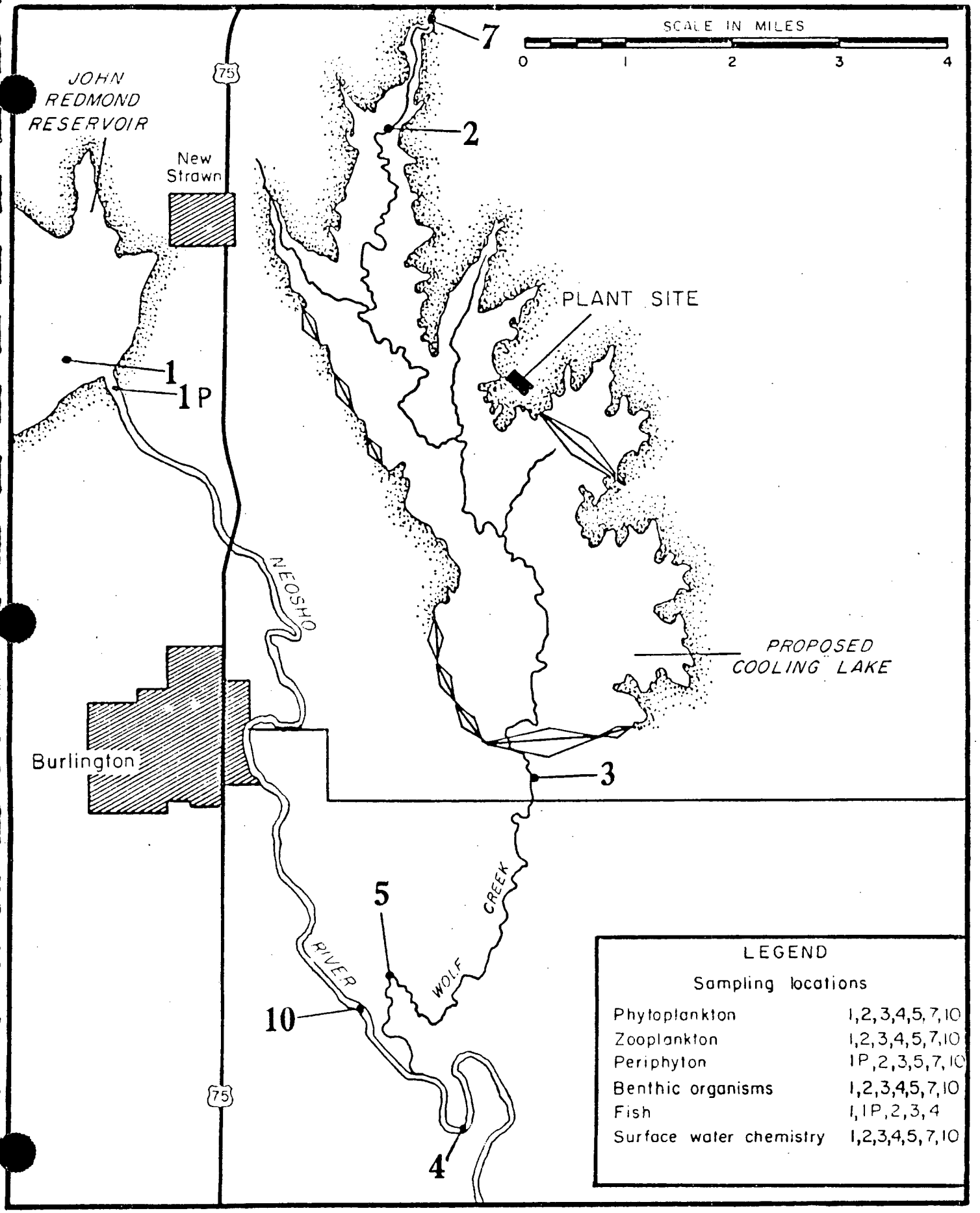

Figure 9.1. Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

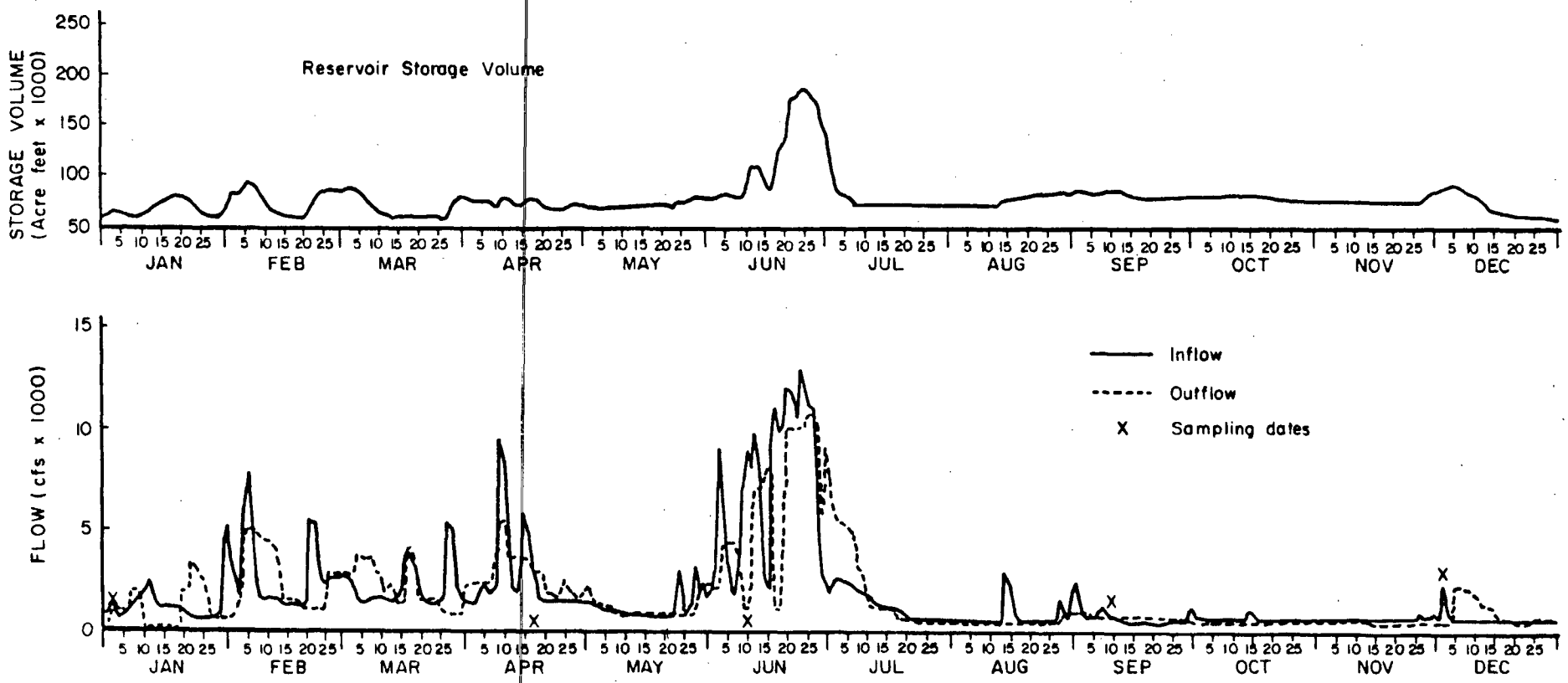

Figure 9.2. Hydrological conditions including reservoir storage volume, reservoi inflow and outflow for John Redmond Reservoir, 1975 (U. S. Army, Corps of Engineers 1975).

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Table 9.1. Water temperatures (°C) recorded at each sampling location in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975.

Sampling Location	Sampling Period			
	17 April	10 June	8 September	3 December
1 Surface	12.3	23.5	23.9	2.7
Bottom	12.2	23.3	23.9	2.8
2	12.3	19.8	18.5	2.5
3	13.5	20.1	20.0	2.2
4	12.1	21.2	26.2	2.8

Table 9.2. Checklist of fish species collected by all sampling methods in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-75.

Family and Scientific Name	Common Name	Year Collected 1973	1974	1975
Lepisosteidae (gars)				
Lepisosteus platostomus	Shortnose gar	X		X
Clupeidae (herrings)				
Dorosoma cepedianum	Gizzard shad	X	X	X
Cyprinidae (carps and minnows)				
Campostoma anomalum	Stoneroller	X		X
Cyprinus carpio	Carp	X	X	X
Notemigonus crysoleucas	Golden shiner	X	X	X
Notropis buchanani	Ghost shiner	X	X	X
Notropis lutrensis	Red shiner	X	X	X
Notropis rubellus	Rosyface shiner		X	X
Notropis stramineus	Sand shiner		X	X
Notropis umbratilis	Redfin shiner		X	X
Phenacobius mirabilis	Suckermouth minnow	X	X	X
Pimephales notatus	Bluntnose minnow	X	X	X
Pimephales promelas	Fathead minnow	X	X	
Pimephales tenellus	Slim minnow		X	X
Pimephales vigilax	Bullhead minnow	X	X	X
Catostomidae (suckers)				
Carpiodes sp.	YOY[a] carpsucker			X
Carpiodes carpio	River carpsucker	X	X	X
Ictiobus sp.	YOY Buffalo			X
Ictiobus bubalus	Smallmouth buffalo	X	X	X
Moxostoma erythrurum	Golden redhorse	X		
Moxostoma macrolepidotum	Shorthead redhorse	X		X
Ictaluridae (freshwater catfishes)				
Ictalurus melas	Black bullhead	X	X	X
Ictalurus natalis	Yellow bullhead		X	X
Ictalurus punctatus	Channel catfish	X	X	X
Pylodictis olivaris	Flathead catfish	X		
Cyprinodontidae (topminnows)				
Fundulus notatus	Blackstripe topminnow	X	X	X
Poeciliidae (livebearers)				
Gambusia affinis	Mosquitofish		X	X
Atherinidae (silversides)				
Labidesthes sicculus	Brook silversides		X	
Percichthyidae (temperate basses)				
Morone chrysops	White bass	X	X	X

Table 9.2. Continued.

Family and Scientific Name	Common Name	Year Collected 1973	1974	1975
Centrarchidae (sunfishes)				
Lepomis cyanellus	Green sunfish	X	X	X
Lepomis humilis	Orangespotted sunfish	X	X	X
Lepomis macrochirus	Bluegill	X	X	X
Lepomis megalotis	Longear sunfish		X	X
Micropterus punctulatus	Spotted bass	X		
Micropterus salmoides	Largemouth bass	X	X	X
Pomoxis annularis	White crappie	X	X	X
Percidae (perches)				
Etheostoma chlorosomum[b]	Orangethroat darter		X	
Etheostoma spectabile	Bluntnose darter	X		
Percina caprodes	Logperch	X	X	X
Percina phoxocephala	Slenderhead darter			X
Stizostedion vitreum	Walleye	X		
Sciaenidae (drums)				
Aplodinotus grunniens	Freshwater drum	X	X	X
Total no. of species		30	31	31
Accumulated total no. of species		30	39	40

[a] Young-of-the-year.

[b] Bluntnose darter (*Etheostoma chlorosomum*) formerly identified as johnny darter (*E. nigrum*) by Kansas Gas and Electric Company (1974).

Table 9.3. Total numbers of fish collected by seining and gill netting in John Redmond Reservoir (Location 1) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-75.

Species	Seining			Gill Netting		
	1973	1974	1975	1973[a]	1974[a]	1975[b]
Gizzard shad	51	500	0	3	13	19
Carp	2	0	0	2	5	4
Golden shiner	2	0	0	0	0	0
Ghost shiner	74	62	35	0	0	0
Red shiner	75	27	21	0	0	0
Fathead minnow	1	0	0	0	0	0
Slim minnow	0	6	1	0	0	0
Bullhead minnow	10	1	3	0	0	0
River carpsucker	8	0	1	15	5	34
Carpiodes sp.	0	0	14	0	0	0
Smallmouth buffalo	0	0	0	3	0	6
Channel catfish	1	3	0	12	4	11
Flathead catfish	0	0	0	1	0	0
Mosquitofish	0	0	2	0	0	0
Brook silverside	0	3	0	0	0	0
White bass	73	9	1	3	7	10
Green sunfish	0	3	0	0	0	0
Orangespotted sunfish	1	1	2	0	0	0
Bluegill	0	35	0	0	0	0
White crappie	16	0	8	4	5	1
Slenderhead darter	0	0	1	0	0	0
Walleye	2	0	0	0	0	0
Freshwater drum	0	2	0	7	3	25
Total no. of species	13	12	11	9	7	8
Total no. of fish	316	652	89	50	46	110

[a] Total catch from one gill net.
[b] Total catch from two gill nets.

Table 9.4. Total numbers of fish collected by seining and hoop netting in the Neosho River (Location 4) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-75.

Species	Seining			Hoop Netting		
	1973	1974	1975	1973	1974	1975
Shortnose gar	0	0	0	2	0	1
Gizzard shad	0	0	3	2	7	0
Carp	0	0	0	1	0	0
Golden shiner	1	0	0	0	0	0
Ghost shiner	35	21	100	0	0	0
Red shiner	42	910	1558	0	0	0
Sand shiner	0	2	1	0	0	0
Redfin shiner	0	6	0	0	0	0
Bluntnose minnow	0	2	3	0	0	0
Slim minnow	0	7	64	0	0	0
Bullhead minnow	92	2	14	0	0	0
Carpiodes sp.	0	0	1	0	0	0
River carpsucker	1	0	0	0	1	0
Ictiobus sp.	0	0	6	0	0	0
Smallmouth buffalo	0	0	0	3	1	0
Black bullhead	0	0	0	0	1	0
Channel catfish	0	0	5	0	0	2
Blackstripe topminnow	0	1	0	0	0	0
Mosquitofish	0	24	108	0	0	0
White bass	5	5	12	0	0	0
Green sunfish	2	0	0	0	0	0
Orangespotted sunfish	10	2	2	0	0	0
Bluegill	0	2	1	0	0	0
Longear sunfish	0	1	2	0	0	0
Spotted bass	1	0	0	0	0	0
Largemouth bass	0	0	2	0	0	0
White crappie	15	4	0	3	0	6
Slenderhead darter	0	0	2	0	0	0
Freshwater drum	3	1	36	0	2	1
Total no. of species	11	15	16	5	5	4
Total no. of fish	207	990	1920	11	12	10

Table 9.5. Total numbers of fish collected by seining at sampling locations on Wolf Creek in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-75.

Species	Location 2			Location 3		
	1973	1974	1975	1973	1974	1975
Stoneroller	1	0	5	1	0	0
Carp	0	0	0	1	0	0
Golden shiner	32	7	2	17	0	2
Red shiner	142	85	148	186	91	161
Rosyface shiner	0	2	1	0	0	0
Redfin shiner	0	3	0	0	0	0
Sand shiner	0	0	0	0	0	2
Suckermouth minnow	5	2	0	2	0	3
Bluntnose minnow	0	6	10	10	3	10
Fathead minnow	14	1	0	5	0	0
Bullhead minnow	0	0	0	4	0	0
River carpsucker	0	0	0	3	0	1
Smallmouth buffalo	0	0	1	2	0	0
Golden redhorse	0	0	0	1	0	0
Shorthead redhorse	0	0	0	1	0	0
Black bullhead	35	0	0	13	5	3
Yellow bullhead	0	0	0	0	1	2
Channel catfish	0	0	0	1	0	0
Blackstripe topminnow	3	4	11	25	8	24
Mosquitofish	0	0	0	0	2	0
Green sunfish	6	5	19	25	4	35
Orangespotted sunfish	14	0	11	14	0	17
Bluegill	0	1	2	5	0	3
Largemouth bass	1	1	0	1	0	3
White crappie	2	1	1	2	0	2
Bluntnose darter	1	0	0	0	0	0
Orangethroat darter	0	0	0	0	2	0
Logperch	1	0	3	0	1	0
Total no. of species	13	12	11	20	9	14
Total no. of fish	257	118	214	319	117	268

Table 9.6. Age and size distribution of selected species of fish collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, April-December 1975.

Sampling Location	Species	Age Group	Mean Total Length (mm) April	June	September	December	Total Number	Range in Total Length (mm)
1 (John Redmond Reservoir)	White bass	0	-[a]	46	-	-	1	-
		II	-	340(1)[b]	-	-	1	-
		III	-	329(4)	-	350(1)	5	295-350
		IV	-	435(1)	353(2)	-	3	330-435
	White crappie	I	99(7)	-	90(1)	-	8	85-112
		II	169(1)	-	-	-	1	168
		III	305(1)	-	-	-	1	-
	Freshwater drum	I	170(2)	-	150(7)	-	9	120-190
		II	-	180(4)	-	-	4	-
		III	-	313(2)	-	-	2	305-320
		IV	-	311(3)	310(3)	-	6	-
		V	-	410(2)	-	-	2	390-430
		VI	-	-	400(1)	-	1	-
3 (Wolf Creek)	White crappie	V	-	240(1)	-	-	1	-
4 (Neosho River)	White crappie	I	-	-	-	210(1)	1	-
		II	235(2)	-	205(1)	250(2)	5	200-270
	Freshwater drum	II	-	-	215(1)	-	1	-

[a] None collected or not applicable.
[b] Number of individuals (n).

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Table 9.7. Relative importance of food items in the stomachs of selected fish collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, April-December 1975.

Sampling Location	Species	Food Items	Percent of Total Volume Consumed			
			April	June	September	December
1 (John Redmond Reservoir)	Channel catfish (5)[a]		(0)	(3)	(1)	(1)
		Fish	-	95	0	91
		Crayfish	-	0	0	9
		Terrestrial insects	-	5	0	0
		Aquatic insects	-	0	Tr[b]	0
		Unrecognizable	-	0	Tr	0
	White bass (5)		(0)	(3)	(1)	(1)
		Fish	-	99	100	100
		Aquatic insects	-	1	0	0
	White crappie (3)		(1)	(1)	(0)	(1)
		Fish	100	100	-	100
		Aquatic insects	0	Tr	-	0
	Freshwater drum (10)		(0)	(7)	(3)	(0)
		Fish	-	64	0	-
		Aquatic insects	-	36	100	-
3 (Wolf Creek)	White crappie (1)		(0)	(1)	(0)	(0)
		Fish	-	100	-	-
4 (Neosho River)	Channel catfish (1)		(0)	(0)	(0)	(1)
		Aquatic insects	-	-	-	100
	White crappie (4)		(1)	(0)	(0)	(3)
		Fish	100	-	-	67
		Aquatic insects	0	-	-	33

[a] Number of stomachs containing food.
[b] Trace.

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Table 9.8. Larval fish collected from John Redmond Reservoir in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 9 June 1975.

Sampling Location	Taxa Collected	No. of Individuals	Density No./m^3	Total Length (mm)	
				Mean	Range
1	Gizzard shad	64	0.43	10.06	5.45-31.70
	Cyprinidae	2	0.01	6.43	6.40- 6.45
1P	No larvae collected				

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2

REPORT ROUTING FORM

Client KANSAS GAS & ELECTRIC Co.
Project Name PRECONSTRUCTION MONITORING NEAR WOLF CREEK GENERATING STATION
Project Number 55010.6814
Section Terrestrial
Group Vegetation
Submitted by W. Buchanan
Date submitted for review process 19 Apr 76 / due 2 April 76 to Proj. Ldr.
Date report due to client 15 MAY 1976

Type Report: __ Nontechnical __ Technical __ Other
__ Monthly
__ Quarterly
X Final

Route to:	Date Received	Date(s) Reviewed	Date Routed	Signature
Group Leader				
Section Head				
Project Leader		20 Apr 22 Apr	21 Apr	
Project Coordinator or Technical Manager		22 Apr		HSC in time
		21 Apr		GWW in time

Comment Review:

Group Representative _____ Date _____
Signature _____

Filed by Project Coordinator

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3

REPORT ROUTING FORM

Client KANSAS GAS & ELECTRIC Co.
Project Name PRECONSTRUCTION MONITORING NEAR WOLF CREEK GENERATING STATION
Project Number 55010 6814
Section Terrestrial
Group W.Y.& Life
Submitted by Joe Sucheche
Date submitted for review process 19 Apr 76 / due 2 April 76 to Proj. Ldr.
Date report due to client 15 MAY 1976

Type Report: __ Nontechnical __ Technical __ Other
__ Monthly
__ Quarterly
X Final

Route to:	Date Received	Date(s) Reviewed	Date Routed	Signature
Group Leader				
Section Head	26 April	26 April		[illegible]
Project Leader	20 Apr 76	20 Apr 23 Apr		[illegible]
Project Coordinator or Technical Manager	26 April 76	22, 23 April 76		HSL
	26 April 1976	26 April 1976		[illegible]

Comment Review:

Group Representative W. Buchanan Date 27 April 76
Signature Warren J. Buchanan, Jr.

Filed by Project Coordinator

REPORT ROUTING FORM

Client KANSAS GAS & ELECTRIC
Project Name Wolf Creek Generating Station (Pre-construction)
Project Number 5561 6814
Section LINCOLN
Group Water Chemistry
Submitted by David J. Byrnes
Date submitted for review process 22 MAR TO NBK
Date report due to client 1 MAY

Type Report: __ Nontechnical __ Technical __ Other
__ Monthly
__ Quarterly
X Final

Route to:	Date Received	Date(s) Reviewed	Date Routed	Signature
Group Leader	3/23/76	3/29 and 30/76	3/30/76	GL Shipley
Section Head	3/30/76	Reviewed + returned for changes 4/1/76 JC Boyd	4/12/76	JC Boyd
Project Leader	12 Apr 76	14 Apr 15 Apr	21 Apr 76	[illegible]
Project Coordinator or Technical Manager	22 April 76	24 April 76		HSL
	26 April 1976	26 April 1976		[illegible]

Comment Review:

Group Representative David J Byrnes Date 21 April 1976
Signature David J Byrnes

Filed by Project Coordinator

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REPORT ROUTING FORM

Client KANSAS GAS & ELECTRIC Co.
Project Name PRECONSTRUCTION MONITORING NEAR WOLF CREEK GENERATING STATION
Project Number 55010 6814
Section
Group Physical Sciences
Submitted by E. [illegible] + S.D. [illegible]
Date submitted for review process 6 May 76 / due 2 April 76 to Proj. Ldr.
Date report due to client 15 MAY 1976

Type Report: __ Nontechnical __ Technical __ Other
__ Monthly
__ Quarterly
X Final

Route to:	Date Received	Date(s) Reviewed	Date Routed	Signature
Group Leader				
Section Head				
Project Leader	6 May 76	10 May complete 6 May	10 May	[illegible]
Project Coordinator or Technical Manager	8 May 76	9/10 May 76	10 May	HSL

Comment Review:

Group Representative _____ Date 12 May 1976
Signature [illegible]

Filed by Project Coordinator

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6

REPORT ROUTING FORM

Client KANSAS GAS & ELECTRIC Co.
Project Name PRECONSTRUCTION MONITORING NEAR WOLF CREEK GENERATING STATION
Project Number 550106814
Section Lincoln
Group Periphyton
Submitted by Rob Farrell
Date submitted for review process 2 April 76 / due 2 April 76 to Proj. Ldr.
Date report due to client 15 MAY 1976

Type Report: __ Nontechnical __ Technical __ Other
__ Monthly
__ Quarterly
X Final

Route to:	Date Received	Date(s) Reviewed	Date Routed	Signature
Group Leader	~~2 Apr 7~~			
Section Head				
Project Leader	2 Apr 76 w/o Tables	14 Apr 15 Apr	22 Apr 76	[illegible]
Project Coordinator or Technical Manager	20 April 76	23 April 76		HSC
	20 April 1976	20 April 1976		[illegible]

Comment Review:

Group Representative R Farrell Date 4/23/76
Signature R Farrell

Filed by Project Coordinator

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7

REPORT ROUTING FORM

Client KANSAS GAS & ELECTRIC Co.
Project Name PRECONSTRUCTION MONITORING NEAR WOLF CREEK GENERATING STATION
Project Number 55010 6814
Section
Group Zooplankton
Submitted by Andrew Repsys
Date submitted for review process 8 Apr 76 / due 2 April 76 to Proj. Ldr.
Date report due to client 15 MAY 1976

Type Report: __ Nontechnical __ Technical __ Other
__ Monthly
__ Quarterly
X Final

Route to:	Date Received	Date(s) Reviewed	Date Routed	Signature
Group Leader				
Section Head				
Project Leader	8 Apr 76	13 Apr 12 Apr 14 Apr	14 Apr	[illegible]
Project Coordinator or Technical Manager	20 April 1976	23 April 1976		Howard S. [illegible]
	20 April 1976			[illegible]

Comment Review:

Group Representative ANDREW REPSYS Date 5/7/76
Signature [illegible]

Filed by Project Coordinator

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3

REPORT ROUTING FORM

Client L&E
Project Name
Project Number [illegible]
Section ES Lincoln
Group Benthos
Submitted by D. L. Andersen
Date submitted for review process 12 Apr 76
Date report due to client

Type Report: __ Nontechnical X Technical __ Monthly __ Quarterly __ Final X Other Annual

Route to:	Date Received	Date(s) Reviewed	Date Routed	Signature
Group Leader				
Section Head				
Project Leader	12 Apr	13 Apr 15 Apr 21 Apr	21 Apr 76	[illegible]
Project Coordinator or Technical Manager	21 April 76	24 April 76		HSC
	26 April 1976	26 April 1976		[illegible]

Comment Review:

Group Representative D.L. ANDERSEN Date 22 Apr 76
Signature [illegible]

Filed by Project Coordinator

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4010 NORTHWEST 39TH ST., BLDG. 1374 ▫ LINCOLN, NEB. 68524 ▫ AREA 402-799-2411

NALCO CHEMICAL COMPANY

May 14, 1976

Mr. Michael E. Miller
Environmental Coordinator
Kansas Gas and Electric Company
P. O. Box 208
Wichita, Kansas 67201

Dear Mike:

Enclosed are three copies of the final report for the 1975-76 Preconstruction Environmental Monitoring Program at Wolf Creek Generating Station.

I hope you will find it satisfactory for your purposes. If you have any comments or questions about the report, please feel free to contact me.

Sincerely,

Darell L. Andersen

Darell L. Andersen
Project Leader

DLA:GDA

cc: H. S. Lewis
G. W. Wadley w/enclosure (one copy)

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9

REPORT ROUTING FORM

Client KANSAS GAS & ELECTRIC Co.
Project Name PRECONSTRUCTION MONITORING NEAR WOLF CREEK GENERATING STATION
Project Number 55010 6814
Section
Group Fisheries
Submitted by Don Szmania
Date submitted for review process 2 April 76 / due 2 April 76 to Proj. Ldr.
Date report due to client 15 MAY 1976

Type Report: __ Nontechnical __ Technical __ Other
__ Monthly
__ Quarterly
X Final

Route to:	Date Received	Date(s) Reviewed	Date Routed	Signature
Group Leader				
Section Head				
Project Leader	9 Apr 76	27 Apr 26 Apr 12 Apr		DLA
Project Coordinator or Technical Manager	29 April 76	1 May 76 30 April 76		HSL
	20 April 1976	21 April 1976		[illegible]

Comment Review:

Group Representative Don Szmania Date 7 May 76
Signature Donald P. Szmania

Filed by Project Coordinator

NALCO ENVIRONMENTAL SCIENCES
4010 NORTHWEST 39TH ST., BLDG. 1374 ▫ LINCOLN, NEB. 68524 ▫ AREA 402-799-2411

NALCO CHEMICAL COMPANY

May 17, 1976

Mr. Michael E. Miller
Environmental Coordinator
Kansas Gas and Electric Company
P. O. Box 208
Wichita, Kansas 67201

Dear Mike:

Enclosed are three corrected copies of page 2 of the final report for the 1975-76 Preconstruction Environmental Monitoring Program at Wolf Creek Generating Station. Please replace them in the copies sent 14 May 1976.

I hope you will accept my apology for this inconvenience.

Sincerely,

Darell L. Andersen
Project Leader

DLA:GDA

55d

Nalco Environmental Sciences,1977. Final Report of Preconstruction Environmental Monitoring Program WCGS, March 1976 - February 1977.

1976 - 1977

55

NALCO ENVIRONMENTAL SCIENCES
4010 NORTHWEST 39TH ST., BLDG. 1374 ▫ LINCOLN, NEB. 68524 ▫ AREA 402-470-2411

NALCO CHEMICAL COMPANY

REPORT TO

KANSAS GAS & ELECTRIC COMPANY
WICHITA, KANSAS

FINAL REPORT OF CONSTRUCTION ENVIRONMENTAL MONITORING PROGRAM WOLF CREEK GENERATING STATION

MARCH 1976 - FEBRUARY 1977
PROJECT NO. 5501-07688

PREPARED AND SUBMITTED
BY
NALCO ENVIRONMENTAL SCIENCES

Darell L. Andersen, Editor

Report approved by:

H. S. Lewis
Manager
Lincoln, Nebraska Laboratory

B. G. Johnson
General Manager

25 May 1977

APR

NALCO ENVIRONMENTAL SCIENCES
4010 NORTHWEST 39TH ST., BLDG. 1374 ▫ LINCOLN, NEB. 68524 ▫ AREA 402-470-2411

NALCO CHEMICAL COMPANY

REPORT TO

KANSAS GAS & ELECTRIC COMPANY
WICHITA, KANSAS

FINAL REPORT OF CONSTRUCTION ENVIRONMENTAL MONITORING PROGRAM WOLF CREEK GENERATING STATION

MARCH 1976 - FEBRUARY 1977
PROJECT NO. 5501-07688

PREPARED AND SUBMITTED
BY
NALCO ENVIRONMENTAL SCIENCES

Darell L. Andersen, Editor

Report approved by:

H. S. Lewis
Manager
Lincoln, Nebraska Laboratory

B. G. Johnson
General Manager

25 May 1977

TABLE OF CONTENTS

Chapter		Page
	PREFACE	ii
	LIST OF FIGURES	iii
	LIST OF TABLES	v
1.	INTRODUCTION Darell L. Andersen	1
2.	WATER QUALITY STUDY David J. Byrnes	4
3.	PHYTOPLANKTON STUDIES Phillip A. Kline and Steven D. Reetz	47
4.	PERIPHYTON STUDY James R. Farrell	71
5.	ZOOPLANKTON STUDY Andrew J. Repsys	89
6.	MACROINVERTEBRATE STUDY Darell L. Andersen	117
7.	FISHERIES STUDY Quentin P. Bliss	145
8.	VEGETATION MONITORING Edward W. Uhlemann and Cynthia J. Talaber	167
9.	WILDLIFE MONITORING Carl N. Becker and Joseph L. Suchecki	214
Appendices		
A	WATER QUALITY DATA	A-1
B	PHYTOPLANKTON DATA	A-24
C	PERIPHYTON DATA	A-112
D	MACROINVERTEBRATE DATA	A-151
E	FISHERIES DATA	A-249
F	VEGETATION DATA	A-266
G	WILDLIFE DATA	A-271

PREFACE

This first construction environmental monitoring program for the proposed Wolf Creek Generating Station was conducted from March 1976 through February 1977. The study followed recommendations for the Construction Monitoring Phase presented in section 6.1 of the Wolf Creek Generating Station Environmental Report. The Draft Environmental Statement (DES) issued in July 1975 and the Final Environmental Statement (FES) released in October 1975 included recommendations for several changes and additions which were incorporated into this study.

The staff of NALCO Environmental Sciences comprised the study group for data acquisition and preparation of this report. The study was directed by D. L. Andersen, Associate Biologsit, Aquatic Ecology. H. S. Lewis, Manager, Lincoln, Nebraska Laboratory served as senior advisor and provided the critical review of this manuscript. Dr. G. W. Wadley, Technical Manager, Northbrook, Illinois, was responsible for overall coordination of the program.

LIST OF FIGURES

No.	Caption	Page
2.1	Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	20
2.2	Precipitation recorded at John Redmond Reservoir, 1976 (U. S. Army, Corps of Engineers 1976)	21
2.3	Inflow and outflow data for John Redmond Reservoir, 1976	22
2.4	Mean water temperature, dissolved oxygen and oxygen saturations recorded in the Neosho River and Wolf Creek, February-December 1976	23
2.5	Mean filtrable residue and specific conductance values measured in the Neosho River and Wolf Creek, February-December 1976	24
2.6	Mean nonfiltrable residue and turbidity measured in the Neosho River and Wolf Creek, February-December 1976	25
2.7	Mean total iron and total manganese in the Neosho River and Wolf Creek, February-December 1976	26
2.8	Mean ammonia, nitrate and organic nitrogen concentrations in the Neosho River and Wolf Creek, February-December 1976	27
2.9	Mean soluble orthophosphate and total phosphorus in the Neosho River and Wolf Creek, February-December 1976	28
2.10	Mean biochemical oxygen demand, chemical oxygen demand, and total organic carbon concentrations in the Neosho River and Wolf Creek, February-December 1976	29
3.1	Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	59
3.2	Comparison of carbon fixation rate, chlorophyll a concentration and density of phytoplankton collected from the Neosho River (Locations 1, 10, and 4) in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	60
3.3	Seasonal and year-to-year variations of phytoplankton in the Neosho River (Locations 10 and 4 mean) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-76	61
3.4	Seasonal comparison of the major groups of phytoplankton in Wolf Creek (Locations 7, 2, 3 and 5) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	62

LIST OF FIGURES (continued)

No.	Caption	Page
4.1	Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	81
5.1	Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	98
5.2	Inflow and outflow data for John Redmond Reservoir, 1976	99
6.1	Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	130
6.2	Inflow and outflow for John Redmond Reservoir, 1976	131
7.1	Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	156
7.2	Inflow and outflow data for John Redmond Reservoir, 1976	157
8.1	Vegetation sampling locations in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	185
8.2	Schematic representation of nested quadrat layout for sampling vegetation in a floodplain woods in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	186
8.3	Tree ring and dendrometer band data from representative trees and saplings in the north floodplain woods, Community 2, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, September 1976	187
8.4	Similarily between 1976 and 1975 monitoring data for each plant community sampled for two years in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas	188
8.5	Tree ring and dendrometer band data from representative trees and sapling in the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, September 1976	189
9.1	Wildlife sampling locations in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	238

LIST OF TABLES

No.	Caption	Page
2.1	Physical measurements and instrumentation used in this study	30
2.2	Water quality parameters measured in surface water samples	31
2.3	Water quality parameters measured in groundwater samples	32
2.4	Methods for analyses of water quality parameters	33
2.5	Summary of minimum, maximum and mean concentrations for water quality parameters measured in the Neosho River and Wolf Creek, 1976	36
2.6	Seasonal water quality data from the Neosho River upstream and downstream of the confluence with Wolf Creek, 1973-76	41
2.7	Water quality criteria for Kansas surface waters (applicable to Neosho River)	44
2.8	Desirable water quality criteria for various uses. All values are maximums unless minimum or range is given	45
3.1	Summary of phytoplankton densities and percent occurrence from samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	63
3.2	Mean carbon fixation rate (mg C/m^3 per hr) from phytoplankton samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-76	66
3.3	Mean chlorophyll a concentration (mg chl a/m^3) from phytoplankton samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-76	67
3.4	Summary of numerically dominant phytoplankton taxa and percent of total phytoplankton density from samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	68
3.5	Shannon's species diversity indices for phytoplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	70
4.1	Number of periphytic algal taxa collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-76	82
4.2	Distribution by division of periphytic algal density and biovolume (expressed as a percentage of the total population) collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	83

LIST OF TABLES (continued)

No.	Caption	Page
4.3	Periphytic algal taxa comprising 10% or more of the density or biovolume of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	84
4.4	Density (no./cm^2), biovolume ($\mu l/dm^2$), biomass standing crop ($\mu g/dm^2$) of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	85
4.5	Mean differences between locations for biomass and chlorophyll a standing crop of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	86
4.6	Yearly mean density and chlorophyll a standing crop of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1974-76	87
4.7	Number of taxa, diversity, evenness, and autotrophic index of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	88
5.1	Zooplankton taxa collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	100
5.2	Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 25 February 1976	102
5.3	Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 5 April 1976	104
5.4	Zooplankton collected in the tailwaters of John Redmond Reservoir (Location 1) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 3 May 1976	106
5.5	Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 14 June 1976	108
5.6	Zooplankton collected in the tailwaters of John Redmond Reservoir (Location 1) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 12 July 1976	110
5.7	Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 10 August 1976	111
5.8	Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 4 October 1976	113

LIST OF TABLES (continued)

No.	Caption	Page
5.9	Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 13 December 1976	115
5.10	Mean densities of major zooplankton groups collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975-76	116
6.1	Summary of macroinvertebrate drift data collected from the tailwaters of John Redmond Dam on the Neosho River (Location 1) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	132
6.2	Benthic macroinvertebrate occurrence in quantitative collections in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	133
6.3	Summary of macroinvertebrate data from Ponar samples from the Neosho River (Locations 10 and 4) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	137
6.4	Summary of quantitative macroinvertebrate data from the Neosho River (Locations 10 and 4) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-76	138
6.5	Macroinvertebrates collected qualitatively in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, February-June 1976	139
6.6	Macroinvertebrates collected qualitatively in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, August-December 1976	142
6.7	Summary of macroinvertebrate data from Ponar samples collected from Wolf Creek (Locations 7, 2, 3 and 5) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	143
7.1	Water temperature (°C) measured at fish sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	158
7.2	Checklist of fish species collected by all sampling methods in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-76	159
7.3	Number of adult and juvenile fish collected by all sampling methods in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, February-December 1976	160

LIST OF TABLES (continued)

No.	Caption	Page
7.4	Number of fish collected by hoop netting in the Neosho River in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, February-December 1976	161
7.5	Number of fish collected by seining at each location in the Neosho River in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, February-December 1976	162
7.6	Number of fish collected by seining at each location in Wolf Creek in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, February-December 1976	163
7.7	Age determinations of selected fish collected in the Neosho River in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, April-October 1976	164
7.8	Relative importance of major food items found in the stomachs of selected fish collected in the Neosho River in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	165
7.9	Number, density and taxa of fish larvae collected at Location 1 in the Neosho River in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	166
8.1	Phytosociological data summary of trees in the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976	190
8.2	Phytosociological data summary of saplings in the north floodplain woods, Cummunity 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976	191
8.3	Phytosociological data summary of species in the shrub stratum of the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976	192
8.4	Frequency of species in the ground layer and average ground layer cover in the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, April, June, and September 1976	193
8.5	Density (stems per hectare) of saplings and trees by diameter classes in the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976	194

LIST OF TABLES (continued)

No.	Caption	Page
8.6	Frequency of species in the ground layer and average ground layer cover in the abandoned railroad right-of-way, Community 2, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, April, June, and September 1976.....	195
8.7	Percent cover of species in the ground layer, community ground layer cover, and mean canopy height in the abandoned railroad right-of-way, Community 2, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, April, June, and September 1976.....	196
8.8	Phytosociological data summary of trees in the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.....	197
8.9	Phytosociological data summary of saplings in the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.....	198
8.10	Phytosociological data summary of species in the shrub stratum of the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.....	199
8.11	Frequency of species in the ground layer and average ground layer cover in the south floodplain woods, Cummunity 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, April, June, and September 1976.....	200
8.12	Density (stems per hectare) of saplings and trees by diameter classes in the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.....	201
8.13	Frequency of species in the ground layer and average ground layer cover on a wet mudflat on John Redmond Reservoir, New Strawn, Kansas, June and September 1976.....	202
8.14	Frequency of species in the ground layer and average ground layer cover on a dry mudflat on John Redmond Reservoir, New Strawn, Kansas, September 1976.....	203
8.15	Ordination of plots in the south floodplain woods, Community 8, based on flood susceptibility continuum index, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.....	204

LIST OF TABLES (continued)

No.	Caption	Page
8.16	Plot-to-plot degree of floristic resemblance for shrub stratum and ground layer stratum data from the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	205
8.17	Distribution of shrub-stratum species along the flood susceptibility continuum in the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	206
8.18	Distribution of ground-stratum species along the flood susceptibility continuum in the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	207
8.19	Ordination of plots in the north floodplain woods, Community 1, based on flood susceptibility continuum index, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	208
8.20	Plot-to-plot degree of floristic resemblance for shrub stratum and ground layer stratum data from the north floodplain woods, Community 1, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976	209
8.21	Distribution of shrub stratum species along the flood susceptibility continuum in the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	210
8.22	Distribution of ground-stratum species along the flood susceptibility continuum in the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	211
8.23	Plot-to-plot degree of floristic resemblance for shrub stratum data from the north floodplain woods, Community 1, and the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	213
9.1	Seasonal capture data from two communities in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	239
9.2	Summary of small mammal densities (No./ha) in two communities in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1974-76	240

LIST OF TABLES (continued)

No.	Caption	Page
9.3	The number captured, number per 100 trapnights (TN), and percent composition of small mammal species captured on two mudflats at John Redmond Reservoir, New Strawn, Kansas, 1976	241
9.4	Incidental mammal observations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976-77	242
9.5	Bird species observed near John Redmond Reservoir, New Strawn, Kansas, 1976	243
9.6	Species list, residency status, and community and monthly occurrence of avifauna in the vicinity of the Wolf Creek Generating Station, May 1976 - January 1977	245
9.7	The number of birds observed per hour in the north floodplain woods community in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, May 1976 - January 1977	251
9.8	The number of birds observed per hour in the abandoned railroad right-of-way community in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, May 1976 - January 1977	252
9.9	Number of species, birds per hour, and species diversity of avifauna recorded in two communities in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, May 1973 - January 1977	253
9.10	Number of avian species and individuals observed along the 20-mile wildlife survey route in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, May 1973 - January 1977	254
9.11	Quail call counts and dove observations along a 20-mile census route in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976	255
9.12	Composite species list of herpetofauna observed in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	256
9.13	Seasonal and community distribution of reptiles and amphibians recorded in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976	257

Chapter 1

INTRODUCTION

By

Darell L. Andersen

I. Introduction

The site for Wolf Creek Generating Station is located approximately 3.5 miles northeast of Burlington, Kansas, near the center of Coffey County. Upon completion in 1981, the nuclear pressurized water reactor will produce 1150 megawatts (net output) of electrical power.

The site encompasses approximately 10500 acres of range, cropland and woodland, typical of that found in southeastern Kansas. The station itself will occupy 135 acres and the dam structures 60 acres. The recirculating type cooling system will use the surface of a 5960-acre cooling lake to dissipate rejected heat.

The cooling lake will be created by an earth-rolled dam on Wolf Creek about 5.5 miles upstream from its confluence with the Neosho River. Precipitation and runoff in the creek watershed, a makeup water line from the tailwaters of John Redmond Dam, and overflow into the creek bed downstream will allow maintenance of the lake's surface elevation at 1087 ft above sea level.

Studies of surface and subsurface waters as well as terrestrial habitats were initiated in March 1973. The Environmental Report (Kansas Gas and Electric Company 1974), and two succeeding Preconstruction Environmental Monitoring Reports (Industrial BIO-TEST Laboratories, Inc. 1975; NALCO Environmental Sciences 1976) discuss data that have been gathered prior to February 1976. The Final Environmental Statement (U. S. Nuclear Regulatory Commission 1975) recommended several changes and additions to the original monitoring program which were included in this first Construction Environmental Monitoring Program. The primary purposes of the program discussed herein were to monitor the aquatic and terrestrial environments as they exist in the study period and to assess the effects caused by construction of Wolf Creek Generating Station.

II. References Cited

Industrial BIO-TEST Laboratories, Inc. 1975. Final report of preconstruction environmental monitoring program, Wolf Creek Generating Station, March 1974-February 1975. (IBT No. 64304971). Report for Kansas Gas and Electric Co., Wichita, Kans. 188 pp. + 8 appendices.

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U. S. Nuclear Regulatory Commission. 1975. Final environmental statement related to the construction of Wolf Creek Generating Station, Unit 1. Docket No. STN 50-482.

Chapter 2

WATER QUALITY STUDIES

By

David J. Byrnes

I. Introduction

Water quality monitoring of surface and groundwater in the vicinity of Wolf Creek Generating Station (WCGS) has been conducted since 1973 (Kansas Gas and Electric Company 1974; Bowling and Ellis 1975; Byrnes 1976) to establish baseline concentrations of various water quality constituents.

The objectives of the 1976 study were:

1. To assess the impact of construction activities on the quality of the surface and groundwater supplies in the vicinity of WCGS;
2. To provide additional data on water quality of the aquatic environments; and
3. To document spatial or temporal variability of water quality parameters.

II. Field and Analytical Procedures

A. Sampling Frequency, Locations, and Parameters

1. Surface Water

Water samples for chemical and bacteriological analyses were collected bimonthly throughout 1976 in conjunction with aquatic biology sampling. Samples were collected from the seven locations identified in Figure 2.1:

a. Location 1: in the tailwaters of John Redmond Dam;

b. Location 10: in the Neosho River, 0.7 km upstream from its confluence with Wolf Creek;

c. Location 4: in the Neosho River, 1.3 km downstream from the confluence with Wolf Creek;

d. Location 2: in Wolf Creek, near the northernmost extent of the proposed cooling lake;

e. Location 3: in Wolf Creek, approximately 1.7 km downstream of the cooling lake dam site;

f. Location 5: in Wolf Creek, approximately 1.6 km upstream from its confluence with the Neosho River;

g. Location 7: in Wolf Creek, upstream of the area to be inundated by the cooling lake.

Water samples for limited analyses also were collected at Location 1 in May and July in association with phytoplankton sampling.

Meteorological and hydrological measurements made at each location are presented in Table 2.1 and the water quality parameters measured are listed in Table 2.2.

2. Groundwater

Groundwater samples were collected in April, June and October from eight wells near the site. These wells are designated B-12, C-6, C-20, C-50, D-28, D-42, D-55 and D-65, and are identified in Figure 2.1. The water quality parameters measured are listed in Table 2.3.

B. Sampling Procedures

1. Surface Water

Whenever possible, duplicate water samples were collected at a depth of one meter using a six-liter, polyvinyl chloride sampler of the Van Dorn design. Whenever it was impossible to use the Van Dorn sampler, a polyethylene funnel was used to obtain the water sample. Immediately after collection, samples were appropriately preserved, placed in insulated containers, packed in ice, and shipped to the laboratory for analysis. The meteorological and hydrological measurements listed in Table 2.1 were recorded at each sampling location. Instrumentation, methodology and precision of measurement for meteorological parameters and current velocity are also presented in Table 2.1.

2. Groundwater

Single groundwater samples were obtained from the tap source serving each well. Water was permitted to run from the faucets or pumps for approximately 5 min before the sample was taken in order to obtain a representative sample of the water in the aquifer.

Groundwater samples were preserved at the time of collection, placed in insulated containers, packed in ice, and shipped to the laboratory for analysis.

C. Analytical Procedures

Water temperature, dissolved oxygen, pH, total alkalinity and turbidity were measured in the field. The other parameters listed in Table 2.2 for surface water samples and Table 2.3 for groundwater samples were measured in the laboratory.

Water analyses were performed according to Standard Methods for the Examination of Water and Wastewater (A.P.H.A. et al. 1976). Analytical testing procedures were conducted in a manner consistent with the guidelines established by the U. S. Environmental Protection Agency (1974). References, preservation techniques, and analytical detection limits for the various water quality parameters are presented in Table 2.4. The quality assurance procedures followed were in strict accordance with recommendations of the U. S. Environmental Protection Agency (1972).

III. Results and Discussion

Water quality data will be discussed with respect to hydrology, effects of site construction, and previously reported data from the WCGS site (Kansas Gas

and Electric Company 1974; Bowling and Ellis 1975; Byrnes 1976).

Results of water analyses and physical and meteorological measurements recorded for each sampling period in 1976 are tabulated in Appendix A. The minimum, maximum and mean concentrations for each parameter on every sampling date for both the Neosho River and Wolf Creek are presented in Table 2.5. Comparisons of data (1973 through 1976) from locations upstream (Location 10) and downstream (4) of the confluence of Wolf Creek and the Neosho River are presented in Table 2.6.

A. Surface Water Hydrology

Precipitation greatly influences the hydrology and water quality of the Neosho River and Wolf Creek. Precipitation in this region of Kansas averages 86.6 cm per year; however, in 1976 precipitation totaled only 34.4 cm (U. S. Army, Corps of Engineers 1976). The heaviest monthly precipitation occurred in June (15.3 cm) and no precipitation was recorded in January or November (Figure 2.2). The most precipitation occurred from mid-April through July.

Flow in the Neosho River below John Redmond Reservoir is regulated by discharge from the reservoir. With the exception of May, June and July, discharge from the reservoir was minimal (<250 cfs) (Figure 2.3). Increases in reservoir storage volume in May, June, and July resulted from higher inflow into the reservoir (Figure 2.3) after periods of higher precipitation. The increases in reservoir storage volume resulted in higher discharges into the Neosho River below the reservoir. Higher flows were also reported during June of previous years (Bowling and Ellis 1975; Byrnes 1976).

Wolf Creek depends upon rainfall and snowmelt runoff for water and no flow was observed on any of the sampling dates in 1976. Small isolated pools were sampled at all locations from February through September. In October, pools existed only at Locations 2 and 7. Location 5 was dry and the pool at Location 3 had been filled with sand and gravel from the construction of a bridge abutment. In December all of the creek locations were either dry (Locations 3, 5) or the pools were frozen to the bottom (Locations 2, 7). The low amount of precipitation and subsequent absence of flow in Wolf Creek resulted in poor water quality, with each isolated pool having distinct water quality characteristics. In 1975, Wolf Creek was intermittent, with no flow during the September or December sampling periods (Byrnes 1976).

B. Surface Water Quality Characteristics

The Kansas State Board of Health Water Quality Standards for surface water are presented in Table 2.7. These criteria are applicable only to the Neosho River. Wolf Creek is classified as an intermittent stream, and the state water quality criteria apply only when water is flowing throughout the creek-bed (J. Travers, Kansas Department of Health and Environment, Topeka, Kansas, personal communication). The water quality of the Neosho River was in compliance with the Kansas surface water quality criteria at all sampling locations on each sampling date (Table 2.7).

1. General Water Quality Parameters

Concentrations of general water quality constituents were similar between Locations 10 and 4 in the Neosho River. However, concentrations of dissolved oxygen, filtrable residue, specific conductance, most ionic constituents, nonfiltrable residue, turbidity and total iron were higher at Location 1, but manganese concentrations and water temperatures were lower than at Locations 10 and 4. Location 1 is situated in the tailwaters of the John Redmond Dam, and differences between locations were partially caused by turbulent mixing of water discharged from the reservoir.

With the exception of considerably higher total dissolved solids, specific conductance, and sulfate, the concentrations of the general water quality constituents measured in the Neosho River were within seasonal ranges documented in previous studies (Table 2.6).

During 1976, sampling locations in Wolf Creek consisted of isolated pools, each with distinct water quality characteristics. Thus, the concentrations of most parameters were highly variable among locations and sampling dates. Comparisons to previous studies on Wolf Creek, with the exception of late 1975 (Byrnes 1976), provide little comparable information due to the drastic change in hydrology. The water quality at each location in the creek in 1976 can be characterized as poor (Larrimore et al. 1959; McKee and Wolf 1963; Hynes 1966). Water quality in the pools was poorest during the summer when higher water temperatures created additional environmental stresses from lower solubility conditions for dissolved oxygen.

a. Neosho River

Water temperatures and dissolved oxygen concentrations ranged from 1.2 to 26.6C and 6.0 to 13.6 mg/l, respectively, and followed normal seasonal patterns (Figure 2.4). Dissolved oxygen concentrations reflected seasonal, temperature-dependent solubility trends, and were highest in winter and lowest in summer, with saturations ranging from 73 to 103% (Figure 2.4). Oxygen concentrations and saturations always were higher at Location 1.

The pH and total alkalinity ranged from 7.6 to 8.5 and 145 to 196 mg/l-$CaCO_3$, respectively. These ranges of concentrations for both constituents reflect a substantial buffering capacity in the river (Hem 1970; Hynes 1972). Alkalinities measured during the summer and fall were considerably lower than those measured in the winter and spring, whereas pH was variable among sampling dates.

Specific conductance and filtrable residue ranged from 442 to 783 μmhos/cm (25C) and 296 to 490 mg/l, respectively. Both parameters were considerably higher in the winter and spring than during summer or fall (Figure 2.5). Maximum concentrations measured for both parameters were much higher than those documented in prior studies (Table 2.6).

The seasonal fluctuation in the concentrations of the major ionic constituents was similar to that of specific conductance and filtrable

residue. The following ranges of concentrations were measured (in milligrams per liter): calcium, 55 to 81; chloride, 12.0 to 42.0; magnesium, 14.0 to 27.4; potassium, 3.2 to 5.1; sodium, 12.0 to 30.9; and sulfate, 53 to 149. With the exception of sulfate, none of the major ionic constituents were measured in previous studies.

Nonfiltrable residue and turbidity ranged from 4 to 137 mg/l and 5.0 to 90 NTU, respectively, and both were lowest in December and highest in June (Figure 2.6). Higher concentrations in June were associated with increased discharge from John Redmond Reservoir and surface runoff transporting soil particles into the river system (Harms et al. 1974; Delfino and Byrnes 1975; Byrnes 1976). Levels of turbidity and nonfiltrable residue below the dam (Location 1) were usually higher than further downstream at Locations 10 and 4 due to the suspension of particulate matter in the turbulent water discharged from the reservoir.

Soluble iron concentrations ranged from <0.001 to 1.0 mg/l (Table 2.5) and, with the exception of April and June, were generally low. The highest concentrations were recorded in June and probably were associated with nonfiltrable residue increases at that time.

Total iron concentrations were consistently higher at Location 1 than at the other locations (Figure 2.7). Concentrations ranged from 0.084 to 2.7 mg/l and were highest in June and lowest in December. Higher concentrations at Location 1 and at all locations in June probably were associated with high nonfiltrable residue concentrations. Total manganese ranged from 0.031 to 0.25 mg/l and also was highest in June and lowest in December (Figure 2.7).

True color values had little spatial variability and ranged from 7 to 22 color units (Table 2.6). Color values were highest in June and were related to organic material increases, and the subsequent leaching of this material.

b. Wolf Creek

Water temperatures at locations in Wolf Creek ranged from 5.5 to 21.0C (Figure 2.4). There was spatial variation on most sampling dates, particularly in August (Appendix A, Table A.2). The isolated pools at each location were shallow and subject to atmospheric temperature fluctuations (Reid 1961; Hutchinson 1957). The variations in air temperatures (Appendix A, Table A.1) at each location (depending upon time of day samples were taken) would account for the spatial differences in water temperature.

Dissolved oxygen concentration ranged from 1.9 to 8.2 mg/l, representing saturations of 20 to 67% (Figure 2.4). Although not applicable, the Kansas Board of Health minimum standard of 5.0 mg/l provides a good criterion for evaluating the dissolved oxygen content of water in Wolf Creek. Concentrations were above 5.0 mg/l in February at Locations 7, 2, and 5, in April at Locations 2 and 5, and in October at Locations 7 and 2 (Appendix A, Table A.2). Oxygen concentrations were below 5.0 mg/l and considered not adequate to support diverse aquatic biota (McKee and Wolf 1963) in February at Location 3, and at all locations in June and August. The low oxygen levels were in part

caused by increased oxygen demand from bacterial decomposition, oxidation of organic material, and low photosynthetic activity in the pools (Reid 1961; Hynes 1966; Slack and Feltz 1968; Chapter 3). A similar condition of very low oxygen levels occurred at Locations 5 and 7 in December 1975 when the locations consisted of isolated pools and increased oxygen demand caused a depletion of oxygen (Byrnes 1976).

The pH and total alkalinity ranged from 7.2 to 7.9 and 109 to 236 mg/l-$CaCO_3$, respectively (Table 2.5). Alkalinity was higher in February and April and lower during subsequent sampling periods.

Filtrable residue and specific conductance ranged from 186 to 368 mg/l and 255 to 517 μmhos/cm. Concentrations of both constituents varied widely among sampling locations and were higher during April and June than in the other months (Figure 2.5).

The major ion concentrations varied widely among sampling locations and dates and exhibited a pattern similar to filtrable residue and specific conductance (Appendix A, Table A.2). In general, most ions were higher at all locations in April and June and ranged as follows (in milligrams per liter): calcium, 38 to 66; chloride, 3.0 to 12.2; magnesium, 6.7 to 14.7; potassium, 3.2 to 5.1; sodium, 5.5 to 25.0; and sulfate, 8 to 55. The low sulfate concentrations were similar to those recorded in September and December 1975 (Byrnes 1976).

Nonfiltrable residue and turbidity were highly variable among locations and sampling dates (Figure 2.6) ranging from 3 to 396 mg/l and 1.0 to 150 NTU, respectively. Differences between locations were due to localized runoff, variable amounts of decaying organic matter (primarily leaf litter), and the amount of use of each pool by domestic livestock. Most sampling locations are used by livestock for watering (Byrnes 1976).

Soluble iron, total iron, and total manganese ranged from 0.014 to 0.57 mg/l; 0.22 to 7.2 mg/l; and 0.10 to 1.2 mg/l, respectively (Figure 2.7). The ranges of concentration for total iron and manganese were considerably higher than those recorded for the Neosho River during the sampling period. Higher concentrations were due in part to the accumulation of leaf litter in the isolated pools of the creek. Decomposition of leaf litter increases the level of iron and manganese (Larrimore et al. 1959; Slack and Feltz 1968), and similar increases were documented in Wolf Creek in December 1975 (Byrnes 1976).

The accumulation of organic matter in the pools and subsequent leaching of color producing organics caused true color values to be high at all locations (20 to 64 color units).

2. Aquatic Nutrients

The range of concentrations measured for aquatic nutrients in the Neosho River was considered adequate to support most aquatic life (McKee and Wolf 1963). With the exception of ammonia and nitrate, concentrations of aquatic nutrients were similar to those documented in previous studies. The

ranges of concentrations measured for ammonia and nitrate were considerably lower than in previous years. Some spatial variability in the various forms of nitrogen and phosphorus was observed among sampling locations. Nitrate, organic nitrogen, and ammonia usually were highest at Location 1 and decreased at the downstream locations (10, 4). With the exception of soluble orthophosphate in August and total phosphorus in October, phosphorus concentrations were generally higher at the downstream locations (10, 4) than at Location 1.

Nutrient concentrations in Wolf Creek varied both temporally and spatially. Organic nitrogen was consistently high at all locations indicating the presence of decomposing organic material. Nitrate and ammonia values were variable, probably a result of the different stages of decomposition, oxidation, and nitrification of organic matter in each pool. Phosphorus concentrations also were variable among the creek sampling locations and dates.

a. Neosho River

Aquatic nutrients in the Neosho River ranged as follows: ammonia, <0.01 to 0.08 mg/l-N; nitrate, <0.01 to 0.80 mg/l-N; nitrite, 0.0003 to 0.13 mg/l-N; organic nitrogen, 0.53 to 1.1 mg/l; soluble orthophosphate, 0.002 to 0.072 mg/l-P; total phosphorus, 0.022 to 0.95 mg/l-P; and soluble silica, 0.18 to 6.7 mg/l-SiO_2 (Table 2.5). Mean concentrations at each location for the various nitrogen forms except nitrite are presented in Figure 2.8, and for the phosphorus forms in Figure 2.9.

The maximum ammonia concentration (0.08 mg/l-N) recorded in December was considerably lower than maximum concentrations documented in previous studies. Nitrate concentrations at Location 4 in August and October were either at or below the analytical detection limit of 0.01 mg/l-N. These concentrations were much lower than those measured slightly upstream at Location 10. Phytoplankton carbon-14 assimilation data (Chapter 3) in August and October were similar between Locations 10 and 4, indicating that nutrient levels were not limiting productivity.

Phosphorus concentrations were highly variable. Soluble orthophosphate was highest at all locations in June and lowest at Location 1 in April. Total phosphorus concentrations were highest at Location 10 in February and lowest at all locations in December (Figure 2.9).

Silica concentrations were much lower during winter and spring than in summer and fall (Table 2.5).

b. Wolf Creek

The concentrations of all aquatic nutrients showed wide temporal and spatial variability and ranged as follows: ammonia, <0.01 to 0.23 mg/l-N; nitrate, <0.01 to 0.50 mg/l-N; nitrite, 0.002 to 0.011 mg/l-N; organic nitrogen, 0.67 to 2.2 mg/l; soluble orthophosphate, 0.001 to 0.075 mg/l-P; total phosphorus, 0.049 to 0.47 mg/l-P; and soluble silica, 1.9 to 15 mg/l-SiO_2 (Table 2.5).

Ammonia concentrations were low at all locations in February and highest at Location 7 in June. Nitrate was low in February and highest at Location 7 in October. Organic nitrogen was always high, with the maximum concentration (2.2 mg/l) measured at Location 7 in February (Figure 2.8). Both total phosphorus and soluble orthophosphate were highly variable among locations and sampling dates (Figure 2.9).

The wide spatial and temporal variability in nutrient concentrations among locations in Wolf Creek resulted from differences in the quantity of organic matter in each pool, the relative stages of bacterial decomposition, and localized runoff in the spring and early summer (Larrimore et al. 1959; Hynes 1966; Slack and Feltz 1969; Byrnes 1976).

3. Indicators of Municipal and Industrial Contamination

With the exception of higher fecal coliform bacteria densities, the ranges of parameters indicative of municipal and industrial contamination in the Neosho River in 1976 were similar to those documented in previous studies (Table 2.6). Also, with the exception of fecal coliform and fecal streptococci bacteria densities, little spatial variability was measured in the concentrations of the indicators of municipal and industrial contaminants. Fecal coliform counts were generally higher at Location 10 than at the other river locations (1, 4), whereas fecal streptococci counts were highly variable among sampling locations and dates.

Indicators of municipal and industrial contamination were variable among sampling locations and dates in Wolf Creek, and concentrations were considerably higher than those in the Neosho River (Table 2.5). Indicators of oxygen demand in the creek generally were higher in the winter and spring (Table 2.5). Fecal streptococci and fecal coliform counts were very high in June and October, probably a result of localized runoff.

a. Neosho River

Fecal coliform and fecal streptococci bacteria densities ranged from 0 to 730 organisms per 100 ml and 0 to 330 organisms per 100 ml, respectively. With the exception of April and August, fecal coliform densities were always highest at Location 10, which is downstream of the town of Burlington, Kansas. Higher counts at Location 10 may have been due in part to improperly treated wastewater releases from Burlington. Fecal streptococci densities were variable, with higher counts recorded at Locations 10 and 4 in June and at all locations in October. These higher densities were probably associated with localized runoff of animal wastes (Bowling and Ellis 1975; Byrnes 1976).

Biochemical oxygen demand (BOD), chemical oxygen demand (COD), and total organic carbon (TOC) ranged from 0.6 to 4.6 mg/l, 14 to 31 mg/l, and 6.0 to 10 mg/l, respectively. Concentrations of all three indicators of oxygen demand were generally low and with the exception of BOD showed little spatial variability (Figure 2.10). Total organic carbon concentration varied little throughout the study, while BOD and COD concentrations were slightly higher in February than on other sampling dates.

Hexane soluble materials were generally low and ranged from <0.1 to 1.4 mg/l (Table 2.5). This range was slightly lower than that observed in previous studies (Table 2.6).

b. Wolf Creek

Fecal coliform and fecal streptococci densities in Wolf Creek exhibited wide spatial and temporal variability and ranged from 0 to 2600 organisms per 100 ml and 11 to 3600 organisms per 100 ml, respectively (Table 2.5). Counts were higher for both types of enteric bacteria in June and October and were probably associated with localized runoff of animal wastes.

Biochemical and chemical oxygen demand also were highly variable and ranged from 1.6 to 7.3 mg/l and 9.3 to 120 mg/l, respectively (Table 2.5). Both constituents were higher in February and March and lowest in August (Figure 2.10). The maximum concentrations measured for both parameters in 1976 were considerably higher than in previous studies. Total organic carbon concentrations ranged from 9.0 to 40 mg/l and with the exception of Location 7 in February were similar throughout the study. The range of concentrations measured for TOC was similar to that documented in the 1975 study (Table 2.6). High concentrations of all three indicators of oxygen demand reflected the severe environmental conditions of the isolated pools (Larrimore et al. 1959; Byrnes 1970).

Hexane soluble materials ranged from <0.1 to 2.8 mg/l, which was similar to ranges documented in previous studies (Table 2.6).

4. Trace Metals

With the exception of mercury, the range of maximum concentrations for trace metals in the Neosho River was much lower in 1976 as compared to previous studies. The range measured for mercury was similar to that recorded in previous years. There was both spatial and temporal variability in trace metal concentrations throughout the study period.

Concentrations of trace metals in Wolf Creek also showed wide temporal and spatial variability. In general, concentrations were higher in February and June and were probably associated with localized runoff and decomposition within the pools. The maximum concentrations measured for copper, lead, and zinc were considerably higher than in previous studies.

a. Neosho River

Trace metals concentrations in the Neosho River ranged as follows (in micrograms per liter): copper, 0.9 to 5.5; lead, <1 to 6; mercury, 0.20 to 98; selenium, <1 to 12; and zinc, 1.2 to 16 (Table 2.5).

Mercury concentrations varied widely among sampling locations and replicates in February 1976. The range of mercury concentrations was 5.0 to 98 μg/l in February and only 0.20 to 2.0 μg/l during the rest of the study period.

Concentrations of trace metals were lowest in December, with the exception of zinc which was lowest in June. Mean copper, lead, and selenium concentrations were higher in June and August probably due to surface runoff. Mean zinc concentrations were highest during April (Table 2.5).

b. Wolf Creek

Trace metals in Wolf Creek ranged as follows (in micrograms per liter): copper, 1.6 to 7.6; lead, <1 to 96; mercury, 0.26 to 69; selenium, <1 to 10; and zinc, 1.4 to 88 (Table 2.5). Concentrations were highly variable among sampling locations and dates.

With the exception of zinc, mean trace metal concentrations were lowest in April. Copper, selenium and zinc concentrations were highest in June due, in part, to surface runoff, whereas mercury and lead were highest in February (Table 2.5). With the exception of copper, trace metals in Wolf Creek had a much broader range with higher maximum values in 1976 than in previous studies.

C. Groundwater

1. Hydrology

The eight wells sampled are located in the South Central Paleozoic groundwater province (Kansas Gas and Electric Company 1974). Aquifers in this area are classified as alluvial, soil and weathered bedrock, and consolidated bedrock. The alluvial aquifer is composed of silts, sands, and gravels. The soil and weathered bedrock aquifer is composed of shale, siltstone, sandstone, and limestone and the soils derived from them. The overlying alluvial aquifer is hydraulically connected to the lower weathered bedrock aquifer. Recharge to both is from local precipitation percolating through the soil. Thus, the water table elevation is responsive to local precipitation and drought conditions (Kansas Gas and Electric Company 1974). However, the primary recharge to the alluvial aquifer in this region is from streams and rivers. The absence of flow in precipitation-dependent streams, low flow in the Neosho River, and the small amount of precipitation resulted in a lowering of the water table in this region (J. Hendersen, Kansas Water Resources Board, Topeka, Kansas, personal communication).

Groundwater samples were never collected from well C-20 (Figure 1) because the pump at this location was inoperable on all sampling dates.

2. Groundwater Characteristics

Groundwater data from the three sampling dates in 1976 are listed in Appendix A, Table A.3, and U.S. Public Health Service (1962) drinking water standards are presented in Table 2.8. There was both temporal and spatial variability in the concentration of most constituents measured in the wells. With the exception of potassium and sulfate, concentrations of ionic constituents, specific conductance, filtrable residue, nitrate, iron and selenium were much higher in well D-65, located south of the proposed dam for the cooling lake, than in the other wells.

The ranges of concentration measured for filtrable residue, specific conductance, calcium, magnesium, chloride, sodium, and sulfate were much greater than those observed in previous studies (Bowling and Ellis 1975; Byrnes 1976) with considerably higher maximum values. The low amount of precipitation and the subsequent decrease in the water table may have caused these increases due to a concentrating effect of these constituents in the aquifer.

The pH of the wells ranged from 7.2 to 8.2, being highest in October at well D-28 (southeast of the WCGS site), and lowest in well D-42 (south of well D-28) in June. Total alkalinity ranged from 161 to 382 mg/l-$CaCO_3$. Higher alkalinities were generally measured in wells B-12 (northeast of the WCGS site) and D-42 and lower alkalinity was consistently measured in well D-65. With the exception of well D-65, alkalinity was much higher in the groundwater than in surface water due to the limestone-rich nature of the geological strata.

Filtrable residue and specific conductance values were high in all of the wells ranging from 478 to 3890 mg/l and 828 to 5200 μmhos/cm (at 25C), respectively. Well D-65 consistently had the highest filtrable residue and specific conductance values. With the exception of B-12, all of the wells exceeded the U. S. Public Health Service drinking water standard of 500 mg/l nonfiltrable residue in April (Table 2.8).

With the exception of potassium and sulfate, well D-65 consistently had the highest concentrations of the major ions measured. The major ionic concentrations ranged as follows (in milligrams per liter): calcium, 78 to 530; chloride, 16.1 to 490; magnesium, 15.4 to 148; potassium, 0.50 to 7.2; sodium, 20 to 290; and sulfate, <1 to 410. Potassium was highest in well C-6 (west of the WCGS site), whereas sulfate was higher in wells D-28 and D-42. Sulfate consistently exceeded the U. S. Public Health Service drinking water maximum of 250 mg/l in well D-42 and in June at wells C-6 and D-28. Concentrations above 250 mg/l are known to have a laxative effect (U. S. Public Health Service 1962).

Soluble iron, total iron, and total manganese ranged from 0.017 to 0.30 mg/l, 0.020 to 6.1 mg/l, and 0.0011 to 1.9 mg/l, respectively, and were generally lower than in surface waters. The soluble iron content of the aquifer may actually have been higher than the concentrations recorded. Iron in most aquifers is in the soluble form due to the reducing environment. When the samples were collected, some of the iron was oxidized into insoluble ferric hydroxide (Hem 1970; Byrnes 1976).

Nitrate concentrations were low in wells B-12, C-6, C-50, D-55. and D-42 ranging from 0.01 to 7.8 mg/l-N; moderately high in well D-28 ranging from 13 to 58 mg/l-N; and very high in well D-65, ranging from 425 to 500 mg/l-N. Nitrate concentrations in excess of the U. S. Public Service maximum drinking water standard of 10 mg/l-N are known to cause cyanosis in infants (U. S. Public Health Service 1962). Total phosphorus concentrations were very low and ranged from <0.001 to 0.32 mg/l-P. Silica concentrations were generally higher in groundwater than in surface water and ranged from 2.7 to 27.4 mg/l-SiO_2.

Selenium concentrations were generally higher in well D-65 and ranged from <1.0 to 18 μg/l.

IV. Summary and Conclusions

1. Below normal precipitation during 1976 had a marked influence upon the hydrology and water quality of the Neosho River and Wolf Creek. With the exception of May through July, flow was minimal (<250 cfs) in the Neosho River. No flow was observed in Wolf Creek.

2. Except for the temporary filling of the pool at Location 3 in Wolf Creek during construction of a bridge abutment, no effects of construction on water quality were documented in the Neosho River or Wolf Creek.

3. The water quality of the Neosho River was acceptable based on the criteria established by the Kansas State Board of Health. The state water quality criteria do not apply to streams when flow is absent; thus, the criteria did not apply to Wolf Creek in 1976.

4. The water quality of the isolated pools in Wolf Creek was very poor. The unfavorable environment for the biota inhabiting the pools was reflected in low dissolved oxygen levels and high oxygen demand.

5. The quality of the water in the Neosho River has not changed greatly on an annual basis, although broader ranges of specific conductance, total dissolved solids, some major ions, fecal coliforms and nitrate concentrations were documented in 1976.

6. Some spatial variability was documented in the Neosho River between Location 1 in the tailwaters of John Redmond Dam and the downstream locations (10, 4), with higher concentrations of dissolved oxygen, filtrable residue, specific conductance, most ionic constituents, nonfiltrable residue, turbidity, and total iron measured at the upstream location.

7. Groundwater was also affected by reduced precipitation during 1976. Broader ranges with much higher maximum values as compared to previous studies were documented for specific conductance, filtrable residue, and major ionic constituents. The increase in maximum concentrations was due, in part, to a lowering of the water table.

8. There was both wide spatial and temporal variability in the water quality constituents measured in the wells.

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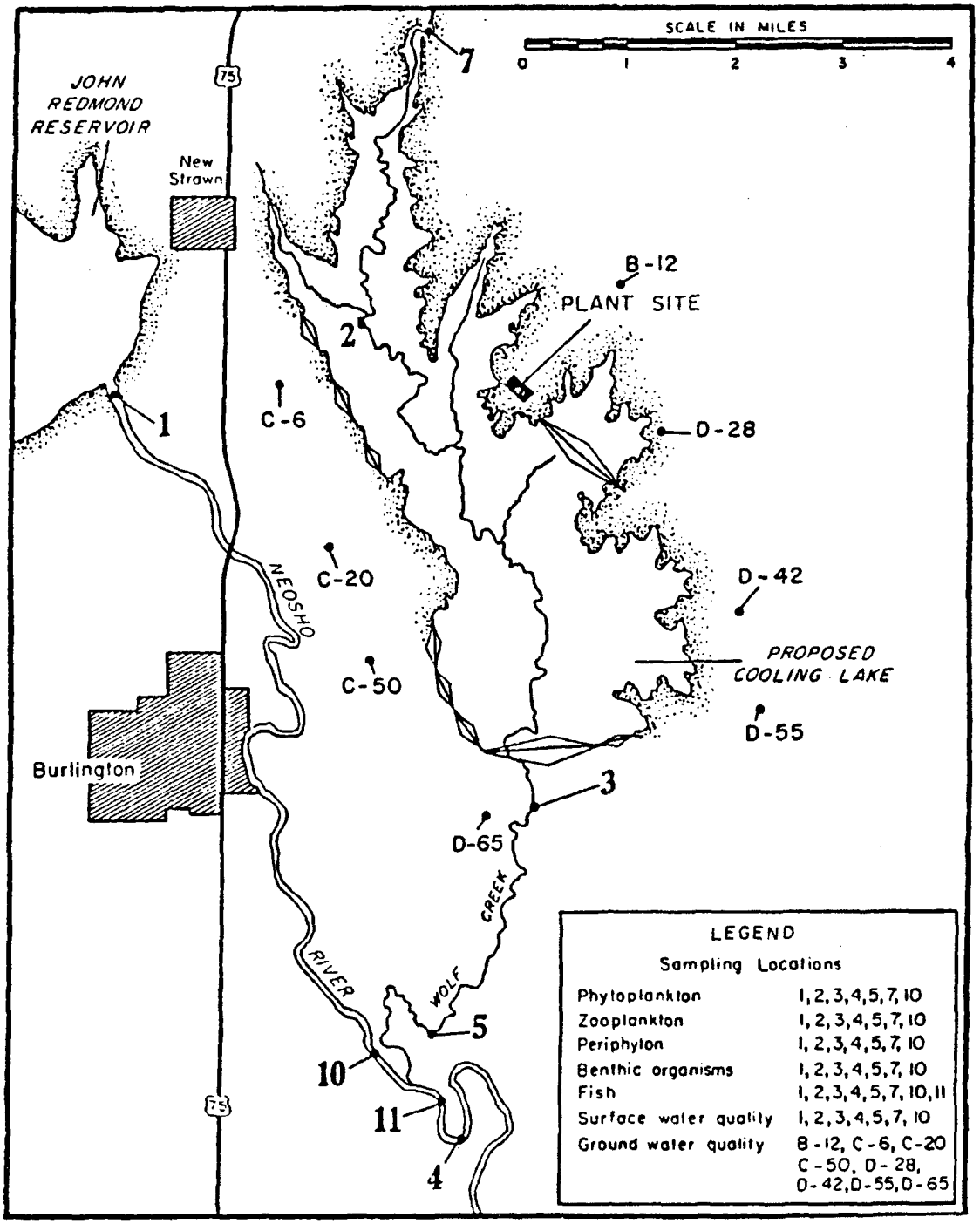

Figure 2.1. Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

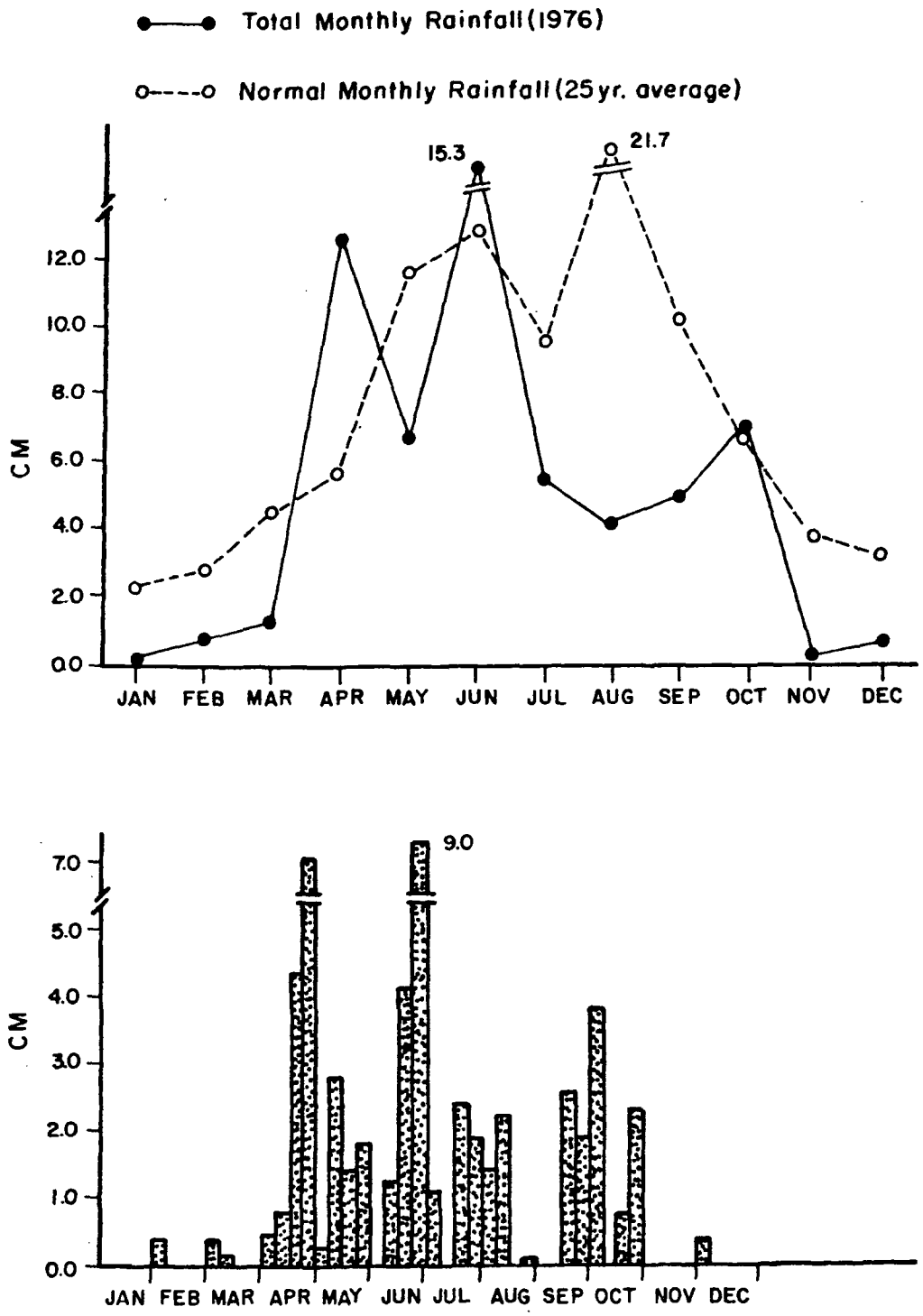

Figure 2.2. Precipitation recorded at John Redmond Reservoir, 1976 (U. S. Army, Corps of Engineers 1976).

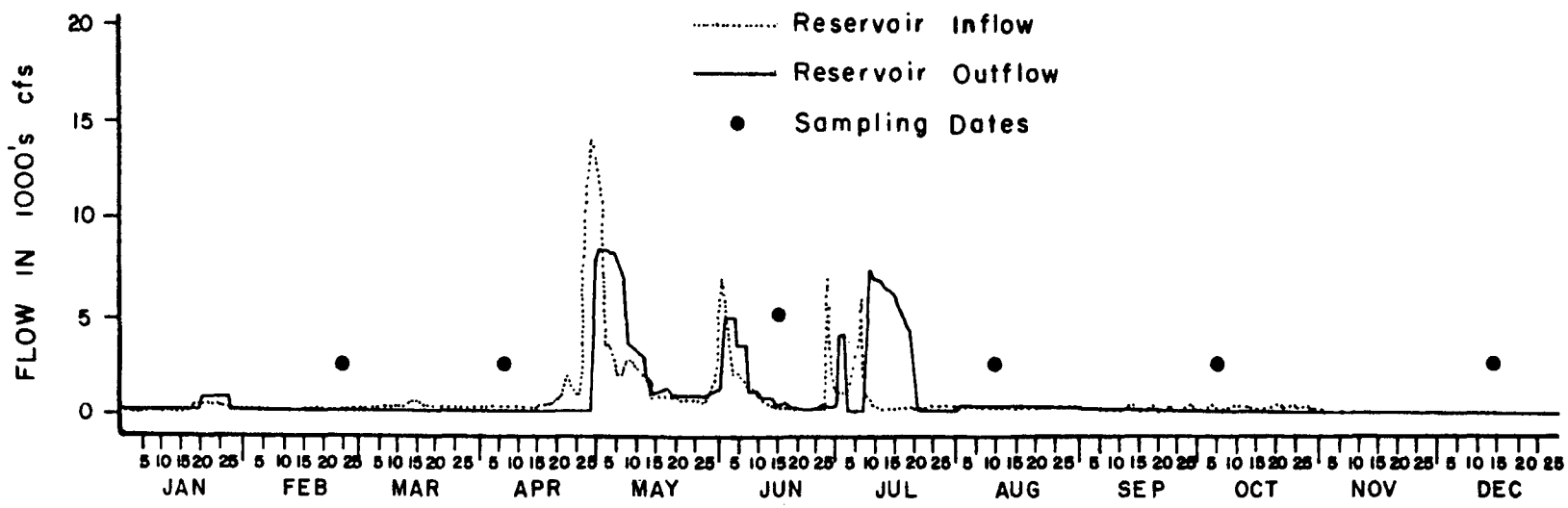

Figure 2.3. Inflow and outflow data for John Redmond Reservoir, 1976.

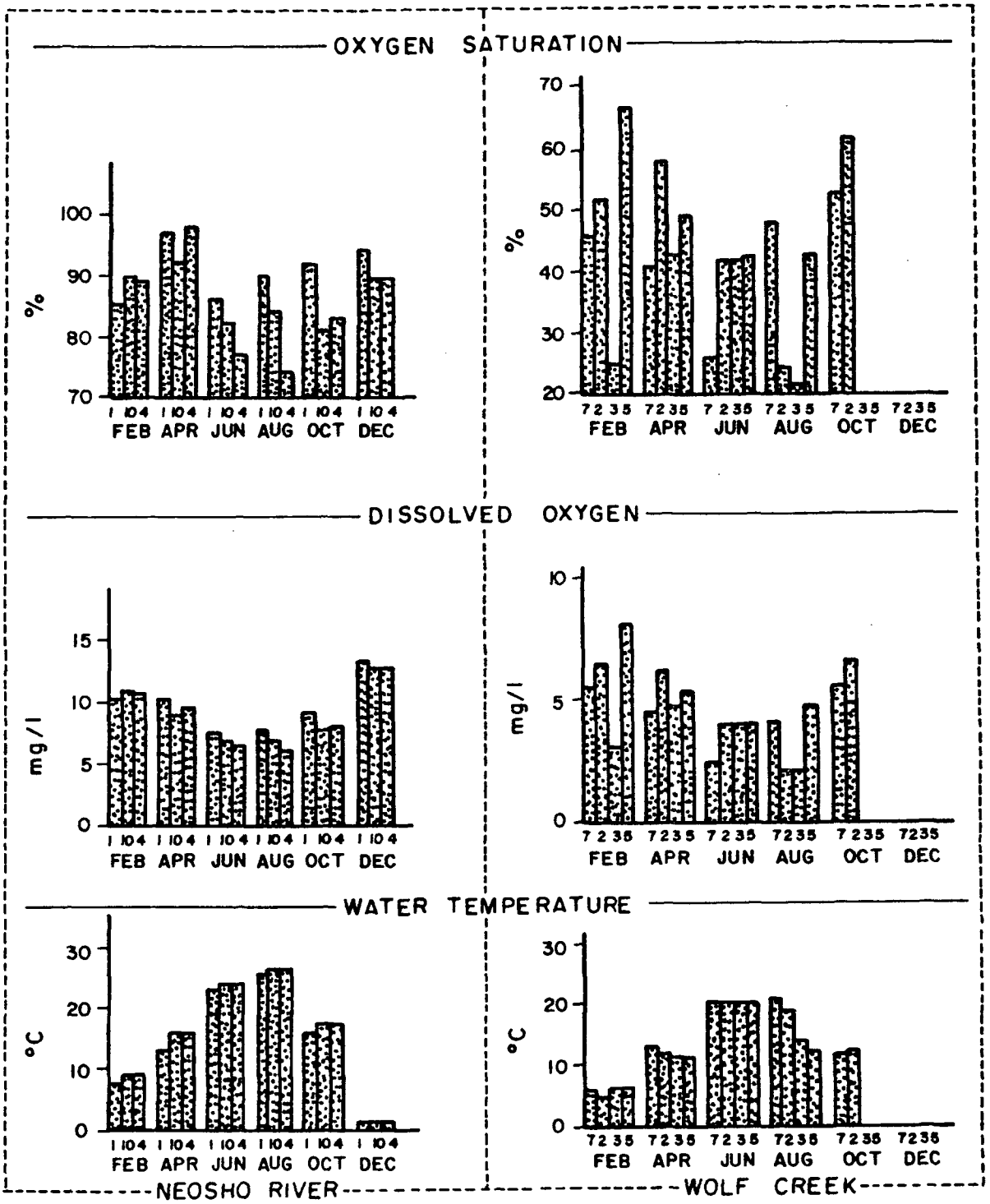

Figure 2.4. Mean water temperature, dissolved oxygen and oxygen saturations recorded in the Neosho River and Wolf Creek, February-December 1976.

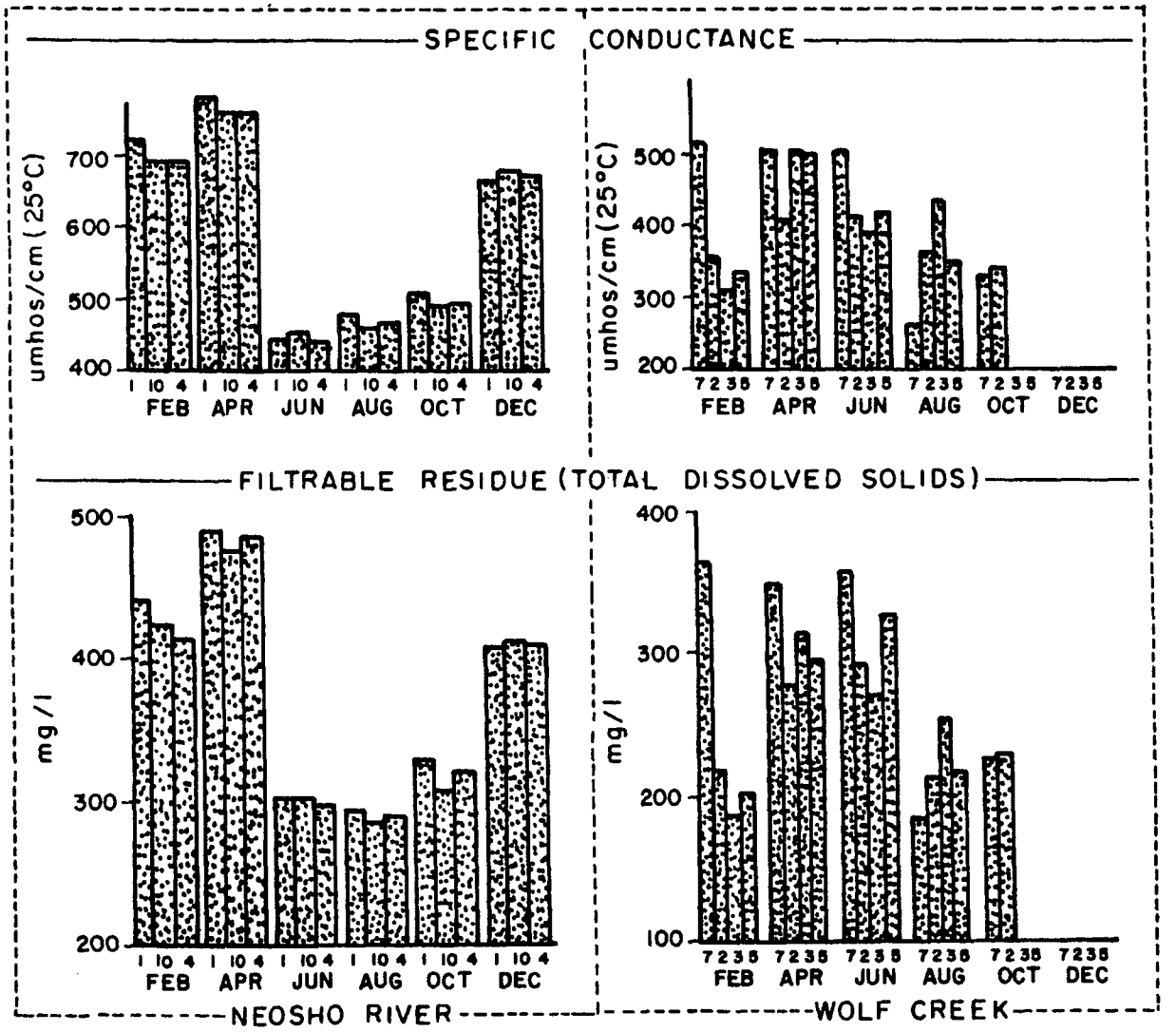

Figure 2.5. Mean filtrable residue and specific conductance values measured in the Neosho River and Wolf Creek, February-December 1976.

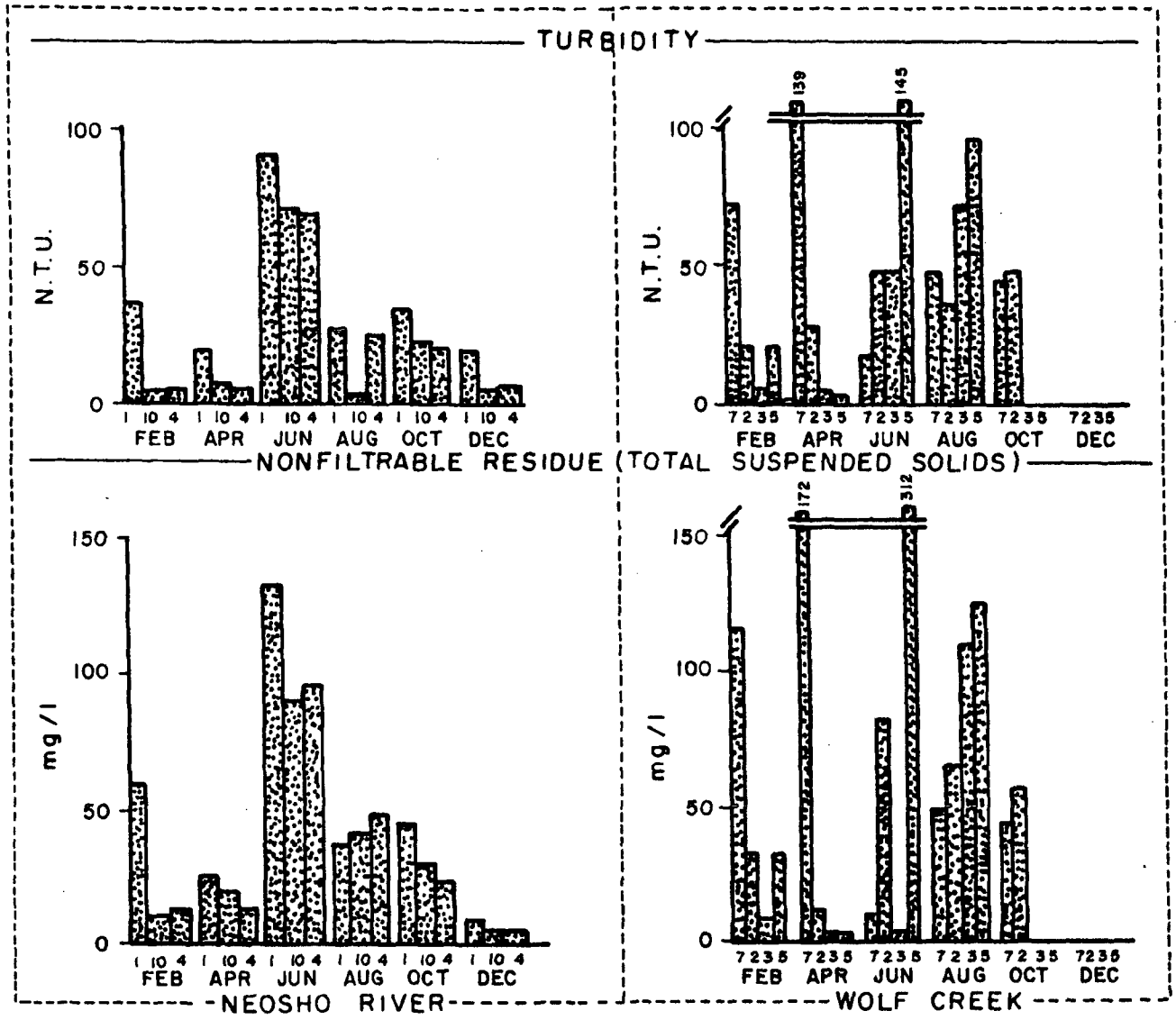

Figure 2.6. Mean nonfiltrable residue and turbidity measured in the Neosho River and Wolf Creek, February-December 1976.

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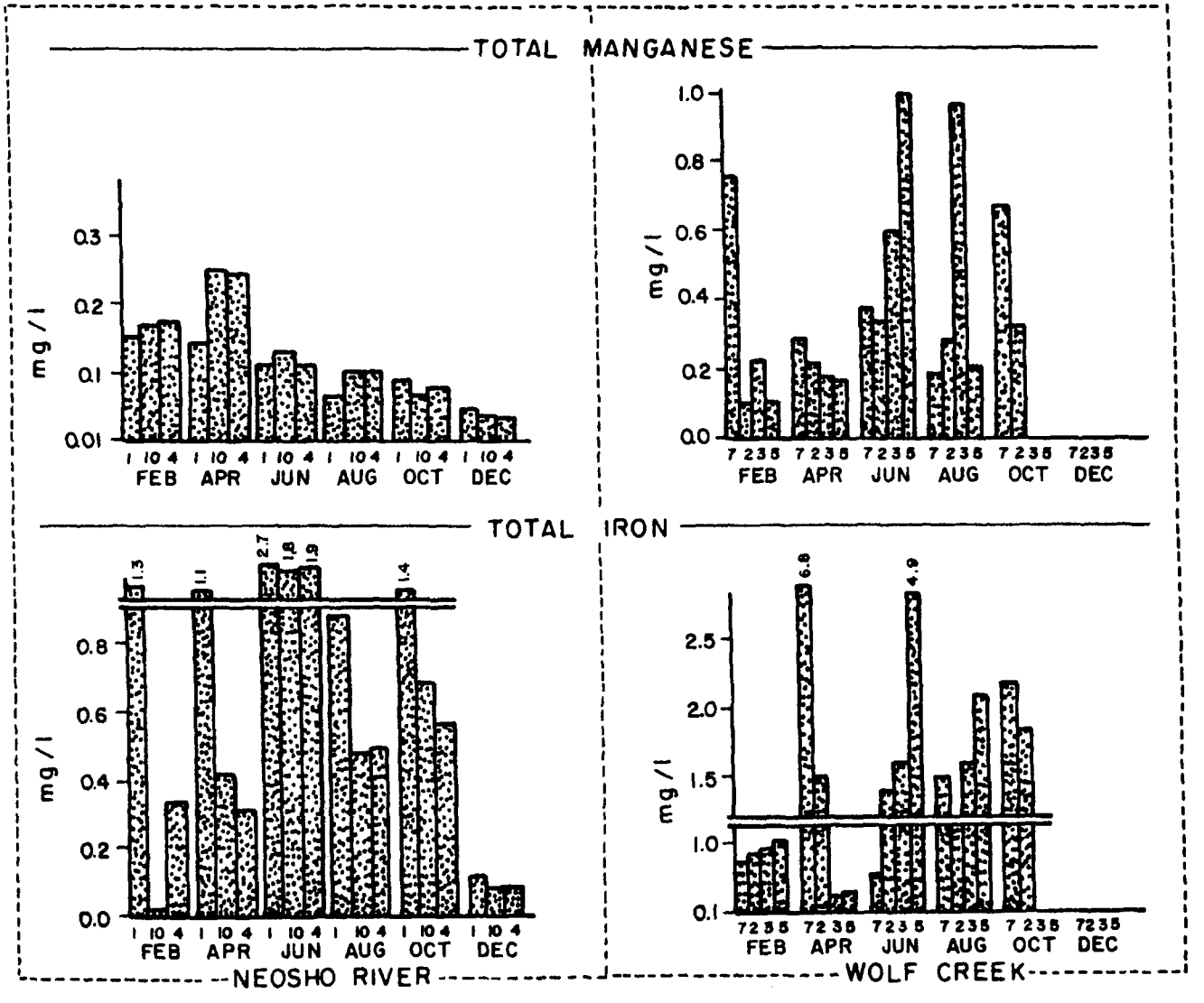

Figure 2.7. Mean total iron and total manganese in the Neosho River and Wolf Creek, February-December 1976.

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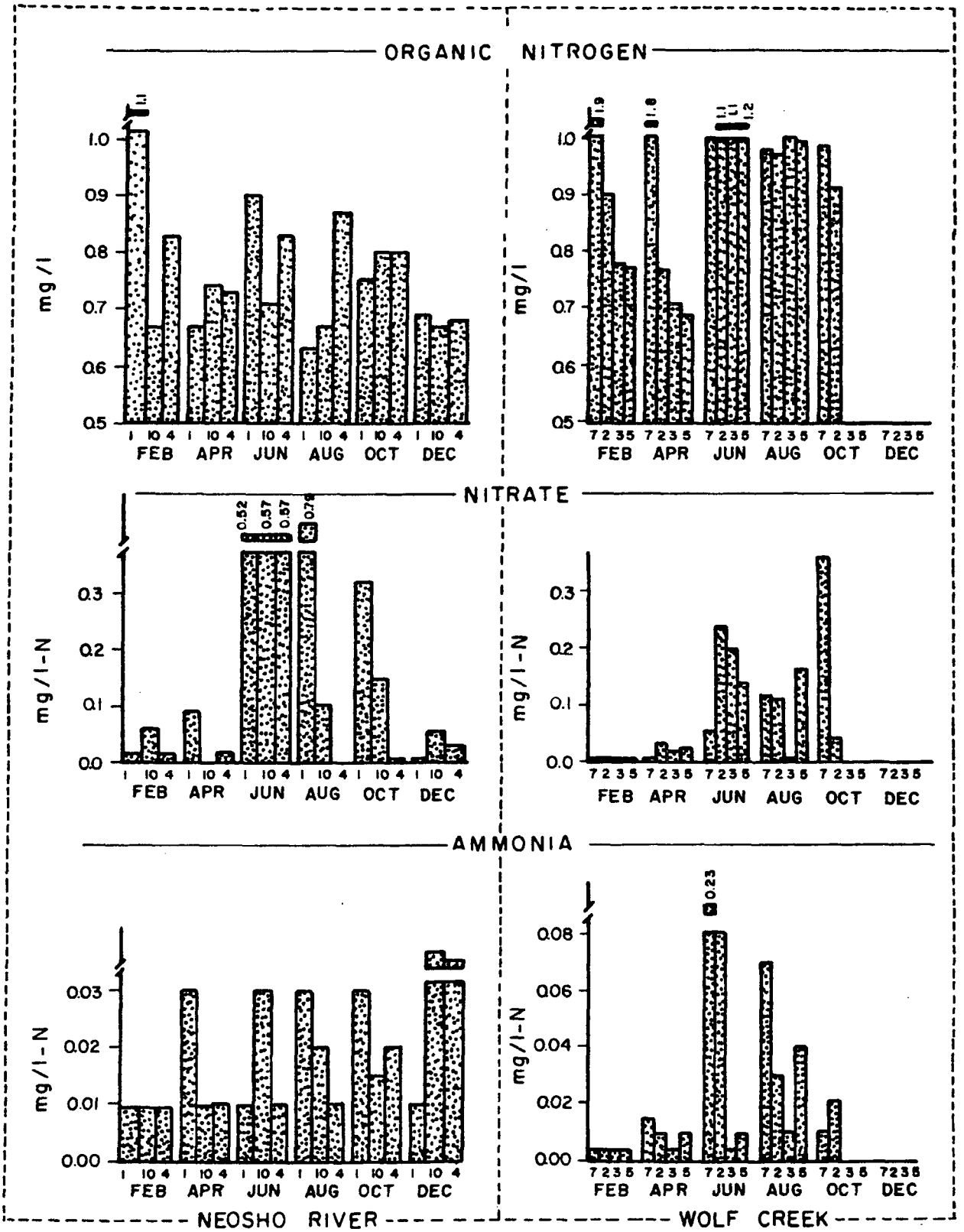

Figure 2.8. Mean ammonia, nitrate and organic nitrogen concentrations in the Neosho River and Wolf Creek, February-December 1976.

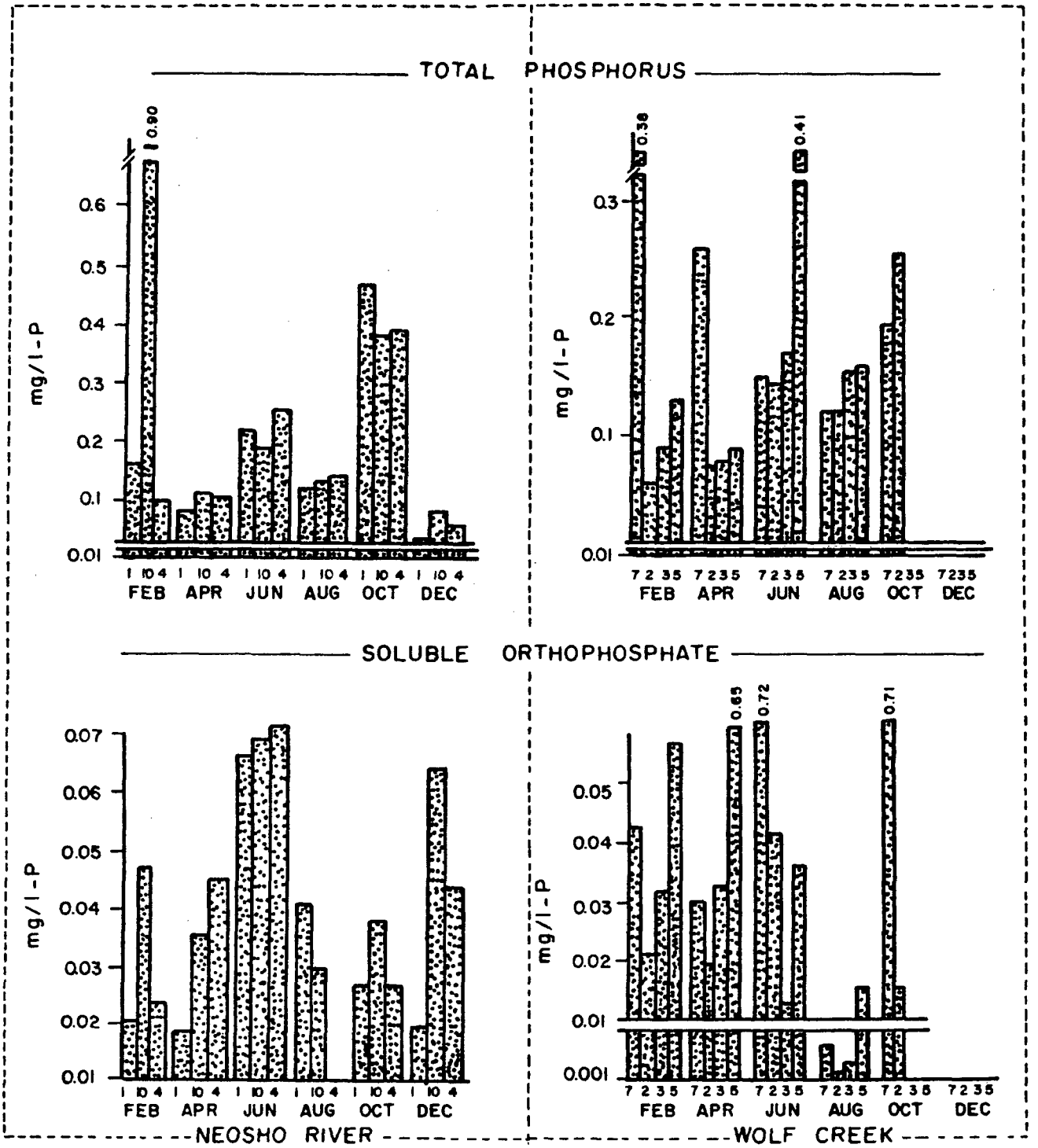

Figure 2.9. Mean soluble orthophosphate and total phosphorus in the Neosho River and Wolf Creek, February - December 1976.

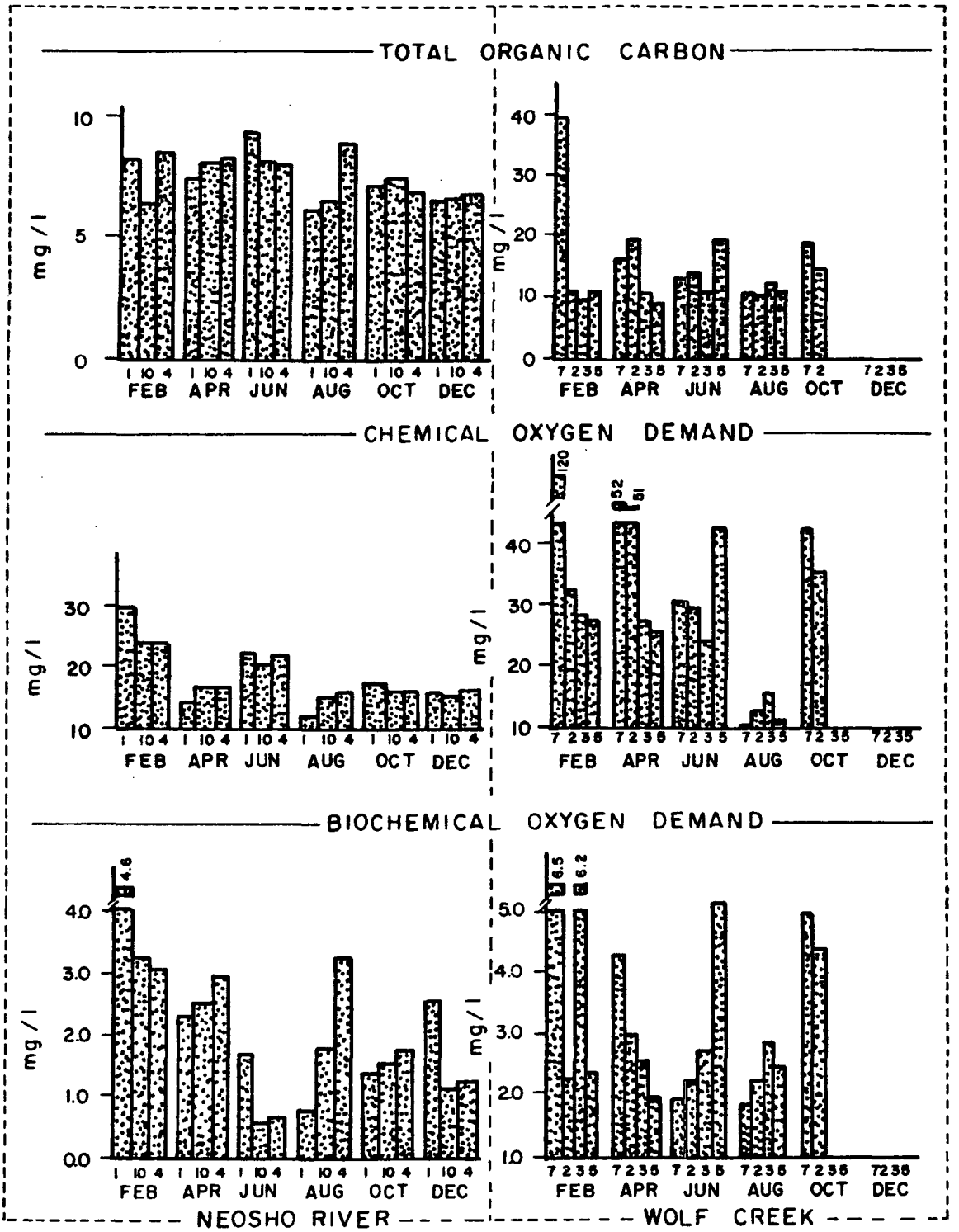

Figure 2.10. Mean biochemical oxygen demand, chemical oxygen demand, and total organic carbon concentrations in the Neosho River and Wolf Creek, February - December 1976.

Table 2.1. Physical measurements and instrumentation used in this study.

Measurement	Instrument	Precision of Measurement
Air temperature wet and dry bulb	Bendix Psychrometer Model 566 or Taylor Sling Psychrometer	± 0.5 C
Cloud cover	Field Observer	± 5%
Relative humidity	Calculated	± 1%
Wind velocity	Field Observer Dwyer Wind Meter	± 3 mph
Current velocity	General Oceanics Digital Flowmeter Model 2031-2035	± 0.1 m/sec

Table 2.2. Water quality parameters measured in surface water samples.

General Water Quality Parameters

* 1. Alkalinity, total
2. Calcium
3. Chloride
4. Color, true
5. Conductance, specific
6. Iron, soluble
7. Iron, total
8. Magnesium
9. Manganese, total
* 10. Oxygen, dissolved
* 11. Oxygen, saturation
* 12. pH
13. Potassium
14. Residue, filtrable (total dissolved solids)
15. Residue, nonfiltrable (total suspended solids)
16. Sodium
17. Sulfate
* 18. Temperature
* 19. Turbidity

Aquatic Nutrients

* 20. Ammonia
* 21. Nitrate
* 22. Nitrite
* 23. Organic nitrogen, total
* 24. Orthophosphate, soluble
* 25. Phosphorus, total
* 26. Silica, soluble

Indicators of Industrial and Municipal Contamination

27. Bacteria, fecal coliform
28. Bacteria, fecal streptococci
29. Biochemical oxygen demand (5-day)
30. Chemical oxygen demand
31. Hexane soluble materials
32. Organic carbon, total

Trace Metals

33. Copper, total
34. Lead, total
35. Mercury, total
36. Selenium, total
37. Zinc, total

* Indicates parameters measured at Location 1 during May and July with phytoplankton sampling.

Table 2.3. Water quality parameters measured in groundwater samples.

General Water Quality Parameters

1. Alkalinity, total
2. Calcium
3. Chloride
4. Conductance, specific
5. Iron, soluble
6. Iron, total
7. Magnesium
8. Manganese, total
9. Potassium
10. Residue, filtrable (total dissolved solids)
11. Sodium
12. Sulfate

Aquatic Nutrients

13. Nitrate
14. Phosphorus, total
15. Silica, soluble

Trace Metals

16. Selenium, total

Table 2.4. Methods for analyses of water quality parameters.

Parameter	Method	Preservation Technique	Reference	Detection Limit
** Alkalinity, total	Method 102	Refrigeration	A.P.H.A. et al. 1971	1 mg/l-$CaCO_3$
* Ammonia	Gas diffusion electrode	$HgCl_2$, refrigeration	Thomas and Booth 1973; Howe and Holley 1969	0.01 mg/l-N
	Method 132C	$HgCl_2$, refrigeration	A.P.H.A. et al. 1971; Howe and Holley 1969	0.01 mg/l-N
	Autoanalyzer colorimetric phenate method	$HgCl_2$, refrigeration	U.S.E.P.A. 1974 Howe and Holley 1969	0.01 mg/l-N
* Bacteria, fecal coliform	Method 408B	$Na_2S_2O_3$, sterile bottle, refrigeration	A.P.H.A. et al. 1971	0 organisms/ 100 ml
* Biochemical oxygen demand (5-day)	Method 219	Refrigeration	A.P.H.A. et al. 1971	0.5 mg/l
*** Calcium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	2 µg/l
*** Chloride	Method 112B	None required	A.P.H.A. et al. 1971	0.5 mg/l
	Autoanalyzer	None required	U.S.E.P.A. 1974	0.1 mg/l
* Chemical oxygen demand	Low level mehhod	Refrigeration	U.S.E.P.A. 1974	0.1 mg/l
* Color, true	Method 118	None required	A.P.H.A. et al. 1971	1 unit
** Conductance, specific	Method 154	None required	A.P.H.A. et al. 1971	1 µmho/cm
* Copper	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.01 mg/l
	Atomic absorption chelation	HNO_3	Fishman and Midgett 1968	0.1 µg/l
	Atomic absorption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	0.2 µg/l
* Hexane soluble	Soxhlet extraction	H_2SO_4 refrigeration	U.S.E.P.A. 1974	0.1 mg/l
** Iron[a]	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.03 mg/l
	Atomic absorption chelation	HNO_3	Fishman and Midgett 1968	1 µg/l
	Atomic absorption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	0.5 µg/l
* Lead	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.1 µm/l

Table 2.4. Continued.

Parameter	Method	Preservation Technique	Reference	Detection Limit
	Atomic absorption chelation	HNO_3	Fishman and Midgett 1968	1 µg/l
	Atomic absorption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	1 µg/l
*** Magnesium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	1 µg/l
** Manganese[b]	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.01 mg/l
* Mercury	Flameless atomic absorption	HNO_3	U.S.E.P.A. 1974	0.05 µg/l
** Nitrate	Method 213C	$HgCl_2$, refrigeration	A.P.H.A. et al. 1971; Howe and Holley 1969	0.01 mg/l-N
	Autoanalyzer cadmium reduction	$HgCl_2$, refrigeration	U.S.E.P.A. 1974; Howe and Holley 1969	0.01 mg/l-N
* Nitrite	Method II.6.	$HgCl_2$, refrigeration	Strickland and Parsons 1972; Howe and Holley 1969	0.1 µg/l-N
* Organic carbon, total	Method 138A	HCl, refrigeration	A.P.H.A. et al. 1971; Ocean. Int. Corp. (1974)a,b	1 mg/l
	Ocean. Int. Analyzer wet oxidation	HCl, refrigeration	Ocean. Inter. Corp. (1974)b.	0.2 mg/l
* Organic nitrogen, total	Methods 135 then 132C	$HgCl_2$, refrigeration	A.P.H.A. et al. 1971; Howe and Holley 1969	0.01 mg/l
* Orthophosphate, soluble	Method II.1.	Filtration, refrigeration	Strickland and Parsons 1972; Ryden et al. 1972	1 µg/l-P
* Oxygen, dissolved	Method 218B	Measured in the field	A.P.H.A. et al. 1971	0.1 mg/l
* Oxygen, saturation	Calculated method 218B	-	A.P.H.A. et al. 1971	Expressed as percent
* pH	Method 144A	Measured in the field	A.P.H.A. et al. 1971	0.1 pH
** Phosphorus, total	Method 223C then method II.1.	None required	A.P.H.A. et al. 1971; Strickland and Parsons 1972	1 µg/l-P
*** Potassium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	5 µg/l
** Residue, filtrable (total dissolved solids)	Method 148B	None required	A.P.H.A. et al. 1971	2 mg/l
* Residue, nonfiltrable (total suspended solids)	Method 148C	None required	A.P.H.A. et al. 1971	1 mg/l

Table 2.4. Continued.

Parameter	Method	Preservation Technique	Reference	Detection Limit
** Silica, soluble	Method 151C	Filtration	A.P.H.A. et al. 1971	0.01 mg/l-SiO_2
	Autoanalyzer method 105-71W	Filtration	Technicon Industrial Systems 1974	0.01 mg/l-SiO_2
*** Sodium	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	2 µg/l
** Sulfate	Method 156C	None required	A.P.H.A. et al. 1971	5 mg/l
	Autoanalyzer method 118-71 W	None required	Technicon Industrial System 1974	1 mg/l
** Temperature	Whitney Thermometer, method 162	Measured *in situ*	A.P.H.A. et al. 1971	0.1 C
* Turbidity	Hach Turbidimeter, method 163A	None required	A.P.H.A. et al. 1971	0.1 N.T.U.
* Zinc	Atomic absorption direct aspiration	HNO_3	Perkin-Elmer Corp. 1968	0.01 mg/l
	Atomic absorption chelation	HNO_3	Fishman and Midgett 1968	1 µg/l
	Atomic abosrption graphite atomizer	HNO_3	Perkin-Elmer Corp. 1972a	0.1 µg/l

* Measured in surface water samples only.

** Measured in surface water and groundwater samples.

*** Measured in groundwater samples only.

[a] Soluble iron determined by same method with prior filtration of sample.

[b] Soluble manganese in groundwater samples determined by same method with prior filtration of sample.

Table 2.5. Summary of minimum, maximum and mean concentrations for water quality parameters measured in the Neosho River and Wolf Creek, 1976.

Parameter	Range	Neosho River						Wolf Creek					
		Feb	Apr	Jun	Aug	Oct	Dec	Feb	Apr	Jun	Aug	Oct[a]	Dec[b]
General Water Quality													
Water temperature (°C)	N	3	3	3	3	3	3	4	4	4	4	2	
	Min	7.5	13.0	23.0	25.6	16.0	1.2	5.5	11.4	20.0	12.4	12.0	
	Max	9.1	16.0	24.0	26.6	17.4	1.5	6.5	13.1	20.5	21.0	12.5	
	Mean	8.6	15.0	23.3	25.9	16.9	1.3	6.2	12.2	20.2	16.7	12.3	
Oxygen, dissolved (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	10.4	8.7	6.5	6.0	7.7	12.8	3.1	4.2	2.3	1.9	5.3	
	Max	11.1	10.6	7.6	7.7	9.3	13.6	8.2	6.5	4.1	4.8	6.7	
	Mean	10.8	9.7	7.0	6.9	8.3	13.1	5.8	5.2	3.5	3.4	6.2	
Oxygen, saturation (%)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	85	89	76	73	80	89	25	40	25	20	49	
	Max	91	103	87	91	93	94	67	61	45	49	63	
	Mean	88	97	82	83	85	91	48	48	38	34	58	
pH	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	7.6	8.0	7.8	8.1	7.7	8.2	7.2	7.5	7.2	7.5	7.2	
	Max	7.9	8.4	7.9	8.2	8.0	8.5	7.9	7.8	7.5	7.8	7.4	
	Mean	7.8	8.3	7.9	8.2	7.9	8.3	7.6	7.7	7.4	7.7	7.3	
Alkalinity, total (mg/l-$CaCO_3$)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	174	188	156	152	145	184	136	155	147	109	118	
	Max	182	194	165	162	156	196	236	226	173	199	146	
	Mean	179	191	160	157	150	192	168	184	160	150	133	
Conductance, specific (μmhos/cm at 25 C)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	696	752	442	451	492	662	316	410	397	255	329	
	Max	725	783	453	481	507	678	517	508	505	436	340	
	Mean	706	766	448	466	496	671	382	481	434	352	336	
Residue, filtrable (solids, total dissolved) (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	414	464	294	279	306	401	187	270	274	186	225	
	Max	446	490	305	296	336	421	368	361	360	259	231	
	Mean	426	482	302	287	320	410	244	309	314	219	228	
Residue, nonfiltrable (solids, total suspended) (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	12	14	79	36	23	4	10	3	6	46	43	
	Max	65	26	137	53	46	11	123	175	396	148	57	
	Mean	29	19	105	42	33	7	47	48	118	88	51	

NALCO ENVIRONMENTAL SCIENCES

Table 2.5. Continued.

Parameter	Range	Neosho River Feb	Apr	Jun	Aug	Oct	Dec	Wolf Creek Feb	Apr	Jun	Aug	Oct[a]	Dec[b]
General Water Quality (continued)													
Turbidity (N.T.U.)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	5.0	5.0	68	15	18	5.0	5.0	1.0	15	34	39	
	Max	38	23	90	29	35	22	70	150	150	105	47	
	Mean	16	12	76	22	25	11	29	43	64	62	43	
Calcium (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	77	76	55	60	56	72	38	52	53	39	42	
	Max	81	79	57	64	64	75	66	64	57	63	48	
	Mean	79	78	56	62	60	74	50	59	54	52	46	
Chloride (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	17.9	35.0	11.0	16.0	25.0	42.0	5.8	4.9	5.2	3.0	4.1	
	Max	18.9	40.0	12.0	18.0	32.0	44.0	11.3	12.2	9.6	11.0	5.8	
	Mean	18.3	36.8	11.2	16.6	26.7	43.5	8.3	8.2	7.6	5.8	5.2	
Magnesium (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	25.8	25.6	14.0	15.0	17.0	20.8	7.5	8.8	9.4	6.7	9.7	
	Max	27.4	27.0	14.0	15.0	18.0	21.2	14.7	13.9	12.0	11.0	9.7	
	Mean	26.4	26.3	14.0	15.0	17.5	20.9	9.7	11.2	10.3	8.8	9.7	
Potassium (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	3.2	3.5	4.5	4.0	4.4	4.4	4.2	4.3	4.8	4.2	9.0	
	Max	3.9	4.4	5.1	4.2	4.9	4.5	9.7	10.0	6.4	5.9	9.2	
	Mean	3.5	4.0	4.7	4.0	4.6	4.4	6.3	7.4	5.7	4.9	9.1	
Sodium (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	26.8	29.6	12.0	14.0	19.0	29.5	6.5	9.4	14.0	7.6	5.5	
	Max	28.0	30.0	12.0	14.0	20.0	30.9	12.6	17.0	25.0	13.0	8.3	
	Mean	27.4	29.8	12.0	14.0	19.3	30.4	8.7	12.7	18.0	10.7	6.9	
Sulfate (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	112	127	53	58	67	94	8	15	32	25	26	
	Max	138	149	55	59	75	96	28	86	99	37	44	
	Mean	122	136	54	59	70	95	17	46	55	29	35	
Iron, soluble (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	0.005	0.060	0.044	0.030	0.014	<0.001	0.014	0.044	0.084	0.016	0.17	
	Max	0.036	0.34	1.0	0.093	0.14	0.003	0.15	0.31	0.54	0.18	0.57	
	Mean	0.017	0.15	0.30	0.055	0.066	0.001	0.060	0.17	0.22	0.089	0.35	

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Table 2.5. *Continued.*

Parameter	Range	Neosho River Feb	Apr	Jun	Aug	Oct	Dec	Wolf Creek Feb	Apr	Jun	Aug	Oct[a]	Dec[b]
General Water Quality (continued)													
Iron, total (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	0.29	0.31	1.7	0.48	0.57	0.084	0.72	0.22	0.56	1.2	1.8	
	Max	1.3	1.1	2.7	0.85	1.4	0.11	1.4	7.2	5.8	2.1	2.2	
	Mean	0.64	0.59	2.1	0.61	0.87	0.094	0.90	2.2	2.1	1.6	2.0	
Manganese, total (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	0.16	0.14	0.11	0.052	0.059	0.031	0.10	0.15	0.32	0.17	0.32	
	Max	0.18	0.25	0.13	0.10	0.089	0.045	0.77	0.28	1.2	0.96	0.67	
	Mean	0.17	0.21	0.12	0.088	0.076	0.037	0.30	0.21	0.58	0.41	0.49	
Color, true (units)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	7	8	17	9	10	8	22	20	24	20	31	
	Max	8	9	22	11	12	9	40	64	40	30	47	
	Mean	7	8	19	10	11	9	28	31	32	24	39	
Aquatic Nutrients													
Ammonia (mg/l-N)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	<0.01	<0.01	<0.01	0.01	0.01	0.01	<0.01	<0.01	<0.01	0.01	0.01	
	Max	<0.01	0.03	0.03	0.03	0.03	0.08	<0.01	0.02	0.23	0.08	0.02	
	Mean	<0.01	0.01	0.02	0.02	0.02	0.05	<0.01	<0.01	0.08	0.04	0.02	
Nitrate (mg/l-N)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	<0.01	<0.01	0.51	<0.01	0.01	<0.01	<0.01	0.01	0.05	<0.01	0.04	
	Max	0.07	0.14	0.57	0.80	0.32	0.06	<0.01	0.06	0.50	0.17	0.36	
	Mean	0.03	0.04	0.55	0.30	0.16	0.03	<0.01	0.02	0.17	0.10	0.20	
Nitrite (mg/l-N)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	0.0025	0.0008	0.049	0.0003	0.0020	0.0014	0.0016	0.0003	0.0081	0.0005	0.002	
	Max	0.0067	0.0025	0.13	0.0084	0.012	0.0039	0.0053	0.0013	0.011	0.0093	0.010	
	Mean	0.0046	0.0014	0.081	0.016	0.006	0.0027	0.0029	0.0009	0.0092	0.0048	0.006	
Nitrogen, total organic (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	0.53	0.66	0.68	0.62	0.74	0.55	0.74	0.67	0.98	0.86	0.88	
	Max	1.1	0.76	0.95	0.91	0.85	0.72	2.2	2.0	1.5	1.1	1.0	
	Mean	0.87	0.71	0.81	0.74	0.78	0.61	1.1	0.99	1.1	0.97	0.95	
Orthophosphate, soluble (mg/l-P)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	0.016	0.018	0.062	0.002	0.020	0.010	0.015	0.019	0.013	0.001	0.013	
	Max	0.052	0.049	0.072	0.040	0.051	0.063	0.059	0.075	0.072	0.028	0.083	
	Mean	0.030	0.032	0.068	0.024	0.030	0.042	0.038	0.037	0.041	0.006	0.044	

Table 2.5. Continued.

Parameter	Range	Neosho River Feb	Apr	Jun	Aug	Oct	Dec	Wolf Creek Feb	Apr	Jun	Aug	Oct[a]	Dec[b]
Aquatic Nutrients (continued)													
Phosphorus, total (mg/l-P)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	0.075	0.068	0.17	0.11	0.34	0.022	0.049	0.072	0.11	0.12	0.19	
	Max	0.95	0.10	0.28	0.14	0.57	0.073	0.39	0.26	0.47	0.20	0.29	
	Mean	0.38	0.087	0.21	0.12	0.40	0.048	0.16	0.13	0.22	0.15	0.23	
Silica, soluble ($mg/l-SiO_2$)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	0.18	0.36	6.2	6.4	3.2	0.22	1.9	3.6	2.0	4.0	4.7	
	Max	0.64	0.78	6.6	6.7	4.5	0.31	15	7.4	9.8	9.0	5.3	
	Mean	0.41	0.59	6.4	6.5	3.6	0.26	8.5	4.9	5.8	6.9	4.9	
Indicators of Industrial and Municipal Contamination													
Bacteria fecal coliform (organisms/100 ml)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	0	1	47	3	170	0	0	4	20	20	1600	
	Max	110	11	530	110	330	730	150	23	2600	120	2600	
	Mean	44	7	240	62	260	260	40	10	780	65	2100	
Bacteria, fecal streptococci (organisms/100 ml)	N			6	6	6	6			6	8	4	
	Min	-[c]	-	23	5	160	0	-	-	980	11	2000	
	Max	-	-	330	32	280	80	-	-	3600	220	2800	
	Mean	-	-	160	15	215	25	-	-	2400	99	2600	
Biochemical oxygen demand (5-day) (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	2.9	2.1	0.6	0.8	1.2	1.0	2.1	1.9	1.2	1.6	4.4	
	Max	4.6	3.0	1.8	3.4	2.0	2.8	7.3	4.4	5.8	3.0	5.4	
	Mean	3.7	2.6	1.0	2.0	1.6	1.7	4.4	3.0	3.0	2.4	4.9	
Chemical oxygen demand (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	24	14	20	12	16	15	27	26	23	9.3	35	
	Max	31	17	23	16	18	17	120	52	43	16	43	
	Mean	26	16	22	14	17	16	53	39	32	13	40	
Hexane soluble materials (mg/l)	N	6	6	5	6	6	6	7	8	5	6	4	
	Min	0.1	<0.1	<0.1	<0.1	0.3	0.2	0.1	<0.1	0.2	<0.1	0.8	
	Max	0.6	1.0	0.5	1.2	0.9	1.4	1.1	0.6	0.5	0.2	2.8	
	Mean	0.3	0.3	0.2	0.3	0.7	0.8	0.6	0.2	0.3	0.1	1.4	
Organic carbon, total (mg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	6.4	7.2	8.0	6.2	6.9	6.0	10	9.0	11	11	15	
	Max	10	8.8	9.4	8.7	7.5	7.2	40	20	21	13	20	
	Mean	7.8	8.0	8.6	7.2	7.2	6.6	18	14	15	12	17	

Table 2.5. Continued.

Parameter	Range	Neosho River						Wolf Creek					
		Feb	Apr	Jun	Aug	Oct	Dec	Feb	Mar	Jun	Aug	Oct[a]	Dec[b]
Trace Metals													
Copper, total (μg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	1.4	0.8	2.6	2.8	1.6	1.3	1.7	0.2	1.6	3.0	2.1	
	Max	4.3	2.4	5.5	4.4	2.4	1.9	3.9	5.4	7.6	6.6	2.5	
	Mean	2.6	1.3	3.7	3.5	1.9	1.5	2.7	2.0	3.4	4.6	2.3	
Lead, total (μg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	1	<1	2	1	<1	<1	12	<1	<1	3	2	
	Max	6	1	4	6	2	<1	38	7	12	96	3	
	Mean	3	<1	3	3	<1	<1	22	2	4	20	2	
Mercury, total (μg/l)	N	6	6	6		6	6	8	8	8		4	
	Min	5.0	0.26	0.38	-[c]	0.62	0.20	11	0.28	0.26	-[c]	0.56	
	Max	98	1.0	2.0	-[c]	1.3	0.95	69	0.47	0.89	-[c]	1.0	
	Mean	30	0.59	0.78	-[c]	0.89	0.36	22	0.37	0.51	-[c]	0.80	
Selenium (μg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	2	1	9	<1	3	1	<1	<1	9	<1	3	
	Max	7	4	12	3	6	1	4	3	11	2	5	
	Mean	4	2	11	<1	4	1	2	1	10	1	4	
Zinc (μg/l)	N	6	6	6	6	6	6	8	8	8	8	4	
	Min	5	12	2.2	6.0	7.9	1.2	6.3	3.5	1.4	8.1	12	
	Max	11	16	6.6	13	14	14	15	40	88	18	18	
	Mean	7.4	15	4.1	8.1	11.5	6.3	9.1	16	22	12	15	

[a] Locations 3 and 5 were dry.
[b] Locations 3 and 5 were dry, and Locations 7 and 2 were frozen.
[c] Not determined.

NALCO ENVIRONMENTAL SCIENCES

Table 2.6. Seasonal water quality data from the Neosho River upstream and downstream of the confluence with Wolf Creek, 1973-76.[a,b]

Parameter	Year	Location 10 (upstream)[c] Spring	Summer	Fall	Winter	Location 4 (downstream) Spring	Summer	Fall	Winter
General Water Quality									
Water temperature (°C)	1973					9.2	24.6	23.0	2.5
	1974	5.0	19.7	19.6	0.9	-[d]	20.0	19.5	0.9
	1975	11.0	21.2	24.1	2.8	11.0	21.2	23.6	2.8
	1976	16.0	24.0	17.4	1.5	16.0	24.0	17.4	1.5
Oxygen, dissolved (mg/l)	1973					12.1	7.7	7.4	14.1
	1974	13.5	8.8	8.7	13.5	13.5	8.8	8.7	13.5
	1975	10.4	5.7	7.5	13.3	10.5	5.9	7.1	12.6
	1976	9.1	7.0	7.8	12.9	9.8	6.6	8.0	12.9
Oxygen, saturation (%)	1973					102	92	85	120
	1974	90	91	94	99	-[d]	97	94	100
	1975	93	60	80	98	95	62	75	93
	1976	93	82	81	90	99	77	82	90
pH	1973					8.2	8.2	7.9	7.6
	1974	7.9	8.0	7.7	8.2	7.8	8.2	7.6	8.0
	1975	8.1	7.2	7.8	7.5	8.2	7.1	7.9	7.7
	1976	8.4	7.9	8.1	8.3	8.4	7.9	8.2	8.3
Alkalinity, total (mg/l-$CaCO_3$)	1973					114	173	194	135
	1974	190	154	141	175	200	164	140	178
	1975	155	139	171	191	153	97	175	195
	1976	193	157	148	194	190	158	146	195
Filtrable residue (mg/l)	1973					213	307	223	238
	1974	315	297	218	228	325	284	214	263
	1975	281	283	313	338	348	223	315	385
	1976	473	304	307	412	485	296	320	409
Conductance, specific (µmhos/cm at 25 C)	1973					293	462	510	375
	1974	525	459	367	462	538	458	368	475
	1975	430	380	512	600	431	274	514	606
	1976	756	453	492	677	758	443	495	672
Nonfiltrable residue (mg/l)	1973					98	48	41	43
	1974	29	89	39	115	42	194	40	93
	1975	93	140	30	4	86	192	37	3
	1976	19	85	42	31	14	95	47	24
Turbidity[e] (N.T.U.)	1973					70	50	23	51
	1974	21	50	6	44	28	80	7	46
	1975	58	120	27	10	73	185	33	8
	1976	8.0	72	22	6.0	6.0	70	20	7.0
Color true (units)	1973					27	14	12	24
	1974	16	17	18	15	16	18	20	15
	1975	21	24	11	8	17	52	12	9
	1976	8	18	11	9	8	17	11	9
Aquatic Nutrients									
Ammonia (mg/l-N)	1973					0.12	0.03	0.01	0.18
	1974	0.19	0.04	0.03	0.22	0.17	0.05	0.02	0.21
	1975	0.15	0.07	0.01	0.03	0.18	0.06	<0.01	0.04
	1976	<0.01	0.03	0.02	0.09	<0.01	0.01	0.02	0.06

Table 2.6. Continued.

Parameter	Year	Location 10 (upstream) Spring	Summer	Fall	Winter	Location 4 (downstream) Spring	Summer	Fall	Winter
Aquatic Nutrients (continued)									
Nitrate (mg/l-N)	1973					0.77	1.2	0.70	0.79
	1974	-[d]	2.0	0.49	0.93	1.4	2.2	0.28	0.89
	1975	1.1	1.2	0.55	0.53	1.3	0.67	0.60	0.52
	1976	0.01	0.57	0.15	0.06	0.02	0.57	0.01	0.03
Nitrite (mg/l-N)	1973					0.015	0.12	0.0018	0.012
	1974	0.025	0.040	0.026	0.011	0.023	0.044	0.032	0.011
	1975	0.020	0.018	0.032	0.045	0.022	0.014	0.028	0.0045
	1976	0.0011	0.056	0.004	0.0029	0.0009	0.061	0.002	0.0037
Organic nitrogen (mg/l)	1973					0.62	0.57	0.86	0.73
	1974	0.50	0.66	0.62	0.66	0.56	0.83	0.60	0.63
	1975	0.93	1.0	0.57	0.42	0.96	1.4	0.60	0.51
	1976	0.74	0.71	0.80	0.58	0.73	0.83	0.80	0.57
Orthophosphate, soluble (mg/l-P)	1973					0.11	0.16	0.066	0.073
	1974	0.067	0.075	0.055	0.093	0.066	0.079	0.057	0.091
	1975	0.015	0.080	0.034	0.031	0.018	0.061	0.037	0.026
	1976	0.035	0.069	0.038	0.063	0.044	0.070	0.026	0.044
Phosphorus, total (mg/l-P)	1973					0.23	0.15	0.12	0.21
	1974	0.11	0.16	0.089	0.16	0.12	0.21	0.11	0.16
	1975	0.21	0.24	0.088	0.041	0.18	0.35	0.088	0.034
	1976	0.097	0.18	0.37	0.071	0.094	0.24	0.38	0.049
Silica, soluble (mg/l-SiO_2)	1973					10.3	7.3	5.5	8.9
	1974	8.8	11.5	4.9	10.4	8.9	8.4	5.9	10.7
	1975	5.1	8.4	3.7	0.31	5.2	8.5	3.8	0.34
	1976	0.54	6.3	6.5	0.26	0.66	6.3	4.1	0.29
Industrial and Municipal Contaminants									
Bacteria, fecal coliform (no./100 ml)	1973					67	43	46	680
	1974	81	41	-[d]	170	81	52	370	190
	1975	215	170	97	38	170	230	135	45
	1976	10	190	320	550	9	480	170	110
Biochemical oxygen demand (5 day) (mg/l)	1973					2.6	2.4	1.5	1.3
	1974	4.8	1.7	0.8	1.1	5.1	2.1	0.7	1.2
	1975	2.7	2.3	0.5	2.0	3.3	2.3	1.1	1.7
	1976	2.6	0.6	1.6	1.2	3.0	0.7	1.8	1.3
Chemical oxygen demand (mg/l)	1973					22	20	16	21
	1974	15	17	15	16	16	21	17	17
	1975	32	23	14	17	28	37	15	21
	1976	17	21	16	15	17	22	16	17
Organic carbon, total (mg/l)	1973					8	6	20	13
	1974	18	9	10	14	21	9	9	14
	1975	28	21	11	9.1	30	24	13	7.6
	1976	8.1	8.3	7.5	6.7	8.4	8.1	7.0	6.6
Hexane soluble materials (mg/l)	1973					<0.1	0.2	1.7	1.6
	1974	1.1	1.7	<0.1	0.2	0.5	1.2	<0.1	0.2
	1975	0.7	2.2	1.4	1.7	0.5	1.5	1.7	0.9
	1976	<0.1	0.3	0.8	0.6	0.2	0.1	0.6	0.9

Table 2.6. Continued.

Parameter	Year	Location 10 (upstream) Spring	Summer	Fall	Winter	Location 4 (downstream) Spring	Summer	Fall	Winter
Trace Metals									
Copper, total (μg/l)	1973					3.0	4.1	1.8	2.2
	1974	1.5	4.9	5.7	5.7	1.6	8.5	5.0	5.3
	1975	3.8	6.5	2.3	1.6	5.3	9.9	1.6	2.6
	1976	0.8	2.7	1.7	1.4	1.2	3.2	1.7	1.5
Iron, total (mg/l)	1973					3.8	2.9	1.0	1.0
	1974	0.85	2.1	2.1	2.1	0.88	3.7	2.0	2.0
	1975	3.0	6.1	0.92	0.22	3.9	11.0	1.0	1.0
	1976	0.41	1.8	0.69	0.088	0.32	1.9	0.58	0.089
Manganese, total (mg/l)	1973					0.57	0.18	0.090	0.11
	1974	0.066	0.068	0.071	0.074	0.068	0.13	0.072	0.082
	1975	0.10	0.15	0.056	0.030	0.13	0.22	0.075	0.032
	1976	0.25	0.13	0.065	0.036	0.25	0.11	0.074	0.032
Mercury, total (μg/l)	1973					0.14	0.07	0.06	0.11
	1974	0.08	0.07	<0.05	0.61	0.05	0.05	<0.05	0.32
	1975	6.5	1.0	0.76	0.54	8.7	1.7	0.92	1.2
	1976	0.76	1.3	0.95	0.28	0.47	0.61	0.83	0.61
Zinc, total (μg/l)	1973					<1	8	1	1
	1974	15	60	39	12	18	26	47	11
	1975	17	28	5.8	1.8	13	46	6.4	3.3
	1976	15	3.5	8.2	13	14	2.2	14	4.4

[a] Means of duplicate samples.
[b] Spring water quality data collected in March 1973-74 and April 1975, 1976.
[c] Location 10 not included in 1973 study.
[d] Not determined.
[e] Turbidity prior to April 1975 reported in JTU.

Table 2.7. Water quality criteria for Kansas Surface waters.[a] (Applicable to Neosho River.)

Parameter	Criterion	Locations and Months in which the Standards were violated
Temperature, water	32.2C (90F)	None
Oxygen, dissolved	Not less than 5 mg/l	None
pH	6.5 to 8.5	None
Ammonia	0.15 mg/l-N maximum	None
Bacteria, fecal coliform	Not to exceed 2000 per 100 ml sample	None
Oil and grease	No evidence of visible oil or grease	None
Turbidity and total suspended solids	No increases from other than natural origin	None
Color	No man-made point source discharges of color producing substances	None
Taste and odor producing substances	No increases from man-made point discharges	None
Toxic substances	Man-made point discharges limited to concentrations in receiving water that will not harm human or aquatic life	None

[a] Kansas State Board of Health (1973).

Table 2.8. Desirable water quality criteria for various uses. All values are maximums unless minimum or range is given.

Parameter	Water Supply Uses: Public Water Supply	Irrigation	Livestock and Wildlife Water Supply	Support of Fish and Aquatic Life
General Water Quality				
Temperature (°C)				
Oxygen, dissolved (mg/l)			5.0[b]	4.2[a], 5.8[c]
pH	4.0-7.0[a]	4.5-9.0[a,b,c,d]	7-9.2[b,d], 6-9[c]	6.5-8.4[a,d] 6-9[b,c]
Alkalinity, total (mg/l-$CaCO_3$)			170[a], 130[b,c,d]	100-200[a]
Calcium (mg/l)	30[a]		1000[a]	15-52[a]
Magnesium (mg/l)	100[a]	24[a]	500[a]	7-14[a]
Sodium (mg/l)	10[a]	100[a], 75% of total ions[a]	2000[a]	10-85[a]
Potassium (mg/l)	1000[a]			400[a]
Chloride (mg/l)	250[f]	100[a]	1500[a]	170[a]
Fluoride (mg/l)	0.7-1.2[a,b] 1.4-2.4[d]	10.0[a], 2.0[c,d]	1.0[a], 2.0[c,d]	1.5[a]
Sulfate (mg/l)	500[a], 250[b,c,d,f]	200[a]	500[a]	32-90[a]
Solids, total dissolved (mg/l)	1000[a], 500[b]	700[a], 500[b] 5000[c,d]	2500[a], 1000[b]	2000[a]
Solids, total suspended (mg/l)			80[c], 25[d]	
Conductance, specific (umhos/cm at 25 C)		2000[a], 3000[e]		4000[a]
Turbidity (N.T.U.)	5-250[a], 5[f]			25[a], 50[b]
Colors (Pt-Co Units)	100[a], 15[f]			
Odor (number)	3[f]			
Aquatic nutrients				
Ammonia (mg/l-N)	0.05-0.10[a] 0.5[b,c,d]			0.02[c,d]
Nitrate (mg/l-N)	10[b,c,d,f]		100(NO_3+NO_2)[c,d]	0.9-4.2[a]
Nitrite (mg/l-N)	2[a]		10[c]	
Orthophosphate (mg/l-P)	0.4[a]			
Silica (mg/l-SiO_2)		10-50[a]		0.5(minimum)[a]
Toxic Contaminants				
Bacteria, Total coliform (No./100ml)	10000[b,c] 20000[d], 1[f]		2000[c]	
Bacteria, fecal coliform (No./100ml)	2000[b,c,d], 1[f]	1000[c]	2000[c]	

Table 2.8. Continued.

Parameter	Water Supply Uses: Public Water Supply	Irrigation	Livestock and Wildlife Water Supply	and Aquatic
Oxygen demand, biochemical (mg/l)	4.0[a]			
Chlorine, total (mg/l)	90[a]	50[a]		0.003[c,d]
Cyanide (mg/l)	0.01[a],0.2[b,c,d,f]			0.005[c,d]
Hexane soluble materials (mg/l)	0.1[a],absent[b] nonvisible[c,d]		30[a] nonvisible[c,d]	None on surface and 1000 mg/kg in sediment[c,d]
Methylene blue-active substances (mg/l)	0.5[c,d,f]			0.5[a],0.2[b,c,d]
Trace Elements				
Aluminum (mg/l)		1.0[b],5.0[c,d]	5.0[c,d]	
Arsenic (mg/l)	0.05[a,b,f],0.1[c,d]	1.0[a,b],0.1[c,d]	1.0[a],0.05[b],0.2[c,d]	1.0[a]
Barium (mg/l)	1.0[a,f]0.05[b],0.1[c,d]			5.0[a]
Beryllium (mg/l)	1.0[b,c,d]	0.5[b],0.1[c,d]		12[a]
Boron (mg/l)		2.0[b,e],1.0[c,d]	0.5[d]	
Cadmium (mg/l)	0.01[a,f],0.1[b,c,d]	0.005[b],0.01[c,d]	0.1[a],0.05[a,c,d]	0.01[a],0.03[c,d]
Chromium (mg/l)	0.05(+6)[a,f]	0.1[c,d],5.0[b]	5.0[a],0.05[b],1.0[c,d]	0.05[a,c,d],0.02[b]
Cobalt (mg/l)		0.2[b],0.05[c,d]	1.0[c,d]	
Copper (mg/l)	1.0[a,b,c,d,f]	0.1[a],0.02[b,c,d]	0.5[c,d]	0.02[a]
Iron (mg/l)	0.3[a,b,c,d,f]	5.0[c,d]		0.2[a]
Lead (mg/l)	0.05[a,b,c,d,f]	5.0[b,c,d]	0.05[b,d],0.1[c]	0.1[a],0.03[c,d]
Lithium (mg/l)	5[a]	5.0[b],2.5[c,d]		
Manganese (mg/l)	0.05[a,c,d,f],0.5[b]	0.5[a],2.0[b],0.2[c,d]	10[a]	1.0[a]
Mercury (mg/l)	0.005[a],0.002[c,d]		1.0[c],10[d]	0.004[a],0.05[c,d]
Molybdenum (mg/l)		0.005[b],0.01[c,d]		
Nickel (mg/l)		0.5[a,b],0.2[c,d]	5[a]	1.0[a]
Selenium (mg/l)	0.05[a,f],0.01[c,d]	0.05[b],0.02[a,c,d]	0.5[a],0.01[b],0.05[a,d]	2.0[a]
Zinc	5.0[a,b,c,d,f]	5.0[b],2.0[d]	25.0[c,d]	0.1[a]

[a] Criteria taken from McKee and Wolf (1963).

[b] National Technical Advisory Committee criteria in U. S. Environmental Protection Agency (1973).

[c] U. S. Environmental Protection Agency (1973).

[d] National Academy of Science criteria in U. S. Environmental Protection Agency (1973).

[e] U. S. Department of Agriculture recommendations in U. S. Department of Agriculture (1954).

[f] U. S. Public Health Service criteria in U. S. Department of Health, Education and Welfare (1962).

Chapter 3

PHYTOPLANKTON STUDIES

By

Phillip A. Kline and Steven D. Reetz

I. Introduction

The phytoplankton community is an essential component of the aquatic environment. These organisms represent the initial link in the aquatic food chain from which other biological communities, either directly or indirectly, derive nutrient requirements. Although adequate phytoplankton quantities are required for aquatic food webs, large populations of some taxa can impair water quality.

Data describing the phytoplankton community of the Neosho River near Wolf Creek Generating Station (WCGS) were collected quarterly in 1973, 1974 and 1975 (Kansas Gas and Electric Company 1974; Wilde et al. 1975; Wilde and Reetz 1976). The results are discussed herein of continuing investigations conducted during 1976 to provide additional data on the phytoplankton populations that may be affected by construction and operation of WCGS.

Specific objectives of the 1976 study were:

1. To document seasonal and year-to-year variations in phytoplankton composition, abundance, biomass (biovolume and chlorophyll a concentrations), and primary productivity (carbon fixation rate) of phytoplankton communities in Wolf Creek and the Neosho River; and

2. To assess the environmental impact of construction of Wolf Creek Generating Station on phytoplankton populations.

II. Field and Analytical Procedures

Duplicate composite water samples for phytoplankton analyses were collected bimonthly at seven locations (Figure 3.1). Additional samples were collected at Location 1 on 3 May and 12 July. Drought conditions prevented the sampling of one or more Wolf Creek locations in October and December. All samples were collected within one meter of the surface with a nonmetallic water sampler. Subsamples were immediately placed in appropriately labeled 1.9 liter polyethylene bottles containing 60 ml of "M^3" preservative (Meyer 1971) for later algal identification, enumeration, and biovolume determinations. Carbon fixation rate and chlorophyll a concentration were assessed from the remaining portions of the duplicate samples.

Two separate procedures were used to analyze the preserved samples. A subsample volume of 10 to 100 ml was used for diatom analyses. Diatoms were cleaned with a concentrated nitric acid/potassium dichromate solution and collected on a 0.45 μ pore size membrane filter. The filter was air-dried and a portion was placed on a glass slide, cleared with immersion oil, and covered with a coverslip. The slide was then examined at 1250X magnification with a microscope equipped with phase contrast. A modification of Lackey's (1938) microtransect method was used to analyze the non-diatom phytoplankton. An 875 ml subsample volume from each sample was placed in a 1000 ml beaker. Liquid detergent was added to break the surface tension (Mackenthun 1969), and the organisms were allowed to settle overnight. The supernatant was removed with a suction pump, and the organisms were further concentrated in successively smaller containers until a density suitable for counting was attained. A 0.1 ml aliquot of the concentrate was placed in a slide and examined at 500X magnification with a microscope equipped with phase contrast.

An area of the coverslip large enough to permit the accurate estimation of the density and diversity of phytoplankton populations was examined for each preparation. All undamaged organisms were identified to the lowest positive taxonomic level using keys by Hustedt (1930), Huber-Pestalozzi (1941, 1968), Smith (1950), Hortobagyi (1960), Prescott (1962, 1964), Patrick and Reimer (1966), Cocke (1967), Stoermer and Yang (1969), Taft and Taft (1971), Weber (1971), and Whitford and Schumacher (1973). Densities were reported as the number of units per milliliter of water (units/ml). A reporting unit consisted of a single frustule for diatoms. For algae other than diatoms, a reporting unit consisted of a single cell for unicellular forms, a 100 μ length for filamentous forms and four cells for all colonial forms other than species of Aphanocapsa, Aphanothece, and Microcystis for which 50 cells comprised a reporting unit. Phytoplankton species diversity was calculated to the base e (Shannon 1948).

Biovolume (cell volume) determinations were made using methods described by Cowell (1960) and Hohn (1969). Biovolume was computed for each taxon using the formula for the geometric configuration that most resembled the shape of the organism. The average biovolume of at least 10 randomly selected individuals was used for abundant forms, and the average biovolume of all individuals examined was used for those observed less than 10 times. All biovolumes were expressed as microliters per liter (μl/l).

The non-preserved portion of the composite samples was analyzed for carbon fixation rate and chlorophyll a concentration. Carbon fixation rate was estimated by the light-dark bottle ^{14}C method (Wetzel 1964; Parkos et al. 1969; Strickland and Parsons 1972). Three 50 ml subsamples were taken from each composite, inoculated with 4-5 microcuries of aqueous ^{14}C bicarbonate solution, and incubated for 3 hr in a constant light (≈1000 ft-c) and temperature (adjusted to near ambient) chamber. The subsamples were then filtered through 0.45 μ porosity filters. The filters were returned to the laboratory, dried, fumed with concentrated HCl for 10 min (Wetzel 1965), and placed in low potassium scintillation vials. Seventeen milliliters of scintillation fluid (12 g/l Butyl PBD, 0.4 g/l PBBO, and 180 ml/l Scintisol-GB in spectrophotometric grade toluene) were added to each vial and the activity was measured with a refrigerated liquid scintillation counter. Carbon fixation rate was expressed as milligrams of carbon fixed per cubic meter per hour (mg C/m^3 per hr).

Chlorophyll a concentration was determined by flouorometric techniques of Lorenzen (1966) and Strickland and Parsons (1972). Three 50 ml subsamples from each composite sample were filtered through glassfiber filter papers on a thin layer of $MgCO_3$. The filters were eluted with 90% acetone for at least 24 hr, ultrasonically disrupted, and centrifuged. The fluorescence was measured before and after the addition of 1 N HCl. Chlorophyll a concentration was expressed as milligrams per cubic meter of water (mg Chl a/m^3).

III. Results and Discussion

Detailed results of phytoplankton analyses are contained in Appendix B.

A. Neosho River

Samples collected from locations in the Neosho River primarily

reflected the discharge of phytoplankton from John Redmond Reservoir. Differences between Location 1 and the downstream locations resulted from the settling out of organisms and the sloughing of individuals from substrates in the river (Chandler 1937; Hynes 1970). Phytoplankton composition, density, species diversity, and biovolume were fairly uniform at all river locations; however, the similarity was greatest at Locations 10 and 4 (Figure 3.2). In contrast to 1975, little seasonal variation in phytoplankton density was evident in 1976 with moderately low values (3000 to 10000 units/ml) recorded on all but two collection dates. However, densities >40000 units/ml and <3000 units/ml were recorded on 25 February and 14 December, respectively (Table 3.1). Carbon fixation rate and chlorophyll a concentration did not demonstrate a seasonal pattern. Variability among sampling dates was less pronounced than in previous years and was generally limited to differences between Location 1 and the two downstream locations (10 and 4).

Diatom taxa were numerically dominant at the river locations on all collection dates, ranging from 445 units/ml (Location 4) on 14 December to 39199 units/ml (Location 4) on 25 February (Table 3.1). Diatoms normally dominate the phytoplankton of streams throughout most of the year (Williams 1964). Centric diatoms including *Stephanodiscus astraea*, *S. hantzschii*, *S. minutus*, *Cyclotella atomus*, and *C. meneghiniana* have dominated the phytoplankton of the Neosho River on all sampling dates from 1973 through 1976. The prevalence of centric diatoms may be related to the turbidity of John Redmond Reservoir; species of *Cyclotella* and *Stephanodiscus* have been described as turbidity-tolerant (Hutchinson 1967). Total diatom biovolume ranged from 0.13 µl/l (Location 4) to 16.32 µl/l (Location 1) on 14 December and 25 February, respectively (Appendix B).

Green algae (Chlorophyta) were generally common and comprised up to 3912 units/ml at Location 10 on 25 February (Table 3.1). No seasonal pattern in the occurrence of green algae was noted in 1976. Seasonal increases in densities of green algae usually occur when ambient water temperatures remain at 30-35C (Patrick 1969); however, the maximum water temperature recorded at Locations 10 and 4 was 26.6C on 10 August (Chapter 2). Densities of green algae in spring and fall collections were higher than in previous years, whereas summer and winter densities were similar to those reported in 1973 (Figure 3.3). *Chlamydomonas* sp., a coccoid unicellular form, was the only numerically important green alga in samples collected from the river (Table 3.4).

Cryptophytes (Cryptophyta) were present on all collection dates with a maximum density of 960 units/ml recorded on 25 February. Densities were low throughout 1976 with seasonal values similar to those reported in 1973 (Figure 3.3). Principal cryptophyte taxa included *Cryptomonas ovata*, *Cryptomonas* sp., *Rhodomonas minuta* var. *nannoplanktonica*, and *Rhodomonas* sp. (Table 3.4).

Euglenoids (Euglenophyta) were a relatively unimportant group, except on 5 October when *Trachelomonas* sp. dominated the phytoplankton both in density and biovolume at Location 4 (Appendix B). Euglenoids often become abundant in pool habitats (Hutchinson 1967), particularly after extended periods of elevated water temperatures (Hynes 1970). The abundance of this taxon at Location 4 (Table 3.4) was probably related to the minimal stream flow since mid-July.

Blue-green algae (Cyanophyta), chrysophytes (Chrysophyta), or dinoflagellates (Pyrrophyta) never comprised more than 2% of the community at any location during the study (Table 3.1). A pulse of the colonial blue-green alga Merismopedia tenuissima was recorded in all previous September collections (Kansas Gas and Electric Company 1974; Wilde et al. 1975; Wilde and Reetz 1976); however, no indication of a pulse was noted on 10 August or 5 October which may indicate that it was of short duration or that no pulse occurred in 1976.

Maximum phytoplankton densities in the Neosho River were recorded on 25 February (31437 units/ml at Location 1 to 43799 units/ml at Location 4) (Table 3.1). Previously, the highest phytoplankton density recorded in the river was 17791 units/ml on 16 April 1975 (Wilde and Reetz 1976). Although the density of phytoplankton was high on 25 February, very low silica values (Appendix A, Table A.1) and relatively low carbon fixation rates (Table 3.2) suggest that the phytoplankton populations were declining. Principal taxa at all three locations included the centric diatoms, Stephanodiscus astraea, S. hantzschii and Stephanodiscus sp. (Table 3.4); species of Stephanodiscus often exhibit a spring maxima (Lowe 1974). Phytoplankton community characteristics were similar at the three locations; however, the downstream locations (Locations 10 and 4) were most alike.

Phytoplankton densities on 6 April were considerably lower than those collected in February. Densities ranged from 5655 units/ml at Location 1 to 7641 units/ml at Location 4 (Table 3.1). Densities were lower than those recorded during the corresponding collection date in 1975, but higher than those reported on similar dates in 1973 and 1974 (Figure 3.3). The centric diatom Stephanodiscus astraea numerically dominated the phytoplankton. Stephanodiscus hantzschii, Stephanodiscus sp., the pennate diatom Nitzschia dissipata, and Chlamydomonas sp., a green alga, were also common (Table 3.4). Biovolume, diversity, and number of taxa of phytoplankton at Locations 10 and 4 were slightly higher than at Location 1 (Table 3.5; Appendix B). Carbon fixation rate (Table 3.2) and chlorophyll a concentration (Table 3.3) displayed no trends.

On 3 May samples were collected only from Location 1. Phytoplankton density (8137 units/ml) was similar to that reported in April. Stephanodiscus sp. replaced S. astraea as the most abundant taxon. Other common taxa included the centric diatoms Cyclotella atomus, Stephanodiscus invisitatus, and S. minutus.

Centric diatoms were again abundant on 15 June when Stephanodiscus astraea, Stephanodiscus sp., and Cyclotella meneghiniana were the more common taxa. Similarity among the three river locations in species composition, density, biovolume, chlorophyll a concentration, and carbon fixation rate was probably the result of increased stream flow earlier in the month (Chapter 2). Total phytoplankton densities ranged from 7440 units/ml at Locations 10 to 8721 units/ml at Location 1 (Table 3.1). Total density, chlorophyll a concentration, and carbon fixation rate were higher in June 1976 than on corresponding collection dates in previous years. Phytoplankton biovolume, diversity, and the number of taxa encountered were similar to those reported in previous years.

Only Location 1 was sampled on 12 July. The community was domianted by Stephanodiscus minutus and the pennate diatom Nitzschia fonticola. Cyclotella meneghiniana, Stephanodiscus astraea, and Stephanodiscus sp. were also common. Total phytoplankton density was 6537 units/ml, slightly lower than in June (Table 3.1).

Stephanodiscus minutus and Cyclotella meneghiniana were the principal taxa at Location 1 on 10 August, whereas C. meneghiniana and Chlamydomonas sp. comprised over 65% of the density at the downstream locations (Table 3.4). Phytoplankton densities ranged from 3549 units/ml at Location 1 to 22695 units/ml at Location 4 (Table 3.1). Downstream locations which were generally similar during periods of low stream flow showed a large difference in density (10138 units/ml at Location 10 vs 22695/ml at Location 4). However, comparisons of composition, diversity, number of taxa, carbon fixation rates, and chlorophyll a concentrations (biomass indicator) indicated similar community structure at the two locations.

Phytoplankton densities on 5 October ranged from 3398 units/ml at Location 10 to 8360 units/ml at Location 1 (Table 3.1). Similarity was noted among the locations in composition, and the slight differences in density, biovolume, and species diversity were attributed to the occurrence of the pennate diatom Nitzschia sp. at Location 1 and the euglenoid Trachelomonas sp. at Location 4. Other abundant taxa included Cyclotella meneghiniana and Chlamydomonas sp. Carbon fixation rate and chlorophyll a concentration were higher at Location 4 than at Locations 1 and 10.

Phytoplankton densities were low on 14 December, ranging from 701 units/ml at Location 4 to 3076 units/ml at Location 1 (Table 3.1). Low chlorophyll a concentration and carbon fixation rate at Locations 10 and 4 were indicative of the reduced densities. Composition was similar at the three locations with centric diatoms comprising over 50% of the phytoplankton. Principal taxa included the centric diatoms Stephanodiscus astraea, Cyclotella atomus, C. pseudostelligera, and Thalassiosira sp., and the cryptophyte Rhodomonas sp. Locations 10 and 4 were again similar in composition and diversity; differences between upstream and downstream locations resulted from the greater abundance of cryptophytes at Location 1 and pennate diatoms at Locations 10 and 4.

The minor differences in the Neosho River phytoplankton community upstream (Location 10) and downstream (Location 4) of the confluence with Wolf Creek were not attributable to construction activities within the drainage area. Flow from Wolf Creek into the Neosho River was not evident on the dates of collection.

B. Wolf Creek

Phytoplankton samples collected from Wolf Creek showed considerable inter-location variation in carbon fixation rates, chlorophyll a concentrations, density, biovolume, diversity, and community composition. Variations in these characteristics and generally low densities were probably due to the lack of stream flow which necessitated sampling from isolated shallow pools on all collection dates. Locations 3 and 5 were dry on 5 October and all creek

locations were either dry or frozen on 14 December. Phytoplankton populations were also limited by shading from bordering stands of hardwood vegetation during the growing season. Later in the year, leaf litter added considerable color which further reduced the amount of light available to primary producers. The lack of precipitation resulted in the concentration of minerals and nutrients (Chapter 2). Williams (1964) reported that after a prolonged period of little or no flow, toxic materials may accumulate and be reflected in low plankton density. Gerhold and Otto (1976) used water samples from the Wolf Creek site in bioassay experiments and found that a two-fold concentration of nutrients by evaporation retarded growth of Selenastrum capricornum.

Diatoms comprised from 6.2 (Location 7 on 25 February) to 99.5% (Location 2 on 10 August) of the phytoplankton during 1976 (Table 3.1). As in previous years, periphytic pennate diatoms were generally the principal taxa; small streams rarely support true phytoplankton populations (Hynes 1970). Common taxa included species of the pennate genera Nitzschia, Navicula, Diploneis, Fragilaria, Achnanthes and species of the centric genera Cyclotella, Melosira, and Stephanodiscus.

Green algae were abundant only on 25 February, comprising up to 31.1% of the phytoplankton (Figure 3.4). Principal taxa included Dictyosphaerium pulchellum, Ankistrodesmus falcatus and Chlamydomonas sp. No green algal taxon comprised more than 10% of the phytoplankton on the remaining collection dates.

Chrysophytes were numerically important in the 25 February and 6 April collections. Seasonal occurrence of chrysophytes in temperate climates is generally restricted to winter months (Whitford and Schumacher 1973). Chromulina sp., Uroglena soniaca, and Synura uvella were the most abundant taxa. Densities of chrysophytes were highest in February (19266 units/ml; Table 3.1).

Cryptophytes were abundant on most collection dates, ranging from 3 units/ml on 10 August to 88675 units/ml on 25 February (Figure 3.4). The most abundant taxa included Chroomonas sp., Cryptomonas ovata, Cryptomonas sp., and Rhodomonas minuta var. nannoplanctonica. Cryptophytes are found throughout the United States in habitats ranging widely in organic content (Smith 1950).

Blue-green algae, euglenoids, dinoflagellates, and chloromonadophytes (Chloromonadophyta) were rare, generally comprising <5% of the phytoplankton.

Phytoplankton densities in samples collected on 25 February ranged from 962 units/ml at Location 3 to 173,954 units/ml at Location 7 (Table 3.1). The phytoplankton communities were dominated by cryptophytes at Location 7, pennate diatoms and chrysophytes at Location 2, and pennate diatoms at Location 5. Cryptophytes, blue-green algae, and pennate diatoms were codominants at Location 3. Principal taxa included Chroomonas sp. (49.1% at Location 7), Chromulina sp. (35.2% at Location 2), Cryptomonas sp. (27% at Location 3), and Nitzschia acicularis (26.6% at Location 5). Highest carbon fixation rate (36.36 mg C/m^3 per hr) and chlorophyll a concentration (51.67 mg chl a/m^3) were recorded at Location 7 which corresponded to peak phytoplankton density

(Tables 3.2 and 3.3). Carbon fixation rate and chlorophyll a concentration were considerably lower at downstream locations.

Excluding slightly higher density and chlorophyll a concentration at Location 7 and a higher rate of carbon fixation at Location 3, the only major difference among locations on 6 April was restricted to variations in species composition. Diatom taxa dominated the communities at Locations 7 and 5, whereas chrysophytes were most abundant at Locations 2 and 3. Uroglena soniaca, a chrysophyte, comprised 50.8% of the phytoplankton density at Location 2. Location 3 was dominated by the chrysophyte Synura uvella (76.5%). The pennate diatoms Fragilaria construens and F. pinnata comprised 29 and 18.7%, respectively, of the community at Location 7. Principal taxa at Location 5 included Cryptomonas ovata (16.5%), Nitzschia acicularis (15.6%), and N. palea (11.6%).

Similar species composition at all locations on 15 June suggested that flow had existed in the creek at some time since 6 April. Diatoms were dominant with principal taxa including Cyclotella meneghiniana, Nitzschia sp., Navicula sp., and Diploneis pseudovalis. Phytoplankton densities increased progressively from upstream to downstream locations, ranging from 1364 units/ml at Location 7 to 8299 units/ml at Location 5 (Table 3.1). Corresponding values of carbon fixation rate and chlorophyll a concentration also demonstrated a downstream increase. Carbon fixation rate ranged from 3.59 to 36.98 mg C/m^3 per hr at Locations 7 and 5, respectively (Table 3.2), whereas chlorophyll a concentration increased from 2.37 mg Chl a/m^3 at Location 7 to 27.00 mg Chl a/m^3 at Location 5 (Table 3.3).

Phytoplankton samples collected on 10 August showed considerable variation in composition and density and only slight variation in carbon fixation rate and chlorophyll a concentration. The communities were dominated numerically by centric diatoms and cryptophytes at Location 7, pennate diatoms at Location 2, centric and pennate diatoms at Location 3, and centric diatoms at Location 5. Principal taxa included Melosira ambigua and Cryptomonas ovata at Location 7; Diploneis pseudovalis and Stephanodiscus sp. at Location 2; Nitzschia acicularis, Melosira distans, and Stephanodiscus minutus at Location 3; and Cyclotella meneghiniana and Nitzschia sp. at Location 5 (Table 3.4). Densities ranged from 2778 units/ml at Location 7 to 10234 units/ml at Location 2 (Table 3.1). Because of major differences in community composition, a relationship could not be established between densities and values of biovolume, carbon fixation rate, and chlorophyll a concentration.

Only Locations 7 and 2 were sampled on 5 October as the remaining locations contained no water. Although phytoplankton density varied from 2945 units/ml at Location 7 to 9997 units/ml at Location 2; species composition and diversity at the two locations indicated similar community development (Tables 3.1 and 3.5). Principal taxa included species of the pennate diatoms Nitzschia, Navicula, Diploneis, and Achnanthes. Phytoplankton biovolume paralleled density, while chlorophyll a concentration and carbon fixation rate demonstrated an inverse relationship with slightly higher values at Location 7 than at Location 2.

Hydrological conditions in Wolf Creek have varied considerably during the four-year study period (Chapter 2). Extreme variation in the physical characteristics of the Wolf Creek environment has resulted in wide spatial and year-to-year variability in the phytoplankton community. Below normal precipitation with a corresponding lack of surface runoff prohibited an assessment of the effects of construction on phytoplankton populations in Wolf Creek.

IV. Summary and Conclusions

1. Centric diatoms including species of *Cyclotella* and *Stephanodiscus* were the principal taxa in the Neosho River in 1976 as well as in previous monitoring studies, and their prevalence may be related to the turbidity of John Redmond Reservoir. Important non-diatom taxa included the green alga *Chlamydomonas* sp. and species of the cryptophyte genera *Cryptomonas* and *Rhodomonas*. The pulse of the blue-green alga *Merismopedia tenuissima* which has been noted in previous years was not recorded in 1976.

2. There was little seasonal variation in the density of phytoplankton collected from the Neosho River with moderately low values (3000 to 10000 units/ml) recorded on all but two dates. Lowest density was recorded on 14 December at Location 4 (701 units/ml), whereas the highest density occurred at Location 1 on 25 February (43799 units/ml).

3. Phytoplankton carbon fixation rates and chlorophyll *a* concentrations from the Neosho River did not demonstrate any seasonal patterns. Carbon fixation rates in the Neosho River ranged from 4.84 mg C/m^3 per hr on 14 December to 95.6 mg C/m^3 per hr on 10 August. Chlorophyll *a* concentrations were lowest on 14 December (2.5 mg/m^3) and highest on 5 October (19.7 mg/m^3).

4. Slight differences in density and carbon fixation were noted between the upstream and downstream locations in the Neosho River on most collection dates.

5. Phytoplankton samples collected from Wolf Creek showed considerable inter-location variation in carbon fixation rate, chlorophyll *a* concentration, density, biovolume, diversity, and composition. Variation of these community characteristics and generally low densities were attributed to the lack of stream flow which necessitated that sampling be conducted in isolated shallow pools on all collection dates.

6. Wolf Creek phytoplankton populations were generally dominated by pennate diatoms and phytoflagellates, primarily Cryptophyta and Chrysophyta.

7. No effect of construction activity on phytoplankton populations was found in either the Neosho River or Wolf Creek.

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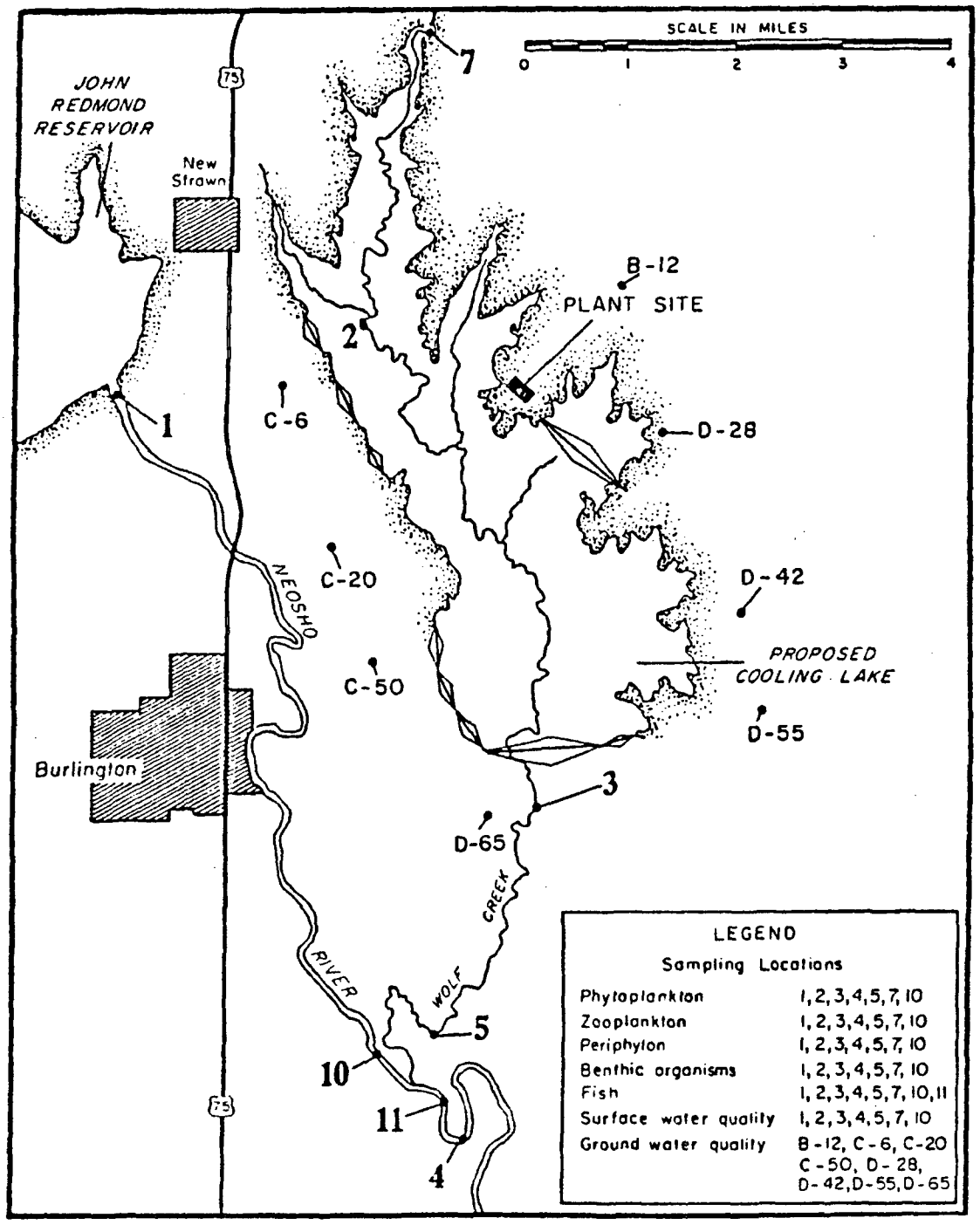

Figure 3.1. Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

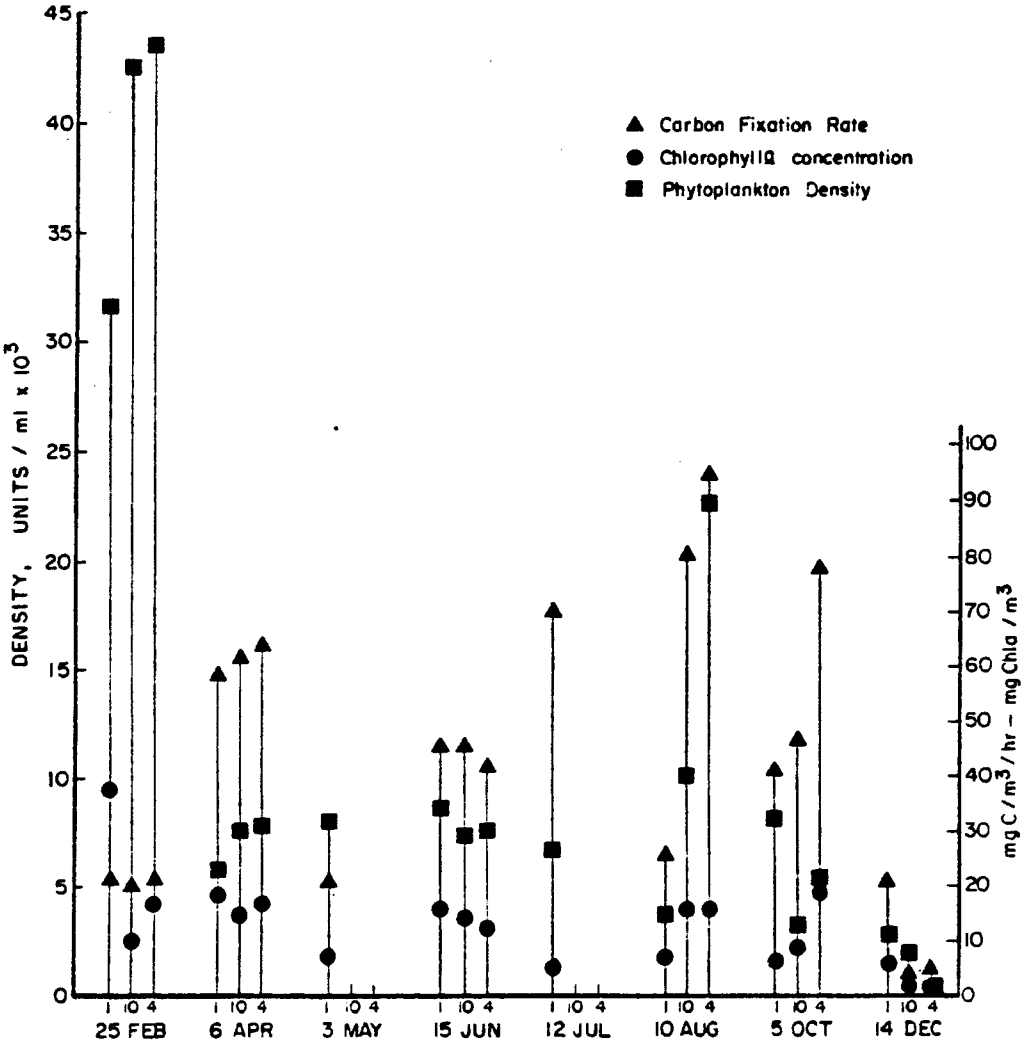

Figure 3.2. Comparison of carbon fixation rate, chlorophyll a concentration and density of phytoplankton collected from the Neosho River (Locations 1, 10, and 4) in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

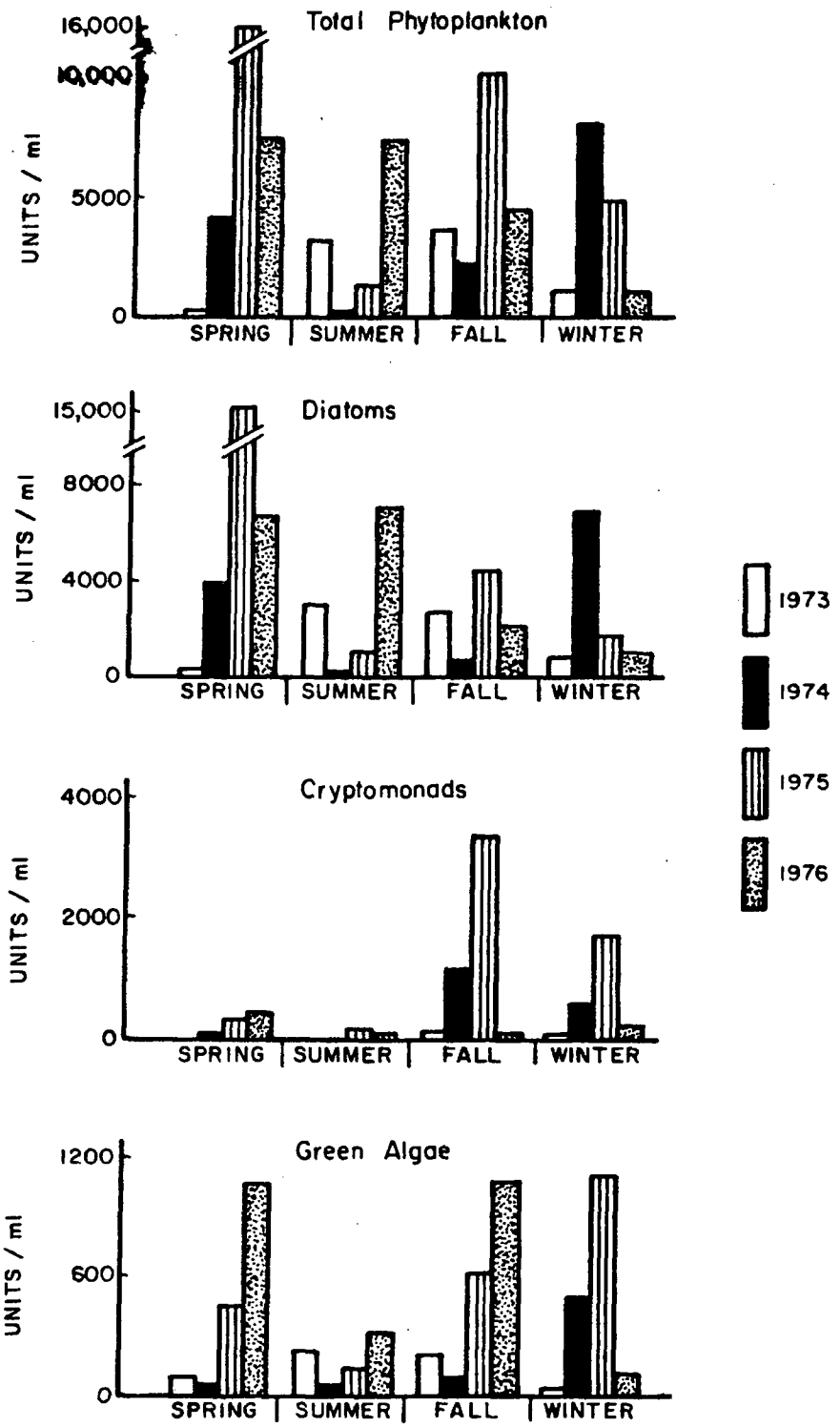

Figure 3.3. Seasonal and year-to-year variations of phytoplankton in the Neosho River (Locations 10 and 4 mean) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-76.

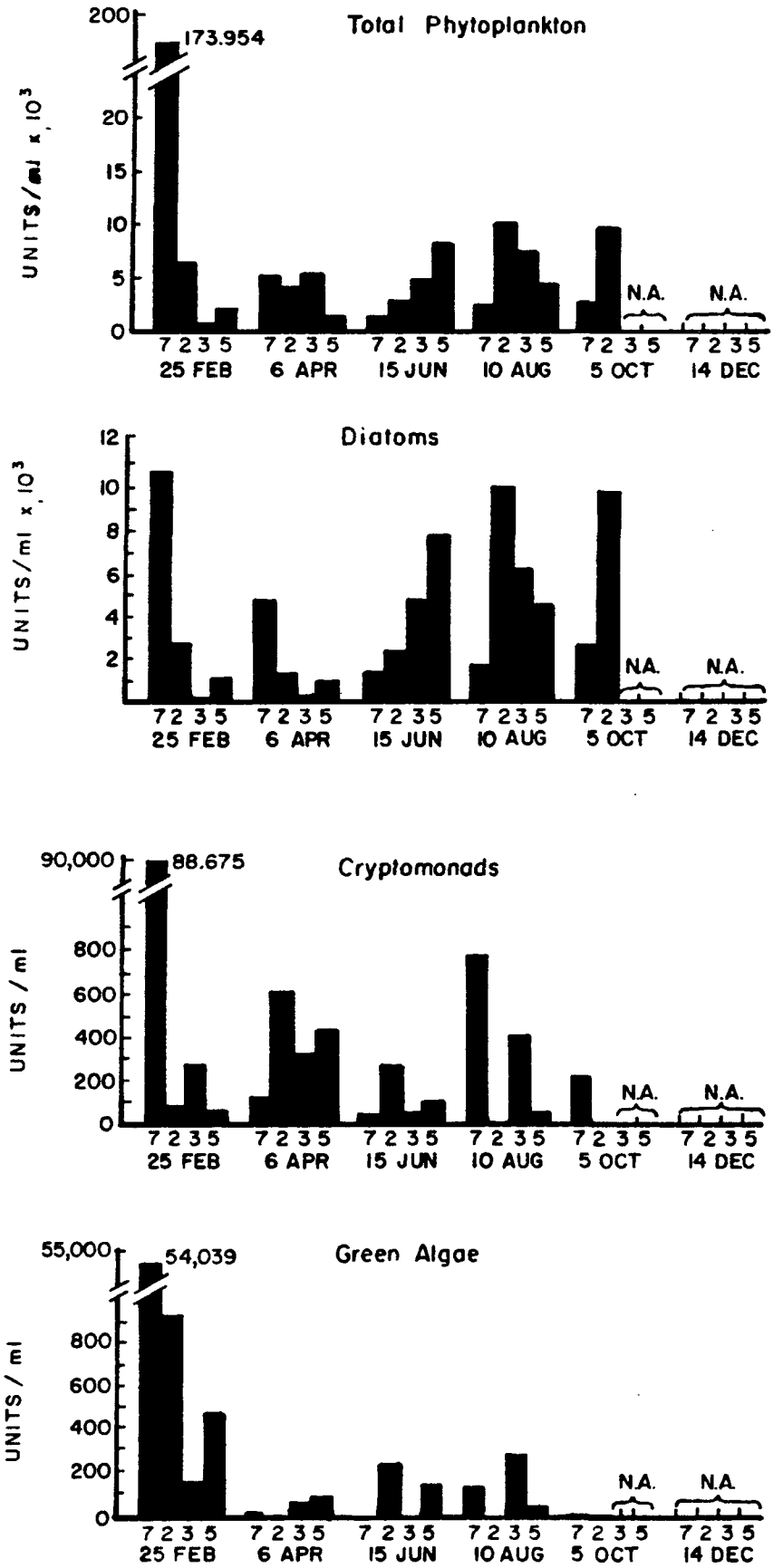

Figure 3.4. Seasonal comparison of the major groups of phytoplankton in Wolf Creek (Locations 7, 2, 3 and 5) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

Table 3.1. Summary of phytoplankton densities and percent occurrence from samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

	Sampling Locations													
	Neosho River						Wolf Creek							
	1		10		4		7		2		3		5	
Date/Taxon	Units per ml	%	Units per ml	%	Units per ml	%	Units per ml	%	Units per ml	%	Units per ml	%	Units per ml	%
25 February														
Bacillariophyta	30,264	96.27	37,062	87.20	39,199	89.50	10,805	6.21	2,662	41.06	169	17.59	1,013	50.13
Centrales[a]	29,569	94.06	34,457	81.07	36,527	83.40	269	0.15	27	0.41				
Pennales[a]	694	2.21	2,604	6.13	2,671	6.10	10,530	6.06	2,635	40.64	169	17.59	1,013	50.13
Chlorophyta	829	2.64	3,912	9.20	3,434	7.83	54,039	31.07	900	13.88	159	16.51	487	24.10
Chrysophyta			360	0.84	180	0.41	19,266	11.08	2,628	40.52	69	7.13	266	13.18
Cyanophyta	26	0.08	76	0.18	16	0.04					180	18.69	19	0.92
Euglenophyta	22	0.07	109	0.26	55	0.12	1,091	0.62	27	0.42	23	2.35	111	5.50
Pyrrhophyta	14	0.04	22	0.05	11	0.02	78	0.04	185	2.86	80	8.27	69	3.39
Cryptophyta	283	0.89	960	2.26	136	0.31	88,675	50.98	82	1.26	283	29.38	56	2.78
Chloromonadophyta											1	0.07		
Total Phytoplankton	31,437	100.00	42,501	100.00	43,799	100.00	173,954	100.00	6,484	100.00	962	100.00	2,021	100.00
6 April														
Bacillariophyta	4,096	72.44	6,629	86.82	5,599	73.28	4,839	94.22	1,264	32.36	638	12.31	926	54.92
Centrales[a]	3,995	70.65	5,072	66.42	4,595	60.13	1,348	26.24	58	1.49	5	0.08	64	3.80
Pennales[a]	101	1.78	1,557	20.39	1,005	13.15	3,492	67.98	1,206	30.88	633	12.31	862	51.12
Chlorophyta	1,029	18.20	692	9.06	1,351	17.69	37	0.71	15	0.38	60	1.16	73	4.35
Chrysophyta	61	1.07	15	0.19	44	0.57			1,988	50.91	4,135	79.80	201	11.95
Cyanophyta			7	0.09			2	0.05						
Euglenophyta	120	2.12	29	0.38	52	0.67	131	2.55			16	0.32	23	1.37
Pyrrophyta			22	0.29	8	0.11	10	0.19	16	0.42			19	1.13
Cryptophyta	349	6.17	242	3.17	586	7.67	117	2.28	622	15.92	333	6.42	443	26.28
Total Phytoplankton	5,655	100.00	7,636	100.00	7,641	100.00	5,136	100.00	3,905	100.00	5,181	100.00	1,686	100.00
3 May[b]														
Bacillariophyta	7,821	96.11												
Centrales[a]	7,195	88.42												
Pennales[a]	626	7.69												
Chlorophyta	183	2.25												
Cyanophyta	8	0.09												
Euglenophyta	48	0.59												
Cryptophyta	78	0.95												
Total Phytoplankton	8,137	100.00												

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Table 3.1. Continued.

Date/Taxon	Sampling Locations													
	Neosho River						Wolf Creek							
	1		10		4		7		2		3		5	
	Units per ml	%	Units per ml	%	Units per ml	%	Units per ml	%	Units per ml	%	Units per ml	%	Units per ml	%
15 June														
Bacillariophyta	8,029	92.07	7,059	94.89	7,181	94.83	1,325	97.10	2,416	81.40	4,893	97.64	7,973	96.07
Centrales[a]	7,628	87.47	6,543	87.95	6,433	84.95	160	11.75	311	10.49	21	0.43	3,138	37.81
Pennales[a]	401	4.59	516	6.94	748	9.87	1,165	85.36	2,105	70.91	4,872	97.21	4,835	58.25
Chlorophyta	642	7.35	337	4.53	340	4.49	1	0.10	233	7.83	5	0.11	141	1.70
Chrysophyta					19	0.25			3	0.09			4	0.05
Cyanophyta	2	0.03			1	0.02	1	0.10	10	0.34	19	0.38	5	0.06
Euglenophyta	8	0.09	8	0.11	15	0.20	1	0.10	23	0.78	49	0.98	68	0.82
Cryptophyta	40	0.45	35	0.48	16	0.22	35	2.60	284	9.55	45	0.89	108	1.30
Total Phytoplankton	8,721	100.00	7,440	100.00	7,572	100.00	1,364	100.00	2,968	100.00	5,012	100.00	8,299	100.00
12 July[b]														
Bacillariophyta	5,936	90.81												
Centrales[a]	4,661	71.30												
Pennales[a]	1,202	18.39												
Chlorophyta	406	6.22												
Chrysophyta	25	0.38												
Cyanophyta	132	2.01												
Euglenophyta	5	0.08												
Pyrrhophyta	3	0.04												
Cryptophyta	23	0.35												
Total Phytoplankton	6,537	100.00												
10 August														
Bacillariophyta	3,369	94.93	8,132	80.21	18,488	81.46	1,587	57.14	10,181	99.48	6,322	86.74	4,505	98.07
Centrales[a]	2,599	73.21	7,140	70.43	14,348	63.22	954	34.34	2,564	25.06	2,933	40.25	2,712	59.03
Pennales[a]	771	21.72	992	9.78	4,140	18.24	633	22.80	7,616	74.42	3,388	46.49	1,793	39.04
Chlorophyta	117	3.30	1,654	16.32	3,870	17.05	121	4.37	15	0.15	282	3.87	33	0.71
Chrysophyta			5	0.05	3	0.01	136	4.91			205	2.81	1	0.03
Cyanophyta	11	0.31	128	1.26	132	0.58	1	0.05			16	0.22		
Euglenophyta	20	0.58	56	0.55	93	0.41	131	4.71	18	0.17	46	0.63	3	0.06
Pyrrophyta			3	0.03	3	0.01	1	0.05						
Cryptophyta	31	0.88	160	1.57	106	0.47	799	28.77	20	0.20	417	5.72	52	1.13
Total Phytoplankton	3,549	100.00	10,138	100.00	22,695	100.00	2,778	100.00	10,234	100.00	7,289	100.00	4,594	100.00

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Table 3.1. Continued.

	Sampling Locations													
	Neosho River						Wolf Creek							
	1		10		4		7		2		3		5	
Date/Taxon	Units per ml	%	Units per ml	%	Units per ml	%	Units per ml	%	Units per ml	%	Units per ml	%	Units per ml	%
5 October														
Bacillariophyta	8,137	97.33	2,627	77.30	1,986	36.63	2,653	90.22	9,963	99.69	-[c]		-	
Centrales[a]	3,516	42.06	1,024	30.14	1,193	22.01	392	13.32	410	4.10				
Pennales[a]	4,621	55.27	1,603	47.17	792	14.62	2,262	76.90	9,554	95.59				
Chlorophyta	178	2.13	629	18.52	1,484	27.39	10	0.32	2	0.02				
Chrysophyta							26	0.88	3	0.03				
Cyanophyta					46	0.85	14	0.46	7	0.06				
Euglenophyta	20	0.24	135	3.97	1,890	34.87	8	0.28	16	0.16				
Cryptophyta	25	0.29	7	0.20	14	0.25	230	7.83	3	0.03				
Total Phytoplankton	8,360	100.00	3,398	100.00	5,420	100.00	2,941	100.00	9,994	100.00				
14 December														
Bacillariophyta	1,967	63.97	1,027	64.68	445	63.56	-		-		-		-	
Centrales[a]	1,914	62.23	805	50.72	318	50.03								
Pennales[a]	53	1.74	222	13.96	87	13.53								
Chlorophyta	343	11.16	150	9.44	126	17.95								
Chrysophyta	3	0.08	3	0.17										
Cyanophyta	33	1.06	4	0.26	1	0.19								
Euglenophyta	4	0.13	1	0.08										
Pyrrophyta	3	0.08	12	0.77	10	1.36								
Cryptophyta	723	23.50	161	10.13	119	16.93								
Total Phytoplankton	3076	100.00	1,588	100.00	701	100.00								

[a]Values for this order of Bacillariophyta presented separately due to their relative importance in the phytoplankton.

[b] Sampling on this date restricted to Location 1.

[c] Samples not collected; location either frozen or dry.

NALCO ENVIRONMENTAL SCIENCES

Table 3.2. Mean carbon fixation rate (mg C/m^3 per hr) from phytoplankton samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-76.

	Sampling Locations						
	Neosho River			Wolf Creek			
Sampling Date	1[a]	10	4	7	2	3	5
25 February 1976	21.66	20.35	20.82	36.36	11.08	5.78	1.79
12 April 1973	3.51	-[b]	3.96	-	6.57	2.99	-
27 March 1974	18.29	17.45	18.90	-	7.31	11.60	14.85
16 April 1975	90.90	125.98	130.65	11.03	12.33	33.82	27.72
6 April 1976	58.82	62.25	64.23	13.90	15.10	43.58	11.50
3 May 1976	21.11	-	-	-	-	-	-
12 June 1973	29.61	-	22.34	-	8.33	22.11	-
11 June 1974	15.57	0.15	11.40	-	2.32	1.40	2.10
10 June 1975	14.24	6.87	2.54	5.15	3.33	2.36	1.61
15 June 1976	45.79	45.97	41.07	3.59	26.34	32.82	36.98
12 July 1976	71.12	-	-	-	-	-	-
10 August 1976	26.23	80.69	95.59	43.86	61.47	53.81	26.89
11 September 1973	28.00	-	35.06	-	45.39	51.71	-
10 September 1974	7.30	5.62	5.94	-	47.89	14.51	10.16
9 September 1975	44.26	36.82	24.66	9.23	14.69	-	93.34
5 October 1976	41.58	46.35	79.01	20.83	8.74	-	-
12 December 1973	5.45	-	5.21	-	0.39	0.25	-
10 December 1974	24.83	22.92	22.92	-	4.05	5.72	2.55
3 December 1975	32.18	10.39	10.38	25.49	0.36	7.09	2.50
14 December 1976	21.39	5.27	4.84	-	-	-	-

[a] Samples collected within John Redmond Reservoir in 1973, 1974, and 1975.
[b] Samples not collected.

NALCO ENVIRONMENTAL SCIENCES

Table 3.3. Mean chlorophyll a concentration (mg chl a/m^3) from phytoplankton samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-76.

	Sampling Locations						
	Neosho River			Wolf Creek			
Sampling Date	1[a]	10	4	7	2	3	5
25 February 1976	38.67	11.67	17.33	51.67	4.63	1.46	1.63
12 April 1973	1.58	-[b]	1.93	-	4.63	2.49	-
27 March 1974	8.77	6.57	7.54	-	5.40	9.00	9.04
16 April 1975	34.97	33.33	34.00	2.59	6.30	14.20	12.43
6 April 1976	18.33	15.37	16.63	7.57	3.30	5.80	3.93
3 May 1976	6.67	-	-	-	-	-	-
12 June 1973	8.13	-	2.23	-	1.01	1.44	-
11 June 1974	0.70	0.77	0.80	-	0.74	2.14	1.74
10 June 1975	3.67	1.84	2.27	2.00	2.07	2.43	2.54
15 June 1976	16.00	14.23	12.77	2.37	7.93	10.90	27.00
12 July 1976	11.43	-	-	-	-	-	-
10 August 1976	7.27	16.00	16.00	13.57	12.10	14.67	6.67
11 September 1973	13.41	-	19.75	-	5.75	4.67	-
10 September 1974	4.14	1.83	0.80	-	10.63	3.54	3.30
9 September 1975	10.97	10.34	6.70	3.57	6.17	10.07	30.00
5 October 1976	7.17	9.73	19.73	7.90	5.37	--	-
12 December 1973	3.57	-	3.13	-	0.28	0.39	-
10 December 1974	10.50	9.17	9.00	-	2.07	3.17	2.68
3 December 1975	21.67	6.57	7.87	9.27	1.75	10.50	3.29
14 December 1976	6.33	2.99	2.53	-	-	-	-

[a] Samples collected within John Redmond Reservoir in 1973, 1974, and 1975.
[b] Samples not collected.

NALCO ENVIRONMENTAL SCIENCES

Table 3.4. Summary of numerically dominant phytoplankton taxa and percent of total phytoplankton density from samples collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

	Sampling Locations						
	Neosho River			Wolf Creek			
Date	1	10	4	7	2	3	5
25 February	Stephanodiscus hantzschii (46.31) S. astraea (37.30)	Stephanodiscus hantzschii (37.71) S. sp. (27.47) S. astraea (14.77)	Stephanodiscus hantzschii (37.35) S. sp. (24.62) S. astraea (15.55)	Chroomonas sp. (49.09) Dictyosphaerium pulchellum (12.68) Ankistrodesmus falcatus (12.30)	Chromulina sp. (35.16) Chlamydomonas sp. (12.45)	Cryptomonas sp. (27.03) Oscillatoria sp. (16.91) Chlamydomonas sp. (15.26)	Nitzschia acicularis (26.55) Chlamydomonas sp. (21.86) Chromulina sp. (12.46) N. palea (12.56)
6 April	Stephanodiscus astraea(44.30) S. sp. (13.93)	Stephanodiscus astraea (27.63) S. sp. (17.01) S. hantzschii (11.00) Nitzschia dissipata (11.00)	Stephanodiscus astraea (27.24) Chlamydomonas sp. (11.31) S. hantzschii (10.89) S. sp. (9.76)	Fragilaria construens (28.97) F. pinnata (18.72) Cyclotella meneghiniana (9.58)	Uroglena sociaca (50.77) Rhodomonas minuta var. nannoplanctica (15.50)	Synura uvella (76.53)	Cryptomonas ovata (16.50) Nitzschia acicularis (15.61) N. palea (11.61)
3 May[a]	Stephanodiscus sp. (51.60) Cyclotella atomus (13.75)						
15 June	Stephanodiscus sp. (29.40) Cyclotella meneghiniana (17.15) S. astraea(14.80) S. minutus (9.90)	Stephanodiscus sp. (29.56) Cyclotella meneghiniana (19.87) Stephanodiscus astraea (17.47) S. minutus (10.41)	Stephanodiscus astraea (20.81) S. sp. (19.75) Cyclotella meneghiniana (19.28) S. minutus (11.99)	Navicula sp. (14.88) Nitzschia frustulum (9.78)	-[b]	Nitzschia sp. (32.40) Navicula sp. (10.66) Diploneis pseudovalis (10.45)	Cyclotella meneghiniana (16.84) Nitzschia sp. (9.65)
12 July[a]	Stephanodiscus minutus (38.72) Nitzschia fonticola (18.39) S. astraea(9.70)						

NALCO ENVIRONMENTAL SCIENCES

Table 3.4. Continued.

Date	Sampling Locations						
	Neosho River			Wolf Creek			
	1	10	4	7	2	3	5
10 August	Stephanodiscus minutus (36.55) Cyclotella meneghiniana (16.99)	Cyclotella meneghiniana (53.37) Chlamydomonas sp. (14.51)	Cyclotella menighiniana (49.52) Chlamydomonas sp. (15.89)	Cryptomonas ovata (26.16) Melosira ambigua (14.56)	Diploneis pseudovalis (33.04) Stephanodiscus sp. (20.43)	Nitzschia acicularis (21.57) Melosira distans (15.29) Stephanodiscus minutus (12.98)	Cyclotella meneghiniana (24.92) Nitzschia sp. (12.46)
5 October	Nitzschia sp. (46.33) Cyclotella meneghiniana (10.86)	Chlamydomonas sp. (17.62) Cyclotella meneghiniana (12.32) Nitzschia sp. (10.22)	Chlamydomonas sp. (26.34) Trachelomonas sp. (34.65)	Nitzschia sp. (24.22) Navicula sp. (14.83)	Nitzschia sp. (17.55) Diploneis sp. (17.02) Navicula hustedeii (14.25) Navicula sp. (11.23) Achnanthes sp. (10.33)	-[a]	-
14 December	Stephanodiscus astraea (32.13) Rhodomona sp. (19.29) Thalassiosira sp. (11.12)	Cyclotella atomus (12.28) Cyclotella pseudostelligera (11.19)	Cyclotella pseudostelligera (13.44) Rhodomonas sp. (10.70)	-	-	-	-

[a] Sampling on this date restricted to Location 1.
[b] No taxa present comprising ≥ 10% of the phytoplankton.
[c] Samples not collected; location either frozen or dry.

NALCO ENVIRONMENTAL SCIENCES

Table 3.5. Shannon's species diversity indices for phytoplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

Date	Location		Species-Diversity	Eveness Value	Number of Taxa	Number of Organisms	Redundancy
25 February	Neosho River	1	1.3909	0.4078	31	31,436	0.5942
		10	2.0322	0.5658	37	42,504	0.4355
		4	1.9975	0.5415	40	43,802	0.4599
	Wolf Creek	7	1.8277	0.4775	46	173,955	0.5231
		2	2.4743	0.6233	53	6,486	0.3842
		3	2.4349	0.7058	32	961	0.3177
		5	2.2235	0.6940	25	2,022	0.3161
6 April	Neosho River	1	2.2728	0.6123	41	5,655	0.3951
		10	2.4719	0.6475	46	7,640	0.3581
		4	2.5581	0.6740	45	7,639	0.3311
	Wolf Creek	7	2.5603	0.6995	39	5,138	0.3065
		2	2.0128	0.5393	42	3,900	0.4732
		3	1.3910	0.4968	21	5,181	0.5189
		5	2.8622	0.7765	40	1,689	0.2366
3 May[a]	Neosho River	1	1.9141	0.4987	47	8,137	0.5088
15 June	Neosho River	1	2.3173	0.6024	47	8,724	0.4032
		10	2.1861	0.5990	39	7,442	0.4067
		4	2.4500	0.6357	48	7,573	0.3703
	Wolf Creek	7	2.6667	0.8342	25	1,363	0.1736
		2	3.1981	0.7921	57	2,966	0.2173
		3	2.6580	0.6813	50	5,007	0.3265
		5	3.1333	0.7610	62	8,305	0.2434
12 July[a]	Neosho River	1	2.1650	0.5642	47	6,538	0.4438
10 August	Neosho River	1	2.3318	0.6434	38	3,553	0.3667
		10	1.8897	0.4873	49	10,141	0.5192
		4	1.9393	0.4945	51	22,694	0.5087
	Wolf Creek	7	2.6281	0.7264	38	2,781	0.2835
		2	2.1709	0.6092	37	10,235	0.3951
		3	2.7217	0.6889	52	7,293	0.3168
		5	2.3724	0.7632	23	4,594	0.2404
5 October	Neosho River	1	2.0211	0.5636	36	8,360	0.4417
		10	2.9185	0.8179	36	3,401	0.1871
		4	2.0885	0.6040	32	5,423	0.4025
	Wolf Creek	7	2.6867	0.7827	31	2,945	0.2236
		2	2.6091	0.6940	43	9,997	0.3097
		3[b]					
		5[b]					
14 December	Neosho River	1	2.3945	0.6537	39	3,075	0.3574
		10	3.0737	0.8056	46	1,587	0.2077
		4	2.9753	0.8373	35	701	0.1815
	Wolf Creek[b]						

[a] Sampling restricted to Location 1 on this date.
[b] Water at this location either frozen or dry.

Chapter 4

PERIPHYTON STUDY

By

James R. Farrell

I. Introduction

Periphytic algae in the Neosho River and Wolf Creek near Wolf Creek Generating Station (WCGS) have been monitored quarterly since 1973 (Kansas Gas and Electric Company 1974; Farrell 1975a, 1976a). The results of previous studies have shown considerable temporal variation in dominant species composition at all sampling locations; however, diatoms (Bacillariophyta) were usually the most abundant division of algae. Dominant algal species in the Neosho River were usually different from those in Wolf Creek, reflecting the hydrological conditions of each water system. The region experienced drouth conditions in 1976 and the flow in Wolf Creek was intermittent, whereas a minimum flow was maintained in the Neosho River by water releases from John Redmond Reservoir.

The objectives of the 1976 periphyton study were:

1. To gather additional baseline information on the abundance, structure, and seasonal variability of the periphyton in the Neosho River and Wolf Creek; and

2. To assess any effects of construction of WCGS on the periphyton community.

II. Field and Analytical Procedures

Sampling locations for periphyton are shown in Figure 4.1. Samples were collected on 25 February, 6 April, 15 June, 10 August, 5 October, and 14 December 1976. Samples were not collected from one or more locations in Wolf Creek in April, October, and December because of low water level or substrate conditions. Eighteen samples delineated by a 0.1 dm^2 template were scraped from suitable natural substrates at Location 1 in the Neosho River below John Redmond Dam, at Locations 10 and 4 downstream in the river, and at Locations 7, 2, 3, and 5 in Wolf Creek. Location 1 was designated as Location 1P in previous studies and Location 5 was designated as Location 4P prior to 1975. Six samples from each location were placed in "M^3" preservative (Meyer 1971) for later identification and enumeration of diatom (3 samples) and non-diatom (3 samples) algal forms. Six more samples were kept on ice in the dark for chlorophyll analysis and the remaining six samples were placed in crucibles for later determinations of biomass in the laboratory.

Diatom samples were cleaned using a boiling concentrated nitric acid/potassium dichromate treatment (Hohn and Hellerman 1963). The samples were allowed to settle and the supernatant decanted and replaced at 24 hr intervals until a pH $\geq$ 6 was reached. After the concentration of the sample was adjusted to a suitable volume, a subsample was mounted in Hyrax mounting medium. All volumes were kept consistent within each sampling period. A predetermined area (16.2 mm^2/sample) of each mount was examined under phase contrast at 1250X magnification. Each diatom frustule was counted as one unit.

Samples for non-diatom analysis were blended to insure uniformity and wet mounts were prepared with 0.1 ml subsamples. An area equal to that used for diatom analysis was examined under light field illumination at 500X magnification. Filamentous algae were reported in units of 10 μm length and each cell of nonfilamentous algae was counted as one unit.

Algal abundance was expressed as number of units per square centimeter (no./cm^2). Biovolume of each algal taxon enumerated was determined using the methods of Cowell (1960) and Hohn (1969) and reported as microliters per square decimeter ($\mu l/dm^2$). Shannon's (1948) diversity index with log base 2 and evenness (Zar 1968) were calculated based on abundance data for each sampling period.

Taxonomic keys used for identification included Hustedt (1930), Smith (1950), Cleve-Euler (1951, 1952, 1953a,b, 1955), Tiffany and Britton (1952), Palmer (1962), Prescott (1962, 1970), Patrick and Reimer (1966, 1975), Drouet (1968), Weber (1971), and Whitford and Schumacher (1973).

Periphyton biomass and chlorophyll a samples were processed according to accepted methods (A.P.H.A. et al. 1976). Biomass standing crop was reported as milligrams of ash-free dry weight per square decimeter (mg/dm^2) and chlorophyll a standing crop was expressed as micrograms per square decimeter ($\mu g/dm^2$). A one-way analysis of variance (Steel and Torrie 1960) was performed on data from each sampling period to identify statistically significant differences ($P \leq 0.05$) in biomass or chlorophyll a standing crops among locations.

III. Results and Discussion

A composite list of all periphytic algae identified from locations in the Neosho River and Wolf Creek and semimonthly data on species composition, density and biovolume are presented in Appendix C, Tables C.1 through C.7.

A. Species Composition and Community Structure

One hundred and fifteen periphytic algal taxa were identified from locations in the Neosho River and Wolf Creek in 1976 (Table 4.1). In previous studies 84 to 113 taxa were observed.

Differences in the number of taxa identified and the structure of periphyton communities between years in the Neosho River and Wolf Creek may reflect: (1) different environmental conditions (Patrick 1961, 1963, 1968); (2) a nonrandom (patchy) distribution of taxa (Blum 1956, 1960; Whitford 1960a; Patrick 1963, 1969, 1971a,b, 1973, 1974; Hynes 1970; Clark and Runnels 1975); (3) sampling error (Brook 1953; Castenholz 1960; Brown 1976); and (4) different numbers of samples collected each year.

1. Bacillariophyta (Diatoms)

The majority of periphytic algal taxa collected near Wolf Creek Generating Station in 1976 were diatoms (Table 4.1). This division comprised from 5.6 to 100% of the density and from 0.3 to 100% of the biovolume of periphyton collected. Diatoms were more numerous in the Neosho River than in Wolf Creek; however, expressed as a percentage of the total population, diatoms were more important in Wolf Creek. Diatoms averaged from 23.5 to 56.9% of the density (20.0 to 48.2% of the biovolume) at locations in the river compared to means of 33.5 to 95.1% of the density (34.7 to 95.2% of the biovolume) at locations in the creek (Table 4.2).

Dominant periphytic taxa (comprising 10% or more of the density or biovolume of periphyton collected) in the Neosho River and Wolf Creek are presented in Table 4.3. Diatom taxa dominant only in the river included Stephanodiscus sp., Cymbella sinuata, Gomphonema sp., Melosira varians, and Gyrosigma sp., whereas those dominant only in the creek were Nitzschia lorenziana, Achnanthes sp., A. linearis, Diatoma tenue var. elongatum, Diploneis sp., D. puella, Amphipleura pellucida, Rhopalodia gibba, R. gibberula, Navicula luzonensis, Surirella sp., and Caloneis ventricosa. Diatom taxa that were dominant in both water systems included Nitzschia sp., N. dissipata, Navicula sp., and N. tripunctata var. schizonemoides. All of these diatoms, except D. tenue var. elongatum, C. sinuata, R. gibberula and N. luzonensis were reported in previous studies.

The planktonic diatom Stephanodiscus sp. was dominant in the periphyton of the Neosho River in previous years, and its dominance probably resulted from entrapment by periphytic algae as it was discharged from John Redmond Reservoir. Similar results were noted downstream from Sutherland Reservoir in south central Nebraska (Farrell 1975b). Chandler (1937) reported that vegetation may act to strain plankton causing a downstream decrease in its abundance.

Distribution of taxa within each water system was generally uniform. Some variability in distribution of dominant taxa was noted; however, part of this variability resulted from the arbitrary designation of dominance. Location 1 tended to have higher populations of Stephanodiscus than the other river locations. Stephanodiscus was the only dominant diatom at Location 1 in February and April (Table 4.3). However, an approximately equal number of diatom taxa were identified from all river locations during these months. In October and December diatoms were dominant only at Location 4 in the river.

Dominant diatom taxa were usually similar in Wolf Creek except at Location 3 after the April sampling period (Table 4.3). Green or blue-green algae were dominant at Location 3 in June and August.

2. Chlorophyta (Green algae)

Fifteen taxa of green algae were found in 1976 compared with 1 to 7 taxa in previous studies (Table 4.1). Five taxa were planktonic forms. The more abundant taxa identified in the Neosho River were the filamentous algae, Ulothrix sp., Cladophora sp., C. glomerata, Stigeoclonium sp., Oedogonium sp., and Zygnema sp., and Spirogyra sp. from Location 3 in Wolf Creek (Table 4.3). Distribution differences were negligible in the river although more green algal taxa were dominant and their densities were usually higher at Location 1 than at Locations 10 and 4. Stigeoclonium sp., Cladophora sp., Oedogonium sp., and Spirogyra sp. were observed in earlier studies. Green algae were not observed at Locations 7, 2, or 5 in Wolf Creek in 1976; however, this division contributed an average of 20.5 to 62.2% of the density (45.4 to 77.0% of the biovolume) of periphyton collected in the Neosho River (Table 4.2).

Green algae were most abundant in June and December at Locations 1 and 3, and in April at Locations 10 and 4.

3. Cyanophyta (Blue-green Algae)

Eight taxa of blue-green algae were identified in the periphyton collected in 1976, whereas 4 to 13 taxa were identified in previous studies (Table 4.1). Oscillatoria sp., O. agardhii, Phormidium sp., and Rivularia sp. were abundant in the Neosho River, and Oscillatoria sp., Phormidium sp., Calothrix sp., and Lyngbya sp. were abundant in Wolf Creek (Table 4.3). No pattern was evident in the occurrence of blue-green algae within the Neosho River or Wolf Creek. Species of Lyngbya, Oscillatoria and Phormidium were reported in earlier studies.

Blue-green algae contributed averages of 14.1 to 22.8% of the density (3.1 to 19.3% of the biovolume) of periphyton collected at locations in the Neosho River. This division contributed means up to 44.1% of the density (40.4% of the biovolume) of the periphyton collected at Wolf Creek locations (Table 4.2).

B. Standing Crop

Density, biovolume, biomass, and chlorophyll a standing crop of periphyton collected from the Neosho River and Wolf Creek are presented in Table 4.4. Periphyton standing crop was generally higher at locations in the Neosho River than in Wolf Creek. Most significant differences in biomass and chlorophyll a standing crop occurred between locations on the Neosho River and Wolf Creek (Table 4.5), indicating basic habitat differences. Mean density, biomass, and chlorophyll a were higher at Location 1 than at Locations 10 and 4, whereas no pattern was evident among locations in Wolf Creek. In previous years, the density and chlorophyll a standing crop at Location 2 in Wolf Creek were approximately half as large as at the other creek locations.

Highest standing crops in the Neosho River generally occurred in April, June or December, depending upon the indicator used. Maximum periphyton standing crop in Wolf Creek generally occurred in June. All measures of periphyton standing crop in 1976 were generally within the ranges reported in previous studies; however, yearly mean density and chlorophyll a have risen steadily at Location 1 in the Neosho River and have declined at locations in Wolf Creek since 1974 (Table 4.6). These trends reflect the positive effects of lower and more stable flow in the Neosho River and the negative effects of no flow in Wolf Creek. During previous studies the Neosho River was characterized by fluctuating water levels and relatively high turbidity which inhibited periphyton growth (Farrell 1976a). Increasing velocity is known to stimulate periphyton growth by increasing nutrient availability, physiological rates and waste export (Odum 1956; Whitford 1960b; Whitford and Schumacher 1964; McIntire 1966; Reisen and Spencer 1970). However, as flows become extreme and silt loads increase, periphyton is scoured off the substrate (Patrick 1971; McIntire 1973).

The autotrophic index (Weber 1973), or ratio of biomass to chlorophyll a, is presented in Table 4.7. This index was generally lower at locations in the Neosho River where it ranged from 238 to 2347, than in Wolf Creek (418 to 15602). Values below 100 indicate a primarily autotrophic community, whereas higher values may indicate conditions of organic pollution favorable to non-chlorophyllous organisms, such as bacteria or stalked protozoans.

The autotrophic index was usually lower at Location 1 than at Locations 10 or 4 and may reflect the stimulatory effects of the faster current on periphytic algae.

C. Diversity

Number of taxa, diversity, and evenness were variable at most locations in 1976. Although the yearly mean number of taxa at locations in the Neosho River was similar, the number of taxa observed was similar on only two sampling dates (Table 4.7). Diversity and evenness were usually higher at the downstream locations (Locations 10 and 4) than at Location 1.

Number of taxa and diversity in Wolf Creek were always higher at Locations 7 and 2 than at Locations 3 and 5. Evenness was usually lower at Location 3 compared to the other Wolf Creek locations.

Diversity values ranged from 0.89 to 3.10 in the Neosho River and from 0.43 to 3.18 in Wolf Creek which are within the ranges reported in previous studies (Kansas Gas and Electric Company 1974; Farrell 1975a, 1976a). Diversity of periphyton communities near Sutherland Reservoir, Nebraska consistently averaged 3.0 to 3.5 (Farrell 1975b, 1976b). Patrick (1968) reported periphyton diversities between 2.29 and 3.45 in Darby Creek, Pennsylvania and Cooper and Wilhm (1975) did not find diversities >2.0 along a stream in Oklahoma that was stressed by domestic and oil refining effluents. Lower diversities (<1.5) were reported in laboratory streams (Kehde and Wilhm 1972). The range in diversity reported by each of these investigators is narrower than that observed in Wolf Creek or the Neosho River and may be related to environmental instability during each study. High diversity reflects community, or more basically, environmental stability (Odum 1971; Pielou 1975).

IV. Summary and Conclusions

1. Most periphytic algal taxa identified near the Wolf Creek Generating Station in 1976 were diatoms. Diatoms generally comprised a higher percentage of the density and biovolume of the periphyton in Wolf Creek than in the Neosho River.

2. Green filamentous algae were an important component of the periphyton in the Neosho River but were usually absent in Wolf Creek. Blue-green algae were common in both water systems.

3. Standing crops of periphyton were usually higher in the Neosho River than in Wolf Creek. Yearly mean standing crop has increased at Location 1 in the Neosho River since 1974, while the converse has been true at locations in Wolf Creek. These trends were attributed to the more favorable water releases from John Redmond Dam and intermittent streamflow in the creek.

4. No effects of construction on the periphytic algae of the Neosho River and Wolf Creek were noted.

V. References Cited

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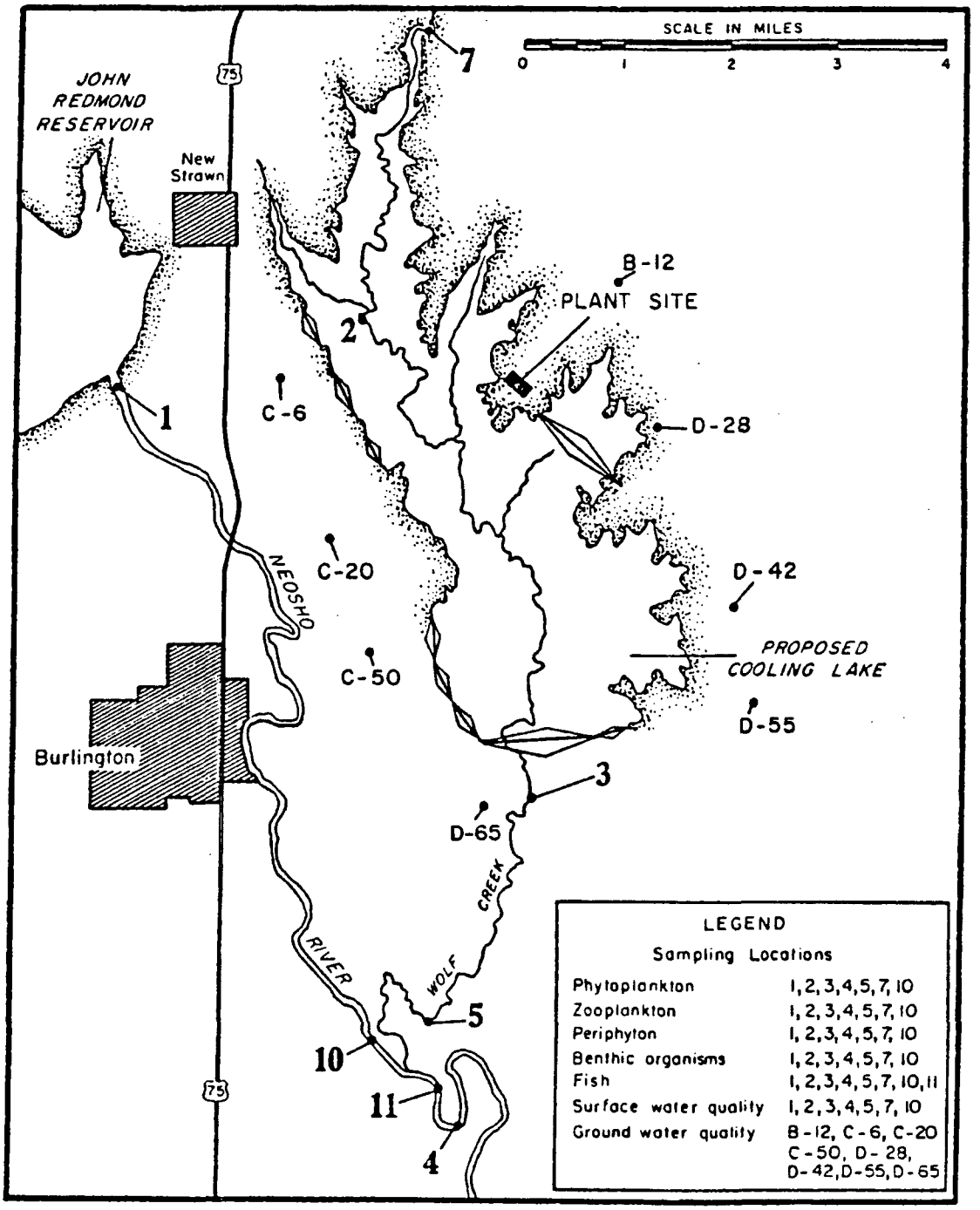

Figure 4.1. Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

Table 4.1. Number of periphytic algal taxa collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-1976.

Year	Bacillariophyta	Chlorophyta	Cyanophyta	Chrysophyta	Total
1973	93	7	13	0	113
1974	88	1	4	0	93
1975	75	5	4	0	84
1976	92	15	8	1	115

Table 4.2. Distribution by division of periphytic algal density and biovolume (expressed as a percentage of the total population) collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

	Bacillariophyta							Chlorophyta							Cyanophyta						
	Neosho River			Wolf Creek				Neosho River			Wolf Creek				Neosho River			Wolf Creek			
Date	1	10	4	7	2	3	5	1	10	4	7	2	3	5	1	10	4	7	2	3	5
Density																					
25 February	29.1	75.5	89.6	100.0	72.2	17.9	100.0	70.8	19.4	1.6	0.0	0.0	0.0	0.0	0.1	5.1	8.8	0.0	27.8	82.1	0.0
6 April	14.1	12.1	29.8	-[a]	100.0	100.0	80.4	59.6	45.1	70.2	-[a]	0.0	0.0	0.0	26.2	42.9	0.0	-[a]	0.0	0.0	19.6
15 June	12.5	63.3	99.9	89.0	92.8	10.5	100.0	64.2	0.0	0.1	0.0	0.0	89.5	0.0	23.3	36.7	0.0	11.0	7.2	0.0	0.0
10 August	68.5	100.0	87.1	100.0	46.7	5.6	100.0	31.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.9	0.0	53.3	94.4	0.0
5 October	9.2	47.7	17.0	90.2	73.0	-[b]	-[a]	54.5	0.0	20.0	0.0	0.0	-[b]	-[a]	36.4	52.3	62.8	9.8	27.0	-[b]	-[a]
14 December	7.6	41.7	18.0	-[c]	-[c]	-[c]	-[c]	92.4	58.3	74.0	-[c]	-[c]	-[c]	-[c]	0.0	0.0	8.0	-[c]	-[c]	-[c]	-[c]
$\bar{x}$	23.5	56.7	56.9	94.8	76.9	33.5	95.1	62.2	20.5	27.7	0.0	0.0	22.4	0.0	14.3	22.8	14.1	5.2	23.1	44.1	4.9
Biovolume																					
25 February	39.4	10.2	97.8	100.0	73.0	32.0	100.0	60.6	89.6	1.7	0.0	0.0	0.0	0.0	<0.1	0.1	0.5	0.0	27.0	68.0	0.0
6 April	0.9	10.0	1.4	-[a]	100.0	100.0	77.8	98.4	84.5	98.6	-[a]	0.0	0.0	0.0	0.7	5.4	0.0	-[a]	0.0	0.0	22.2
15 June	4.9	63.6	99.9	93.4	94.0	0.3	100.0	83.3	0.0	<0.1	0.0	0.0	99.7	0.0	11.8	36.4	0.0	6.6	6.0	0.0	0.0
10 August	69.0	100.0	82.6	100.0	65.4	6.3	100.0	31.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.4	0.0	34.6	93.7	0.0
5 October	0.9	26.3	5.8	87.3	36.4	-[b]	-[a]	93.4	0.0	81.7	0.0	0.0	-[b]	-[a]	5.7	73.7	12.6	12.7	63.6	-[b]	-[a]
14 December	4.6	1.7	1.4	-[c]	-[c]	-[c]	-[c]	95.4	98.3	98.4	-[c]	-[c]	-[c]	-[c]	0.0	0.0	0.2	-[c]	-[c]	-[c]	-[c]
$\bar{x}$	20.0	35.3	48.2	95.2	73.8	34.7	94.5	77.0	45.4	46.8	0.0	0.0	24.9	0.0	3.1	19.3	5.1	4.8	26.2	40.4	5.6

[a] Suitable substrate not available for quantitative sampling.
[b] Location dry.
[c] Location dry or frozen.

NALCO ENVIRONMENTAL SCIENCES

Table 4.3. Periphytic algal taxa comprising 10% or more of the density or biovolume of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

	Location						
	Neosho River			Wolf Creek			
Date	1	10	4	7	2	3	5
25 February							
	Ulothrix sp. *Stephanodiscus* sp.	*Nitzschia* sp. *Stephanodiscus* sp. *Nitzschia dissipata* *Cladophora glomerata*	*Stephanodiscus* sp. *Nitzschia* sp.	*Navicula* sp. *Nitzschia* sp. *Caloneis ventricosa* *Achnanthes* sp. *Stephanodiscus* sp.	*Nitzschia* sp. *Navicula* sp. *Calothrix* sp. *Phormidium* sp.	*Nitzschia* sp. *Oscillatoria* sp. *Phormidium* sp.	*Nitzschia* sp. *Nitzschia lorenziana* *Diatoma tenue* var. *elongatum*
6 April							
	Cladophora sp. *Oscillatoria agardhii* *Stephanodiscus* sp.	*Ulothrix* sp. *Zygnema* sp. *Oscillatoria* sp. *Phormidium* sp.	*Cladophora* sp.	–[a]	*Nitzschia* sp. *Navicula* sp. *Diploneis puella*	*Nitzschia* sp. *Navicula* sp.	*Nitzschia* sp. *Navicula* sp. *Phormidium* sp.
15 June							
	Stigeoclonium sp. *Nitzschia dissipata*	*Oscillatoria* sp. *Cymbella sinuata* *Gomphonema* sp. *Nitzschia* sp.	*Nitzschia dissipata* *Nitzschia* sp. *Navicula* sp. *Melosira varians*	*Nitzschia* sp. *Navicula* sp.	*Nitzschia* sp. *Diploneis* sp. *Surirella* sp.	*Spirogyra* sp.	*Nitzschia* sp. *Diploneis* sp. *Navicula* sp. *Nitzschia dissipata* *Amphipleura pellucida* *Rhopalodia gibba* *Rhopalodia gibberula*
10 August							
	Navicula tripunctata var. *schizonemoides* *Nitzschia* sp. *Stigeoclonium* sp.	*Nitzschia* sp. *Stephanodiscus* sp. *Navicula tripunctata* var. *schizonemoides* *Navicula* sp. *Cyrosigma* sp.	*Nitzschia* sp. *Navicula tripunctata* var. *schizonemoides* *Oscillatoria* sp.	*Nitzschia* sp. *Diploneis* sp.	*Diploneis* sp. *Nitzschia* sp. *Navicula tripunctata* var. *schizonemoides* *Lyngbya* sp. *Oscillatoria* sp.	*Oscillatoria* sp.	*Nitzschia* sp. *Achnanthes* sp.
5 October							
	Stigeoclonium sp. *Cladophora* sp. *Phormidium* sp. *Oscillatoria* sp.	*Nitzschia* sp. *Rivularia* sp.	*Cladophora* sp. *Phormidium* sp.	*Navicula* sp. *Navicula luzonensis* *Nitzschia* sp. *Oscillatoria* sp.	*Diploneis* sp. *Achnanthes linearis* *Nitzschia* sp. *Phormidium* sp.	–[b]	–[a]
14 December							
	Oedogonium sp. *Cladophora* sp.	*Nitzschia* sp. *Cladophora* sp. *Ulothrix* sp.	*Oedogonium* sp. *Cladophora* sp.	–[c]	–[c]	–[c]	–[c]

[a] Suitable substrate not available for quantitative sampling.
[b] Location dry.
[c] Location dry or frozen.

NALCO ENVIRONMENTAL SCIENCES

Table 4.4. Density (no./cm^2), biovolume (µl/dm^2), biomass standing crop (mg/dm^2) and chlorophyll a standing crop (µg/dm^2) of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

	Location						
	Neosho River			Wolf Creek			
	1	10	4	7	2	3	5
Density (no./cm^2)							
25 February	6,217,269	2,529,619	2,093,815	48,145	448,140	69,134	39,503
6 April	3,772,832	3,945,669	6,943,196	-[a]	150,614	59,258	113,579
15 June	30,330,830	37,035	1,139,501	359,255	1,070,360	540,738	61,725
10 August	8,123,444	839,501	222,219	296,292	148,145	175,308	56,789
5 October	3,883,943	2,116,041	683,947	150,613	274,071	-[b]	-[a]
14 December	8,651,842	1,214,808	3,518,507	-[c]	-[c]	-[c]	-[c]
$\bar{x}$	10,163,360	1,780,446	2,433,531	213,576	418,266	211,110	67,899
Biovolume (µl/dm^2)							
25 February	570.3	1273.0	247.2	1.4	11.6	1.1	1.4
6 April	487.5	5036.9	10903.2	-[a]	3.9	1.5	2.8
15 June	1175.1	0.7	13.4	5.7	25.0	582.6	2.7
10 August	932.9	10.4	31.4	5.4	1.7	8.9	0.7
5 October	521.4	94.8	96.8	1.5	3.3	-[b]	-[a]
14 December	2227.3	1729.6	1853.7	-[c]	-[c]	-[c]	-[c]
$\bar{x}$	985.8	1358.6	2191.0	3.5	9.1	148.5	1.9
Biomass standing crop (mg/dm^2)							
25 February	606.5	528.2	-[d]	313.6	147.0	8.0	57.4
6 April	3024.7	628.7	862.7	-[a]	50.9	25.7	317.9
15 June	782.0	181.7	48.0	84.2	593.8	60.7	-[e]
10 August	381.7	634.7	459.3	37.4	43.5	116.0	249.1
5 October	305.6	981.7	464.2	88.0	115.0		-[a]
14 December	163.2	576.5	311.8	-[c]	-[c]	-[c]	-[c]
$\bar{x}$	877.3	588.6	429.2	130.8	190.0	52.6	208.1
Chlorophyll a standing crop (µg/dm^2)							
25 February	594.7	-[f]	-[d]	20.1	18.7	8.9	7.6
6 April	6172.0	1123.1	1082.1	-[a]	16.5	14.3	20.5
15 June	2451.9	148.8	71.3	201.5	174.9	142.1	-[d]
10 August	1602.9	679.5	360.0	41.0	38.0	130.5	67.3
5 October	751.7	318.1	197.8	7.0	26.3	-[b]	-[a]
14 December	280.7	1108.0	1242.9	-[c]	-[c]	-[c]	-[c]
$\bar{x}$	1975.7	675.5	590.8	67.4	54.9	74.0	31.8

[a] Suitable substrate not available for quantitative sampling.
[b] Location dry.
[c] Location dry or frozen.
[d] Sample not collected.
[e] Ash weight exceeded dry weight.
[f] Sample lost.

NALCO ENVIRONMENTAL SCIENCES

Table 4.5. Mean differences between locations for biomass and chlorophyll a standing crop of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

		Biomass (mg/dm^2)						
	Location	1	2	3	4	5	7	10
25 February Chlorophyll a ($\mu g/dm^2$)	1		459.4*	598.5*	-	549.1*	292.9	78.3
	2	576.0*		139.0	-	89.7	166.6	381.1
	3	585.8*	9.8		-	49.4	305.6	520.2*
	4	-	-	-		-	-	-
	5	587.2*	11.1	1.3	-		256.3	470.8*
	7	574.7*	1.3	11.1	-	12.4		214.6
	10	-	-	-	-	-	-	
	Location	1	2	3	4	5	7	10
6 April Chlorophyll a ($\mu g/dm^2$)	1		2973.8*	2999.0*	2162.0*	2706.8*	-	2396.0*
	2	6155.5*		25.2	811.8	267.0	-	577.8
	3	6157.7*	2.3		837.0	292.2	-	603.0
	4	5089.8	1065.7	1067.9		544.8	-	234.0
	5	6151.5*	4.0	6.3	1061.6		-	310.8
	7	-	-	-	-	-		-
	10	5048.8	1106.7	1108.9	41.0	1102.6	-	
	Location	1	2	3	4	5	7	10
15 June Chlorophyll a ($\mu g/dm^2$)	1		188.2	721.4*	734.0*	-	697.8*	600.3*
	2	2277.1*		533.2*	545.8*	-	509.6*	412.1*
	3	2309.8*	32.7		12.6	-	23.5	121.1
	4	2380.6*	103.6	70.8		-	36.2	133.7
	5	-	-	-	-		-	97.5
	7	2250.4*	26.7	59.4	130.3	-		97.5
	10	2303.1*	26.1	6.7	77.5	-	52.7	
	Location	1	2	3	4	5	7	10
10 August Chlorophyll a ($\mu g/dm^2$)	1		338.2	265.7	77.6	-	344.3	256.0
	2	1565.0		72.4	415.8	-	6.1	591.1*
	3	1472.4	92.6		343.4	-	78.6	518.7*
	4	1242.9	322.1	229.5		-	421.9	175.3
	5	1535.6	29.3	63.3	292.8		-	-
	7	1561.9	3.0	89.5	319.0	26.3		597.2*
	10	923.4	641.5	549.0	319.5	612.2	638.5	
	Location	1	2	3	4	5	7	10
5 October Chlorophyll a ($\mu g/dm^2$)	1		190.6	-	158.5	-	217.7	676.1*
	2	725.4*		-	349.2	-	27.0	866.7*
	3	-	-		-	-	-	-
	4	553.9*	171.5	-		-	376.2	517.6*
	5	-	-	-	-		-	-
	7	744.8*	19.3	-	190.9	-		893.7*
	10	433.6*	291.8	-	120.3	-	311.1	
	Location	1	2	3	4	5	7	10
14 December Chlorophyll a ($\mu g/dm^2$)	1		-	-	148.6	-	-	413.3*
	2	-		-	-	-	-	-
	3	-	-		-	-	-	-
	4	962.3*	-	-		-	-	264.7*
	5	-	-	-	-		-	-
	7	-	-	-	-	-		-
	10	827.3	-	-	135.0	-	-	

[a] Biomass or chlorophyll a samples not collected.
[b] Asterisk (*) indicates significant difference ($p \leq 0.05$) between locations.

Table 4.6. Yearly mean density and chlorophyll a standing crop of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1974-76.

Neosho River (Location 1)

Year	Mean Flow[a] (cfs)	Yearly Mean Flow (cfs)	Density (no./cm^2 x 10^6)	Chlorophyll a (μg/dm^2)
1974	2438	1790	0.7	84.5
1975	1644	1637	1.5	430.0
1976	435	594	10.1	1975.7

Wolf Creek

Year	Annual Precipitation (cm)	Density (no./cm^2 x 10^6) Location 7	2	3	5	Chlorophyll a (μg/dm^2) Location 7	2	3	5
1974	78.6	-[b]	2.2	4.4	3.2	-	957.6	883.4	1270.3
1975	60.3	1.0	0.4	0.9	0.6	462.6	162.8	595.9	456.6
1976	34.1	0.2	0.4	0.2	0.1	67.4	54.9	74.0	31.8

[a] Mean flow at Burlington, Kansas for 14 day period before each sampling date.
[b] Location 7 not sampled until 1975.

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Table 4.7. Number of taxa, diversity[a], evenness[b], and autotrophic index[c] of periphyton collected from natural substrates in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

	Location						
	Neosho River			Wolf Creek			
	1	10	4	7	2	3	5
Number of Taxa							
25 February	27	31	27	10	21	7	10
6 April	14	21	17	-[d]	14	6	5
15 June	25	7	13	17	30	8	9
10 August	11	10	13	18	8	5	5
5 October	11	17	14	15	8	-[e]	-[d]
14 December	14	18	23	-[f]	-[f]	-[f]	-[f]
$\bar{x}$	17	17	18	15	16	7	7
Diversity							
25 February	1.59	3.10	2.13	2.13	2.71	0.80	1.59
6 April	0.98	1.50	1.78	-[d]	2.34	0.97	1.09
15 June	1.44	1.11	1.31	1.96	2.28	1.17	2.18
10 August	1.57	2.66	2.71	2.47	2.14	0.43	1.45
5 October	2.51	2.28	1.87	3.18	2.36	-[e]	-[d]
14 December	0.89	2.54	2.63	-[f]	-[f]	-[f]	-[f]
$\bar{x}$	1.50	2.20	2.07	2.44	2.37	0.84	1.58
Evenness							
25 February	0.31	0.68	0.46	0.83	0.76	0.66	0.78
6 April	0.44	0.61	0.39	-[d]	0.71	0.71	0.64
15 June	0.31	0.89	0.39	0.53	0.48	0.37	0.83
10 August	0.45	0.80	0.73	0.59	0.71	0.18	0.62
5 October	0.72	0.56	0.49	0.81	0.79	-[e]	-[d]
14 December	0.23	0.61	0.58	-[f]	-[f]	-[f]	-[f]
$\bar{x}$	0.41	0.69	0.51	0.69	0.69	0.48	0.72
Autotrophic Index							
25 February	1020	-[h]	-[g]	15602	7861	899	7553
6 April	490	560	797	-[d]	3084	1797	15507
15 June	320	1221	673	418	3395	427	-[g]
10 August	238	934	1276	912	1144	888	3702
5 October	407	3086	2347	12571	4372	-[e]	-[d]
14 December	581	520	251	-[f]	-[f]	-[f]	-[f]
$\bar{x}$	509	1264	1069	7376	3971	1003	8921

[a] Shannon (1948).
[b] Zar (1968).
[c] Weber (1973).
[d] Suitable substrate not available for quantitative sampling.
[e] Location dry.
[f] Location dry or frozen.
[g] Sample not collected.
[h] Sample lost.

Chapter 5

ZOOPLANKTON STUDY

by

Andrew J. Repsys

I. Introduction

Zooplankton constitute an important link in aquatic food chains in that most species of fish at some stage of their development depend heavily on zooplankton for growth and survival. Availability of zooplankton at critical periods in the annual cycle may affect survival of larvae and juvenile stages of fish species that are of commercial and recreational value (Siefert 1972; Clady 1977). Alterations of existing environments can have major effects on zooplankton populations and aquatic food chains indigenous to the water systems near Wolf Creek Generating Station (WCGS). Accumulation of background information on zooplankton in the area began in 1973 (Kansas Gas and Electric Company 1974) and has continued each succeeding year (Repsys 1975, 1976).

Objectives of the present monitoring were to determine natural, seasonal, and year-to-year variability in the zooplankton populations of Wolf Creek and the Neosho River to provide a basis for assessment of effects on zooplankton populations attributable to construction and operation of WCGS.

II. Field and Analytical Procedures

Sampling locations for zooplankton are indicated on Figure 5.1. Duplicate horizontal drift samples were collected at Locations 1, 10, and 4 in the Neosho River and at Locations 7, 2, 3, and 5 in Wolf Creek using a metered no. 25 (64 μm) mesh plankton net with a 428 cm^2 apperture. When flow was minimal or absent, the net was towed through a measured horizontal distance of 6 to 10 m. All samples were preserved at the time of collection in 5% formalin and stored in labeled containers.

In the laboratory, samples were concentrated or diluted to a workable density of organisms and then thoroughly mixed to obtain a representative subsample which was withdrawn and placed in a Bogorov counting chamber. Stratified counts of zooplankton in the subsample were obtained using a binocular dissection microscope at 50X magnification. Subsampling was continued until a sufficient number of organisms was enumerated to estimate population densities, usually after counting at least 5% of the total sample. Microcrustacea were identified to species with the exception of taxonomically indistinct immature copepods and cladocerans which were identified to the lowest positive taxon. Rotifers were identified to genus, except certain littoral-benthic genera in the order Bdelloidea. Identifications were made with taxonomic keys by Pennak (1953), Brooks (1957, 1959), Edmondson (1959), Wilson and Yeatman (1959), Goulden (1968), Roberts (1970), Ruttner-Kolisko (1974) and Smirnov (1974).

III. Results and Discussion

A. Current Study

Zooplankton taxa collected in the vicinity of WCGS during 1976 are listed in Table 5.1.

1. Neosho River

Total zooplankton density discharged from John Redmond Reservoir (Location 1) on 25 February was 2,222,370 organisms/m^3 of which rotifers,

primarily Keratella and Polyarthra, comprised 95% (Table 5.2). Copepod nauplii (61327/m^3), Bosmina longirostris (25789/m^3), and cyclopoid copepodites (16950/m^3) represented the most abundant microcrustacean taxa collected in February. Other common microcrustacean species present at Location 1 included Diaptomus siciloides (4400/m^3) and Cyclops bicuspidatus thomasi (2330/m^3).

Total zooplankton at Location 1 declined 90% by April due to the collapse of the rotifer population from 2,108,453 organisms/m^3 in February (Table 5.2) to 1937/m^3 in April (Table 5.3). Microcrustacean taxa (copepods and cladocerans) increased from 113,937 organisms/m^3 to 232,050/m^3 during the same period, reflecting increases primarily in copepod nauplii and cyclopoid copepodite densities. Cyclopoid copepodites and Bosmina longirostris persisted as dominant microcrustacean forms at Location 1 in April. Daphnia parvula densities increased from 727/m^3 in February to 4755/m^3 in April, whereas the density of Cyclops bicuspidatus thomasi remained relatively stable between sampling dates at approximately 2000/m^3.

On 3 May total zooplankton at Location 1 had decreased almost 10-fold to 23679 organisms/m^3 (Table 5.4). This decline was due to a sharp reduction in microcrustacean densities, particularly those of immature copepods and Bosmina longirostris. Rotifer densities increased 5-fold over April levels but populations still remained low (9893/m^3).

Total zooplankton density at Location 1 increased sharply to 607,641 organisms/m^3 on 14 June (Table 5.5). Rotifers, primarily Brachionus sp., attained maximum densities observed for the spring period (385,879/m^3). Total microcrustaceans densities were similar to those observed in April. Principal microcrustacean taxa in June included copepod nauplii (113,162/m^3), Bosmina longirostris (73929/m^3), and Daphnia parvula (14927/m^3). June densities of Bosmina longirostris and Daphnia parvula represented yearly maxima for these cladoceran species at Location 1.

A sharp decline in microcrustacean densities similar to that observed in May occurred again in July at Location 1. Microcrustacean densities were reduced from 221,762 organisms/m^3 in June to 40816 organisms/m^3 by 12 July due mainly to sharp declines in the density of Bosmina (2242/m^3) and immature copepods (Table 5.6). Rotifer populations were also reduced from 385,879 organisms/m^3 in June to 104,459 organisms/m^3 in July. Major microcrustacean taxa at Location 1 were copepod nauplii and Diaphanosoma leuchtenbergianum, whereas Hexarthra and Conochiloides represented principal rotifer genera in July.

Total zooplankton showed a moderate increase at Location 1 from 145,275 organisms/m^3 in July (Table 5.6) to 197,983 organisms/m^3 in August (Table 5.7). Principal microcrustacean taxa included immature copepods, Diaphanosoma leuchtenbergianum, and Daphnia parvula, while Keratella and Hexarthra were dominant rotifer genera collected on 10 August.

Zooplankton decreased to 99758 organisms/m^3 by 4 October at Location 1 (Table 5.8) due primarily to a decline in the rotifer population which comprised 71% of total zooplankton in August. Copepod populations decreased only slightly, whereas cladoceran densities were reduced by about 45%

due mainly to a reduction in the density of Diaphanosoma leuchtenbergianum.

Total zooplankton densities increased to 106,042 organisms/m^3 on 13 December at Location 1 (Table 5.9). Further reductions in rotifer densities were offset by moderate increases in copepod nauplii and Bosmina longirostris. Other common taxa in December included cyclopoid copepodites, Daphnia parvula, Diaptomus siciloides, and Synchaeta sp.

Zooplankton population densities at Location 1 were more stable from July to December than those observed prior to July (Tables 5.2-5.9). Substantial variability in zooplankton densities from February to July was attributed to a corresponding variability in volume and pattern of reservoir water releases during this period (Figure 5.2).

Total zooplankton densities at downstream Locations 10 and 4 were lower than those at Location 1 throughout 1976 (Tables 5.2-5.9). Density decreases between Location 1 and Locations 10 and 4 ranged from 28 to 99% for microcrustaceans and 13 to 93% for rotifers. The magnitude of these decreases appeared to be inversely related to volume of river flow on most sampling dates. A similar inverse relationship between flow and decreasing zooplankton density was reported by Ward (1975). Increases in rotifer densities at Locations 10 and 4 noted in April were primarily caused by river production of Brachionus urceolaris, a littoral species that was not collected at Location 1 (Table 5.3). Other examples of riverine production were evident in October when littoral cladocerans, primarily Disparalona, Macrothrix, and Alona spp., were collected at Location 4 and not at Location 1 (Table 5.8). Principal zooplankton taxa at Location 10 and 4 that were discharged from John Redmond Reservoir at Location 1 included immature copepods, Bosmina longirostris, Keratella, Polyarthra, and Brachionus.

2. Wolf Creek

Flow was absent in Wolf Creek on all sampling dates during the present study. The creek was reduced to a series of isolated pools, each with its own physical and chemical characteristics. Variations in the latter can be expected to produce differences in zooplankton species composition and abundance between pools.

Total zooplankton in Wolf Creek in February ranged from 2,325,174 organisms/m^3 at Location 3 to 120,278 organisms/m^3 at Location 2 (Table 5.2). Mean total zooplankton for all four locations was 885,114 organisms/m^3. Rotifers comprised 76% of total zooplankton with Filinia, Synchaeta, and Brachionus being the dominant genera. Principal microcrustacean taxa in February included immature copepods and Chydorus sphaericus.

Mean zooplankton densities in Wolf Creek increased slightly in April. Maximum densities at Location 7 (2,713,342 organisms/m^3) included high densities of copepod nauplii (1,632,761/m^3) and rotifers (927,345/m^3). Zooplankton densities were lowest at Location 3 (47904 organisms/m^3). Immature copepods, Chydorus sphaericus, and Cyclops bicuspidatus thomasi were important microcrustaceans in April, and Keratella, Polyarthra, and Synchaeta were the dominant rotifer genera.

Mean zooplankton densities in Wolf Creek decreased in June due to a decline in immature copepods and rotifers at upstream Locations 7 and 2. Total zooplankton densities ranged from 491,374 organisms/m^3 at Location 7 to 72182 organisms/m^3 at Location 5 (Table 5.5). Immature copepods, Polyarthra, Bosmina longirostris, and Daphnia ambigua were the most common taxa collected.

In August the mean zooplankton density in Wolf Creek increased to the maximum recorded in the 1976 study. High densities of immature copepods and rotifers at all locations accounted for most of the increase (Table 5.7). Dominant taxa present included copepod nauplii and the rotifers Keratella, Polyarthra, and Pompholyx.

Pools at downstream Locations 3 and 5 were dry on 4 October. Microcrustacean densities at Location 7 (7626 organisms/m^3) were greatly reduced from the August levels (Table 5.8). Rotifers, primarily Polyarthra and Rotaria, were present in moderate numbers (36450 organisms/m^3). Total zooplankton densities at Location 2 declined from 385,889 organisms/m^3 in August to 281,321 organisms in October (Table 5.8). Principal taxa included immature copepods, Diaptomus pallidus, Keratella, and Tropocyclops prasinus mexicanus (Table 5.9).

In December all locations on Wolf Creek were dry or frozen and contained insufficient water volume for sampling (Table 5.9).

B. Comparison with Previous Studies

Comparisons of mean zooplankton densities collected in 1975 and 1976 are presented in Table 5.10. Substantial variation in microcrustacean and rotifer densities and species composition was observed between studies. Variation in April zooplankton densities at Location 1 between 1975 and 1976 may have been related to large differences in reservoir discharges between years, in addition to seasonal effects. Differences in zooplankton composition and density in June may be attributed to the same factors. Comparable reservoir discharges in December of 1975 and 1976 probably resulted in similar zooplankton populations at Location 1.

Differences in reservoir discharges between 1975 and 1976 may have caused variation in zooplankton densities and composition at downstream Locations 10 and 4 in April and June. Uniform reservoir discharges and river flows later in the year apparently produced similar zooplankton populations at downstream locations in December of both years (Table 5.10). Substantially higher densities of total zooplankton in Wolf Creek in April and June 1976 compared to the same period in 1975 were the result of the absence of flow during the present study (Table 5.10). Large populations of zooplankton develop in Wolf Creek pools when flow is severely reduced or stops completely (Repsys 1976).

C. Relationship of Zooplankton to Environment

Ward (1975) studied downstream changes in zooplankton density and composition 5 miles downstream of a reservoir discharge. The results of his study indicated that (1) size of zooplankton species and volume of river flow were related to survival of reservoir zooplankton in the receiving river, (2) microcrustaceans decreased more rapidly downstream than smaller rotifer

species, and (3) high flows favored zooplankton persistence (survival?), whereas low flows further reduced zooplankton at downstream locations. Similar results were obtained in the spring and summer months of 1976 at Locations 10 and 4 in the Neosho River.

High zooplankton survival in December of 1975 and 1976 was not interpretable from flow data since flows were uniformly low in both instances (Byrnes 1976; Figure 5.2). Other factors favoring zooplankton survival include decreased water temperatures and turbidity (Chandler 1937; Williams 1966).

Zooplankton in intermittent streams, such as Wolf Creek, are subjected annually to environmental extremes of drought and flooding which may produce greater variability in seasonal population structure than that normally found in larger streams. High spring flows may deplete zooplankton populations by carrying organisms downstream more rapidly than recruitment can replenish indigenous communities. More moderate currents with pools and backwaters generally result in increased stream zooplankton populations, whereas the cessation of flow often produces dramatic increases in zooplankton densities in the isolated pools (Repsys 1976). Zooplankton may then persist in large numbers until the pools dry up or other conditions become limiting. Formation of ice over shallow stream pools may cause depletion of oxygen supplies through the decomposition of accumulated organic matter, which, together with subsequent increases in hydrogen sulfide, methane, and other toxic substances, may bring about the collapse of winter zooplankton populations. Some zooplankton can survive severe conditions by forming resting eggs or encysted forms which become viable when conditions are more favorable. Zooplankton species which do not produce resting stages may be recruited from upstream areas (ponds, pools) when flow resumes in the creek.

IV. Summary and Conclusions

1. Total zooplankton densities in the tailwaters of John Redmond Reservoir (Location 1) were highest in February (2,222,370 organisms/m^3) and lowest in May (23679 organisms/m^3). Zooplankton densities were more stable from July to December than from February to July. High variability in zooplankton densities during the first half of 1976 was attributed to the variability in volume and pattern of reservoir water releases.

2. Zooplankton densities in the Neosho River (Locations 10 and 4) appeared to be related to reservoir zooplankton densities, volume of reservoir water releases, turbidity, and water temperature. Maximum annual densities in the Neosho River were observed in February (mean 714,297 organisms/m^3), whereas minimum zooplankton populations were present in August and October (mean 10760 organisms/m^3).

3. Dominant taxa in the Neosho River during 1976 included immature copepods, *Bosmina longirostris*, *Daphnia parvula*, *Diaptomus siciloides*, *Keratella*, *Polyarthra*, *Brachionus*, and *Hexarthra*. Small zooplankton populations, primarily littoral rotifers, which probably originated in the Neosho River itself, were observed at Locations 10 and 4 during periods of low flow.

4. Zooplankton densities in Wolf Creek ranged from 242,879 organisms/m^3

in June to 1,320,761 organisms/m^3 in August 1976. Consistently large zooplankton populations were attributed to the absence of flow in Wolf Creek on all sampling dates. In December, pools at all sampling locations were virtually dry. Zooplankton densities and species composition in Wolf Creek were primarily governed by flow characteristics and seasonal factors.

5. Major zooplankton taxa collected in Wolf Creek included copepod nauplii, *Chydorus sphaericus*, *Bosmina longirostris*, *Daphnia ambigua*, *Tropocyclops prasinus mexicanus*, *Filinia*, *Keratella*, *Polyarthra*, and *Pompholyx*.

6. No effects on zooplankton populations in the Neosho River or Wolf Creek were observed that could be attributed to construction of Wolf Creek Generating Station.

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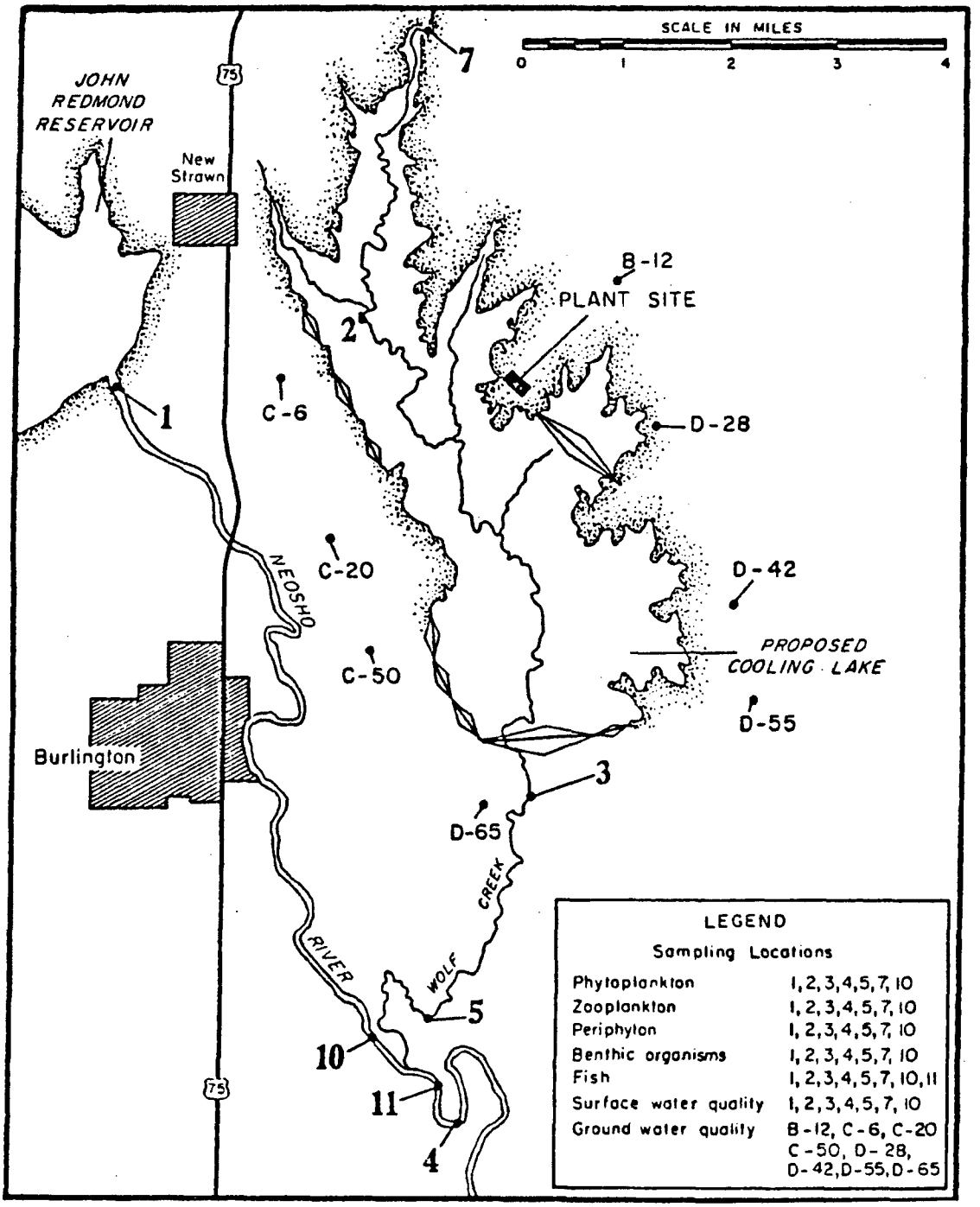

Figure 5.1. Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

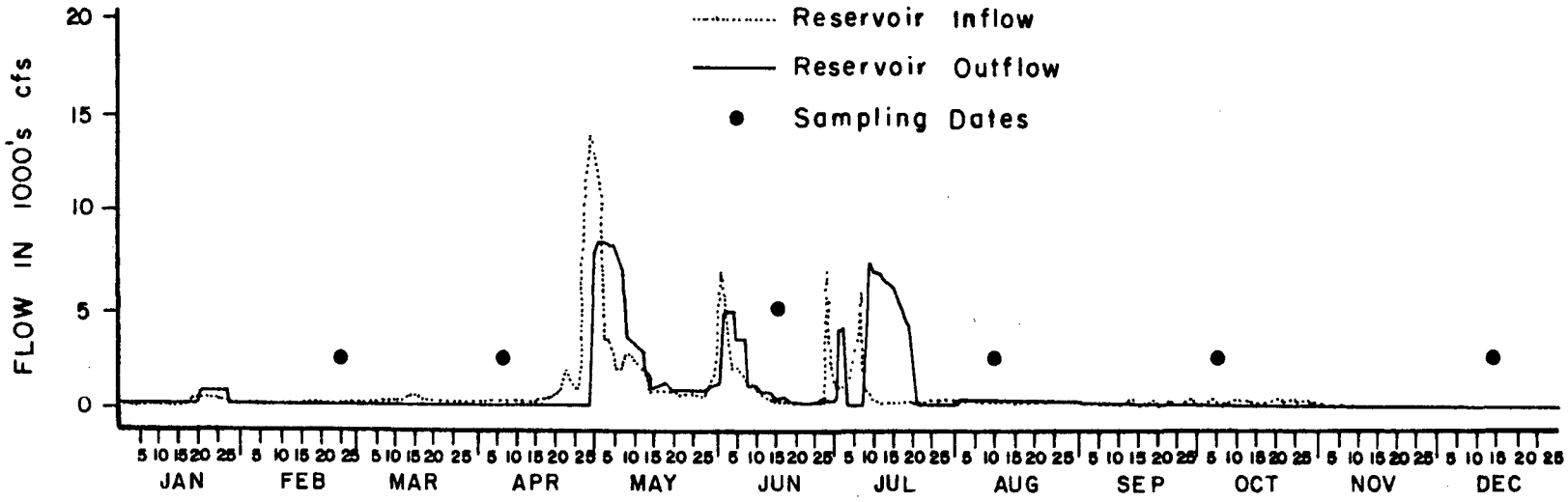

Figure 5.2. Inflow and outflow data for John Redmond Reservoir 1976.

Table 5.1. Zooplankton taxa collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

COPEPODA

Cyclops bicuspidatus thomasi S. A. Forbes
Cyclops vernalis Fischer
Diaptomus clavipes Schaeht
Diaptomus pallidus Herrick
Diaptomus siciloides Lilljeborg
Ergasilus chautauquaensis Fellows
Ergasilus megaceros Wilson
Ergasilus versicolor Wilson
Eucyclops agilis (Koch)
Eucyclops agilis montanus (Brady)
Eucyclops speratus (Lilljeborg)
Macrocyclops albidus (Turine)
Mesocyclops edax (S. A. Forbes)
Orthocyclops modestus (Herrick)
Paracyclops fimbriatus poppei (Rehberg)
Tropocyclops prasinus mexicanus Kiefer
Harpacticoida

CLADOCERA

Alona circumfimbriata (Meegard)
Alona pulchella King
Alona spp. (Baird)
Bosmina longirostris (O. F. Muller)
Ceriodaphnia lacustris Birge
Ceriodaphnia quadrangula (O. F. Muller)
Chydorus sphaericus (O. F. Muller)
Daphnia ambigua Scourfield
Daphnia parvula Fordyce
Daphnia pulex Leydig
Disparalona rostrata (Koch)
Diaphanosoma leuchtenbergianum Fischer
Ilyocryptus sordidus (Lieven)
Kurzia latissima (Kurz)
Leydigia acanthocercoides (Fischer)
Leydigia leydigi (Schoedler)
Macrothrix laticornis (Jurine)
Moina affinis Birge
Moina micrura Kurz
Pleuroxus denticulatus Birge
Pleuroxus hamulatus Birge
Pseudochydorus globosus (Baird)
Scapholeberis kingi Sars
Simocephalus serrulatus (Koch)

Table 5.1. Continued.

ROTIFERA

- Anuraeopsis sp. Lauterborn
- Asplanchna sp. Gosse
- Bdelloid rotifers
- Brachionus spp. Pallas
- Cephalodella spp. Bory St. Vincent
- Collotheca sp. Harring
- Conochiloides sp. Hlava
- Euchlanis spp. Ehrenberg
- Filinia spp. Bory St. Vincent
- Gastropus sp. Imhof
- Hexarthra spp. Schmarda
- Itura sp. Harring and Myers
- Keratella spp. Bory St. Vincent
- Lecane spp. Nitzsch
- Lepadella spp. Bory St. Vincent
- Lophocharis sp. Ehrenberg
- Monostyla sp. Ehrenberg
- Mytilina sp. Bory St. Vincent
- Notholca spp. Gosse
- Notommata sp. Ehrenberg
- Notommatid rotifers
- Platyias sp. Harring
- Polyarthra spp. Ehrenberg
- Pompholyx sp. Gosse
- Rotaria sp. Scopoli
- Synchaeta spp. Ehrenberg
- Testudinella sp. Bory St. Vincent
- Trichocerca spp. Lamarck
- Trichotria sp. Bory St. Vincent
- Wolga sp. Skorikov

Table 5.2. Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 25 February 1976.

	Sampling Locations													
	Neosho River						Wolf Creek							
	1		10		4		7		2		3		5	
	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
COPEPODA														
Nauplii	61327[a]	2.76	10560	1.29	13640	2.23	99266	37.65	50689	42.14	207	0.01	11000	1.32
Calanoid copepodites	446	0.02	40	0.00	120	0.02	0		13	0.01	7	0.00	7	0.00
Cyclopoid copepodites	16950	0.76	1280	0.16	1610	0.26	15399	5.84	865	0.72	117	0.00	1991	0.24
Cyclops bicuspidatus thomasi	2330	0.10	9	0.00	130	0.02	299	0.09	0		0		207	0.02
Cyclops vernalis	1538	0.07	0		20	0.00	0		64	0.05	0		62	0.01
Diaptomus pallidus	264	0.01	31	0.00	0		0		136	0.11	0		26	0.00
Diaptomus siciloides	4400	0.20	590	0.07	600	0.10	0		0		0		0	
Eucyclops agilis	14	0.00	0		0		0		0		0		0	
Eucyclops speratus	14	0.00	0		0		48	0.02	103	0.08	0		62	0.01
Ergasilus megaceros	28	0.00	20	0.00	10	0.00	0		0		0		0	
Macrocyclops albidus	0		0		0		0		4	0.00	0		0	
Mesocyclops edax	0		0		0		82	0.03	9	0.01	0		0	
Tropocyclops prasinus mexicanus	0		0		0		0		31	0.02	0		0	
Harpacticoida	90	0.00	20	0.00	60	0.01	634	0.24	1615	1.34	0		0	
TOTAL COPEPODA	87401	3.93	12649	1.55	16190	2.65	115658	43.87	53529	44.50	331	0.01	13355	1.61
CLADOCERA														
Alona circumfimbriata	0		0		0		0		607	0.50	0		0	
Alona spp. (Imm.)	0		0		0		0		73	0.06	0		0	
Bosmina longirostris	25789	1.16	2380	0.29	1060	0.17	0		689	0.57	207	0.01	3436	0.41
Chydorus sphaericus	20	0.00	9	0.00	10	0.00	0		6820	5.67	13	0.00	20	0.00
Daphnia ambigua	0		0		0		0		31	0.02	0		0	
Daphnia parvula	727	0.03	0		0		0		0		0		7	0.00
Daphnia spp. (Imm.)	0		0		0		0		44	0.04	7	0.00	0	
Ilyocryptus sordidus	0		9	0.00	20	0.00	0		4	0.00	0		0	
Kurzia latissima	0		0		0		0		35	0.03	0		0	
Leydigia leydigi	0		0		0		0		436	0.36	0		0	
Macrothrix laticornis	0		0		0		0		13	0.01	0		0	
Pleuroxus denticulatus	0		0		0		0		9	0.01	0		0	
Pleuroxus hamulatus	0		0		10	0.00	0		0		0		0	
Pseudochydorus globosus	0		0		0		0		4	0.00	0		0	
Simocephalus serrulatus	0		0		0		0		79	0.06	0		0	
TOTAL CLADOCERA	26536	1.19	2398	0.29	1100	0.18	0		8844	7.35	227	0.01	3463	0.42
ROTIFERA														
Asplanchna spp.	4591	0.21	220	0.03	220	0.04	0		0		75	0.00	1135	0.14
Bdelloid Rotifera spp.	242	0.01	440	0.05	990	0.16	1226	0.46	3828	3.18	0		220	0.03
Brachionus spp.	310619	13.98	94162	1.15	88771	14.53	83760	31.77	264	0.22	4400	0.19	12575	1.51
Cephalodella spp.	0		0		110	0.02	1172	0.44	352	0.29	0		330	0.04
Conochiloides spp.	1922	0.09	220	0.03	330	0.05	0		0		0		0	
Filinia spp.	13309	0.60	3080	0.38	1540	0.25	746	0.28	924	0.77	1947920	83.77	755166	90.83
Keratella spp.	1252124	56.34	349037	42.68	263015	43.06	106	0.04	924	0.77	31	0.00	2895	0.35
Lecane spp.	0		110	0.01	0		0		0		0		0	
Lepadella spp.	0		0		0		13747	5.21	1012	0.84	0		110	0.01
Lophocharis spp.	0		0		0		0		352	0.29	0		0	
Monostyla spp.	0		0		0		0		88	0.07	0		0	

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Table 5.2. Continued.

	Sampling Locations													
	Neosho River						Wolf Creek							
	1		10		4		7		2		3		5	
	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%
Notholca spp.	81	0.00	220	0.03	0		0		132	0.11	0		0	
Notommata spp.	0		0		0		0		88	0.07	0		0	
Platyias spp.	0		0		0		160	0.06	44	0.04	0		0	
Polyarthra spp.	497936	22.40	340017	41.58	225174	36.86	45130	17.12	6820	5.67	17255	0.74	6895	0.83
Rotaria spp.	0		0		0		639	0.24	1672	1.39	37	0.00	110	0.01
Synchaeta spp.	27629	1.24	13860	1.69	13310	2.18	852	0.32	39997	33.25	354427	15.24	33586	4.04
Testudinella spp.	0		0		0		426	0.16	220	0.18	0		0	
Trichocerca spp.	0		0		0		0		264	0.22	0		0	
Trichotria spp.	0		0		0		0		572	0.48	0		0	
Unidentified Rotifera spp.	0		1320	0.16	110	0.02	0		352	0.29	471	0.02	1540	0.18
TOTAL ROTIFERA	2108453	94.87	802686	98.16	593571	97.17	147964	56.13	57905	48.14	2324616	99.98	814562	97.98
TOTAL ZOOPLANKTON	2222370		817733		610861		263622		120278		2325174		831380	

[a]Mean of two replicates.

NALCO ENVIRONMENTAL SCIENCES

Table 5.3. Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 5 April 1976.

	Locations													
	Neosho River						Wolf Creek							
	1		10		4		7		2		3		5	
Taxa	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%
COPEPODA														
Nauplii	129,524[a]	55.36	46	0.46	70	0.22	1,632,761	60.18	139,593	18.46	30,581	63.84	110,222	58.33
Calanoid copepodites	388	0.16	1	0.01	0		1,133	0.04	57	0.01	31	0.06	163	0.09
Cyclopoid copepodites	52,106	22.27	12	0.12	40	0.13	59,634	2.20	3,489	0.46	3,489	7.28	10,230	5.41
Cyclops bicuspidatus thomasi	2,099	0.90	0		0		26,789	0.99	0		40	0.08	130	0.07
Cyclops vernalis	1,289	0.55	0		0		2,265	0.08	202	0.03	0		123	0.06
Diaptomus pallidus	0		0		0		0		9	0.00	0		40	0.02
Diaptomus siciloides	202	0.09	0		0		0		9		24	0.05	0	
Eucyclops agilis	0		0		0		0		24	0.00	202	0.42	90	0.05
Eucyclops speratus	0		0		0		4,152	0.15	431	0.06	31	0.06	145	0.08
Macrocyclops albidus	0		0		0		0		40	0.00	0		31	0.02
Mesocyclops edax	7	0.00	0		0		4,152	0.15	0		0		0	
Orthocyclops modestus	0		0		0		0		0		18	0.04	24	0.01
Paracyclops fimbriatus poppei	0		0		0		0		0		0		18	0.01
Tropocyclops prasinus mexicanus	0		0		0		0		0		15	0.03	9	0.00
Harpacticoida	50	0.02	16	0.16	310	0.99	5,662	0.21	1,175	0.16	18	0.04	66	0.03
Total Copepoda	185,665	79.35	75	0.75	420	1.35	1,747,500	64.40	145,029	19.17	34,449	71.91	121,291	64.18
CLADOCERA														
Alona circumfimbriata	0		2	0.02	16	0.05	0		11,770	1.56	0		9	0.00
Alona spp.	0		0		0		3,775	0.14	3,630	0.48	0		0	
Bosmina longirostris	41,630	17.79	5	0.05	20	0.06	378	0.01	1,716	0.23	4,085	8.53	579	0.31
Ceriodaphnia lacustris	0		0		0		0		48	0.01	24	0.05	40	0.02
Chydorus sphaericus	0		1	0.01	32	0.10	34,346	1.27	81,952	10.83	130	0.27	235	0.12
Daphnia ambigua	0		0		0		0		81	0.01	2,424	5.06	1,148	0.61
Daphnia parvula	4,755	2.03	0		0		0		15	0.00	9	0.02	0	
Daphnia spp. (Immature)	0		0		0		0		123	0.02	1,465	3.06	0	
Diaphanosoma leuchtenbergianum	0		0		0		0		9	0.00	0		0	
Ilyocryptus sordidus	0		6	0.06	33	0.10	0		75	0.01	0		0	
Kurzia latissima	0		0		0		0		57	0.01	0		0	
Leydigia leydigi	0		0		0		0		708	0.09	0		0	
Macrothrix laticornis	0		0		0		0		24	0.00	0		0	
Pleuroxus denticulatus	0		0		1	0.00	0		66	0.01	0		0	
Pleuroxus hamulatus	0		0		0		0		0		0		9	0.00
Simocephalus serrulatus	0		0		1	0.00	0		994	0.13	9	0.02	9	0.00
Daphnia catawba	0		0		0		0		0		0		0	
Total Cladocera	46,385	19.82	14	0.14	103	0.33	34,498	1.42	101,268	13.39	8,146	17.00	3,142	1.66
ROTIFERA														
Asplanchna spp.	7	0.00	0		0		0		3,018	0.40	911	1.90	0	
Bdelloid Rotifera spp.	0		0		385	1.24	19,815	0.73	220	0.03	627	1.31	251	0.13
Brachionus spp.	616	0.26	7,487	74.94	28,050	90.02	5,284	0.19	0		125	0.26	440	0.23

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Table 5.3. Continued.

Taxa	Locations													
	Neosho River						Wolf Creek							
	1		10		4		7		2		3		5	
	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%	No./m^3	%
Cephalodella spp.	0		791	7.92	770	2.47	0		92	0.01	125	0.26	92	0.05
Conochiloides spp.	126	0.05	0		0		0		0		0		0	
Euchlanis spp.	0		0		0		0		42	0.00	0		62	0.03
Filinia spp.	50	0.02	0		0		27,741	1.02	16,830	2.22	942	1.97	220	0.12
Gastropus spp.	0		0		0		0		0		125	0.26	0	
Keratella spp.	219	0.09	548	5.48	440	1.41	792,603	29.21	462,230	61.11	598	1.25	409	0.22
Lepadella spp.	0		46	0.46	110	0.35	7,926	0.29	312	0.04	0		31	0.02
Lophocharis spp.	0		0		0		0		0		92	0.19	92	0.05
Monostyla spp.	0		0		0		0		502	0.07	0		0	
Notholca spp.	0		0		0		25,099	0.93	0		251	0.52	1,980	1.05
Polyarthra spp.	886	0.38	374	3.74	330	1.06	30,383	1.12	0		884	1.84	11,739	6.21
Rotaria spp.	0		0		0		0		660	0.09	0		0	
Synchaeta spp.	33	0.01	518	5.18	495	1.59	1,321	0.05	24,750	3.27	378	0.79	48,181	25.50
Testudinella spp.	0		0		0		9,247	0.34	376	0.05	0		0	
Trichocerca spp.	0		0		0		5,284	0.19	629	0.08	0		125	0.07
Trichotria spp.	0		0		0		0		440	0.06	220	0.46	818	0.43
Unidentified Rotifera	0		137	1.37	55	0.18	2,624	0.10	0		31	0.06	95	0.05
Total Rotifera	1,937	0.83	9,901	99.11	30,635	98.32	927,345	34.18	510,101	67.44	5,309	11.08	64,535	34.15
TOTAL ZOOPLANKTON	233,987		9,990		31,158		2,713,342		756,389		47,904		188,968	

[a]Mean of two replicates.

NALCO ENVIRONMENTAL SCIENCES

Table 5.4. Zooplankton collected in the tailwaters of John Redmond Reservoir (Location 1) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 3 May 1976.

Taxa	Location 1 No./m^3	Location 1 %
COPEPODA		
Nauplii	7428[a]	31.37
Calanoid copepodites	1026	4.33
Cyclopoid copepodites	2527	10.67
Cyclops bicuspidatus thomasi	79	0.33
Cyclops vernalis	158	0.67
Diaptomus pallidus	14	0.06
Diaptomus siciloides	224	0.94
Eucyclops agilis	1	0.00
Eucyclops agilis montanus	10	0.04
Eucyclops speratus	2	0.01
Mesocyclops edax	2	0.01
Paracyclops fimbriatus poppei	2	0.01
Harpacticoida	2	0.01
Total Copepoda	11475	48.46
CLADOCERA		
Alona circumfimbriata	14	0.06
Alona pulchella	2	0.01
Bosmina longirostris	1670	7.05
Ceriodaphnia lacustris	9	0.04
Chydorus spaericus	224	0.94
Daphnia ambigua	20	0.08
Daphnia parvula	134	0.56
Daphnia pulex	2	0.01
Daphnia spp. (Immature)	211	0.89
Diaphanosoma leuchtenbergianum	2	0.01
Leydigia leydigi	12	0.05
Macrothrix laticornis	1	0.00
Simocephalus serrulatus	10	0.04
Total Cladocera	2311	9.76
ROTIFERA		
Asplanchna spp.	18	0.08
Bdelloid Rotifera spp.	110	0.46
Brachionus spp.	2284	9.64
Cephalodella spp.	32	0.14
Colurella spp.	15	0.06
Conochiloides spp.	60	0.25

Table 5.4. Continued.

Taxa	Location 1 No./m^3	Location 1 %
ROTIFERA (continued)		
Filinia spp.	738	3.12
Keratella spp.	3964	16.74
Polyarthra spp.	490	2.07
Platyias spp.	18	0.08
Pompholyx spp.	32	0.14
Rotaria spp.	98	0.41
Synchaeta spp.	1883	7.95
Testudinella spp.	53	0.22
Trichocerca spp.	50	0.21
Trichotria spp.	15	0.06
Wolga spp.	18	0.08
Total Rotifera	9893	41.78
TOTAL ZOOPLANKTON	23679	

[a] Mean of two replicates.

Table 5.5. Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 14 June 1976.

Taxa	Locations													
	Neosho River						Wolf Creek							
	1		10		4		7		2		3		5	
	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
COPEPODA														
Nauplii	113162[a]	18.62	65234	13.74	54873	12.05	181776	36.99	34346	20.79	58294	24.00	33178	45.96
Calanoid copepodites	554	0.09	152	0.03	262	0.06	12150	2.47	7477	4.53	0		21	0.03
Cyclopoid copepodites	12238	2.01	12598	2.65	10580	2.32	25701	5.23	8178	4.95	29206	12.03	4072	5.64
Cyclops bicuspidatus thomasi	0		0		0		9	0.00	210	0.13	0		0	
Cyclops vernalis	3150	0.52	3961	0.83	4804	1.05	75	0.02	547	0.33	84	0.03	0	
Diaptomus pallidus	968	0.16	232	0.05	279	0.06	1467	0.30	5981	3.62	0		0	
Diaptomus siciloides	464	0.08	284	0.06	228	0.05	107	0.02	1112	0.67	0		0	
Ergasilus chautauquaensis	9	0.00	0		10	0.00	0		0		0		0	
Eucyclops agilis	0		0		0		0		0		9	0.00	0	
Eucyclops agilis montanus	0		0		0		21	0.00	0		0		42	0.06
Eucyclops speratus	0		0		0		21	0.00	72	0.04	93	0.04	650	0.90
Macrocyclops albidus	0		0		0		0		30	0.02	0		0	
Mesocyclops edax	9	0.00	0		0		617	0.12	1500	0.91	33	0.01	0	
Paracyclops fimbriatus poppei	0		0		0		0		0		9	0.00	0	
Tropocyclops prasinus mexicanus	44	0.01	16	0.00	0		341	0.07	654	0.40	1072	0.44	84	0.12
Harpacticoida	0		0		0		9	0.00	9	0.00	0		0	
Total Copepoda	130598	21.49	82477	17.34	71036	15.60	222249	45.24	60116	36.40	88800	36.57	38047	52.71
CLADOCERA														
Alona circumfimbriata	0		0		0		0		182	0.11	0		0	
Alona spp.	18	0.00	0		0		0		70	0.04	0		0	
Bosmina longirostris	73929	12.17	49896	10.51	42950	9.43	245327	49.93	26168	15.84	1411	0.58	392	0.54
Ceriodaphnia lacustris	46	0.01	24	0.00	61	0.01	785	0.16	34287	20.76	839	0.34	63	0.09
Ceriodaphnia quadrangula	0		0		0		5542	1.13	535	0.32	0		33	0.04
Chydorus sphaericus	0		16	0.00	10	0.00	416	0.08	2145	1.30	743	0.30	42	0.06
Daphnia ambigua	26	0.00	30	0.01	60	0.01	9346	1.90	35280	21.36	1678	0.69	84	0.12
Daphnia parvula	14927	2.46	6847	1.44	5792	1.27	9	0.00	1026	0.62	107	0.04	0	
Daphnia pulex	0		0		0		4206	0.86	516	0.31	0		0	
Daphnia spp. (Immature)	0		0		0		0		0		0		84	0.12
Diaphanosoma leuchtenbergianum	2138	0.35	271	0.06	215	0.05	96	0.02	42	0.02	33	0.01	9	0.01
Ilyocryptus sordidus	0		0		0		0		70	0.04	33	0.01	9	0.01
Kurzia latissima	0		0		0		9	0.00	70	0.04	0		0	
Leydigia acanthocercoides	0		0		0		0		9	0.00	0		0	
Leydigia leydigi	18	0.00	0		0		0		215	0.13	0		0	

NALCO ENVIRONMENTAL SCIENCES

Table 5.5. Continued.

Taxa	Locations: Neosho River						Wolf Creek							
	1 No./m³	%	10 No./m³	%	4 No./m³	%	7 No./m³	%	2 No./m³	%	3 No./m³	%	5 No./m³	%
Moina affinis	26	0.00	0		0		0		0		0		0	
Moina micrura	18	0.00	7	0.00	0		0		0		0		0	
Pleuroxus denticulatus	0		0		0		0		42	0.02	0		9	0.01
Pleuroxus hamulatus	9	0.00	0		0		0		0		0		0	
Pseudochydorus globosus	0		0		0		0		9	0.00	0		0	
Scapholeberis kingi	0		0		0		1909	0.39	21	0.01	210	0.09	21	0.03
Simocephalus serrulatus	0		0		0		42	0.01	19	0.01	255	0.10	21	0.03
Total Cladocera	91164	15.00	57091	12.03	49098	10.78	267687	54.48	100706	60.97	5309	2.19	767	1.06
ROTIFERA														
Anuraeopsis spp.	0		0		0		0		0		100	0.04	0	
Asplanchna spp.	598	0.10	440	0.09	564	0.12	0		0		98	0.04	0	
Bdelloid Rotifera spp.	0		878	0.18	852	0.19	65	0.01	0		201	0.08	367	0.51
Brachionus spp.	298077	49.05	291320	61.38	286404	62.88	65	0.01	58	0.04	299	0.12	5406	7.49
Cephalodella spp.	0		242	0.05	309	0.07	0		192	0.12	332	0.14	98	0.14
Conchiloides spp.	1100	0.18	440	0.09	1333	0.29	0		0		0		0	
Euchlanis spp.	0		0		96	0.02	33	0.01	0		0		0	
Filinia spp.	103	0.02	0		96	0.02	0		0		0		0	
Hexarthra spp.	39766	6.54	12367	2.60	17558	3.85	0		0		133	0.05	33	0.04
Keratella spp.	14193	2.34	10946	2.31	13342	2.93	869	0.18	1269	0.77	967	0.40	0	
Lecane spp.	0		0		0		33	0.01	26	0.02	33	0.01	0	
Lepadella spp.	0		0		0		133	0.03	84	0.05	100	0.04	266	0.37
Monostyla spp.	0		0		0		0		51	0.03	33	0.01	65	0.09
Notommata spp.	0		0		0		0		0		33	0.01	0	
Platyias spp.	0		0		0		65	0.01	0		0		0	
Polyarthra spp.	27974	4.60	17187	3.62	13505	2.96	0		2056	1.24	138551	57.06	133	0.18
Pompholyx spp.	509	0.08	0		0		0		0		0		0	
Rotaria spp.	103	0.02	0		288	0.06	0		206	0.12	33	0.01	1201	1.66
Synchaeta spp.	3154	0.52	752	0.16	351	0.08	0		0		7009	2.89	20794	28.81
Testudinella spp.	0		0		0		65	0.01	151	0.09	367	0.15	902	1.25
Trichocerca spp.	302	0.05	0		330	0.07	65	0.01	0		0		33	0.04
Trichotria spp.	0		0		0		0		84	0.05	0		0	
Wolga spp.	0		0		0		0		58	0.04	434	0.18	3972	5.50
Unidentified Rotifera spp.	0		508	0.11	309	0.07	0		117	0.07	0		98	0.14
Total Rotifera	385879	63.50	335080	70.60	335337	73.62	1393	0.28	4352	2.63	148723	61.24	33368	46.23
TOTAL ZOOPLANKTON	607641		474648		455471		491374		165174		242832		72182	

[a]Mean of two replicates.

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Table 5.6. Zooplankton collected in the tailwaters of John Redmond Reservoir (Location 1) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 12 July 1976.

Taxa	Location 1 No./m^3	Location 1 %
COPEPODA		
Nauplii	15836[a]	10.90
Calanoid copepodites	1900	1.31
Cyclopoid copepodites	2356	1.62
Cyclops vernalis	61	0.04
Diaptomus pallidus	339	0.23
Diaptomus siciloides	812	0.56
Ergasilus chautauquaensis	54	0.04
Ergasilus megaceros	31	0.02
Ergasilus versicolor	8	0.00
Tropocyclops prasinus mexicanus	39	0.03
Total Copepoda	21436	14.76
CLADOCERA		
Bosmina longirostris	2242	1.54
Ceriodaphnia lacustris	15	0.01
Daphnia parvula	420	0.29
Diaphanosoma leuchtenbergianum	15946	10.98
Moina affinis	110	0.08
Moina micrura	625	0.43
Sida crystallina	22	0.02
Total Cladocera	19380	13.34
ROTIFERA		
Asplanchna spp.	434	0.30
Brachionus spp.	23617	16.26
Collotheca spp.	508	0.35
Conochiloides spp.	32760	22.55
Filinia spp.	3590	2.47
Hexarthra spp.	37474	25.80
Keratella spp.	346	0.24
Polyarthra spp.	2486	1.71
Synchaeta spp.	670	0.46
Trichocerca spp.	2316	1.59
Unidentified Rotifera spp.	258	0.18
Total Rotifera	104459	71.90
TOTAL ZOOPLANKTON	145275	

[a] Mean of two replicates.

Table 5.7. Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 10 August 1976.

	Sampling Locations													
	Neosho River						Wolf Creek							
	1		10		4		7		2		3		5	
Taxa	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
COPEPODA														
Nauplii	34813[a]	17.58	69	1.19	434	2.80	150818	6.55	103738	26.88	107710	5.32	152336	26.69
Calanoid copepodites	3570	1.80	4	0.07	4	0.02	5664	0.24	33645	8.72	4673	0.23	9813	1.72
Cyclopoid copepodites	1093	0.55	8	0.14	76	0.49	36098	1.57	12930	3.35	24299	1.20	162617	28.49
Cyclops vernalis	107	0.05	0		0		12	0.00	12	0.00	12	0.00	23	0.00
Diaptomus pallidus	51	0.02	0		0		5245	0.23	17210	4.46	1953	0.10	6075	1.06
Diaptomus siciloides	107	0.05	6	0.10	0		51	0.00	3182	0.82	257	0.01	911	0.16
Ergasilus chautauguaensis	1626	0.82	52	0.89	14	0.09	0		0		0		0	
Ergasilus versicolor	33	0.02	10	0.17	3	0.02	0		0		0		0	
Ergasilus spp.	33	0.02	2	0.03	0		42	0.00	12	0.00	0		0	
Eucyclops agilis	0		0		0		0		12	0.00	0		0	
Eucyclops agilis montanus	0		0		0		0		0		0		131	0.02
Eucyclops speratus	0		0		0		0		23	0.00	12	0.00	131	0.02
Mesycyclops edax	33	0.02	0		0		9	0.00	189	0.05	0		47	0.01
Paracyclops fimbriatus poppei	0		0		0		12	0.00	0		0		0	
Tropocyclops prasinus mexicanus	9	0.00	0		3	0.02	4701	0.20	17991	4.66	5762	0.28	88785	15.55
TOTAL COPEPODA	41475	20.95	151	2.60	534	3.45	202652	8.80	188944	48.96	144678	7.15	420869	73.74
CLADOCERA														
Alona pulchella	0		0		0		0		12	0.00	0		0	
Bosmina longirostris	1713	0.87	0		1	0.01	556	0.02	7556	1.96	56	0.00	467	0.08
Ceriodaphnia lacustris	21	0.01	0		0		84	0.00	2056	0.53	0		23	0.00
Chydorus sphaericus	0		0		0		0		23	0.00	0		0	
Daphnia ambigua	0		0		0		42	0.00	346	0.09	0		0	
Daphnia parvula	3939	1.99	0		2	0.01	42	0.00	1224	0.32	0		0	
Diaphanosoma leuchtenbergianum	8061	4.07	9	0.15	8	0.05	5547	0.24	713	0.18	44	0.00	6542	1.15
Ilyocryptus sordidus	0		0		0		0		0		12	0.00	0	
Leydigia leydigi	0		0		0		21	0.00	0		0		0	
Macrothrix laticornis	0		0		2	0.01	166	0.01	0		12	0.00	0	
Moina affinis	1103	0.56	0		8	0.05	0		0		0		0	
Moina micrura	182	0.09	2	0.03	0		0		636	0.16	56	0.00	420	0.07
Pleuroxus denticulatus	0		0		0		0		44	0.01	0		0	
Pleuroxus hamulatus	0		0		0		0		12	0.00	0		0	
Scapholeberis kingi	0		0		0		0		645	0.17	0		0	
Simocephalus serrulatus	0		0		1	0.01	0		0		0		0	
TOTAL CLADOCERA	15037	7.60	11	0.18	22	0.14	6458	0.28	13267	3.44	180	0.01	7452	1.30

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Table 5.7. Continued.

Taxa	Sampling Locations													
	Neosho River						Wolf Creek							
	1		10		4		7		2		3		5	
	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
ROTIFERA														
Asplanchna spp.	584	0.29	12	0.21	91	0.59	0		0		8140	0.40	0	
Bdelloid Rotifera spp.	0		106	1.82	190	1.23	105	0.00	77	0.02	77	0.00	542	0.09
Brachionus spp.	27336	13.81	4223	72.60	12032	77.74	57009	2.47	74299	19.25	805841	39.84	13159	2.30
Cephalodella spp.	0		178	3.06	487	3.15	33	0.00	0		117	0.00	776	0.14
Collotheca spp.	234	0.12	0		0		0		0		0		0	
Conochiloides spp.	584	0.29	22	0.38	20	0.13	112	0.00	3778	0.98	37	0.00	0	
Euchlanis spp.	0		60	1.03	10	0.06	0		37	0.01	0		0	
Filinia spp.	467	0.24	46	0.79	70	0.45	4322	0.19	14757	3.82	254673	12.59	11836	2.07
Hexarthra spp.	35280	17.82	270	4.64	560	3.62	0		117	0.03	7710	0.38	4126	0.72
Keratella spp.	53972	27.26	37	0.64	49	0.32	1547547	67.18	37850	9.81	633645	31.32	96729	16.95
Lecane spp.	0		0		0		178	0.01	0		37	0.00	0	
Lepadella spp.	0		0		10	0.06	33	0.00	0		79	0.00	308	0.05
Lophocharis spp.	0		0		0		37	0.00	77	0.02	0		0	
Monostyla spp.	0		0		0		100	0.00	4827	1.25	0		1168	0.20
Polyarthra spp.	13551	6.84	360	6.19	772	4.99	291005	12.63	11528	2.99	79439	3.93	2645	0.46
Pompholyx spp.	4439	2.24	0		0		189252	8.22	778	0.20	15734	0.78	1948	0.34
Rotaria spp.	0		0		0		238	0.01	544	0.14	2727	0.13	3425	0.60
Synchaeta spp.	4790	2.42	106	1.82	0		0		0		350	0.02	0	
Testudinella spp.	0		0		0		33	0.00	196	0.05	117	0.00	1556	0.27
Trichocerca spp.	234	0.12	141	2.42	260	1.68	4477	0.19	34813	9.02	68925	3.41	3430	0.60
Wolga spp.	0		24	0.41	19	0.12	0		0		0		388	0.07
Unidentified Rotifera spp.	0		70	1.20	110	0.71	0		0		311	0.02	388	0.07
TOTAL ROTIFERA	141471	71.46	5655	97.22	14921	96.41	2094481	90.92	183678	47.60	1877959	92.84	142424	24.95
TOTAL ZOOPLANKTON	197983		5817		15477		2303591		385889		2022817		570745	

[a] Mean of two replicates.

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Table 5.8. Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 4 October 1976.

	Sampling Locations													
	Neosho River						Wolf Creek							
	1		10		4		7		2		3		5	
Taxa	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
COPEPODA														
Nauplii	20622[a]	20.67	130	1.06	169	1.78	6636	15.06	117056	41.61	-[b]		-	
Calanoid copepodites	5008	5.02	0		0		0		35047	12.46	-		-	
Cyclopoid copepodites	9175	9.20	16	0.13	72	0.76	570	1.29	7089	2.52	-		-	
Cyclops vernalis	531	0.53	0		0		0		9	0.00	-		-	
Diaptomus pallidus	380	0.38	0		0		0		14850	5.28	-		-	
Diaptomus siciloides	858	0.86	0		0		0		2673	0.95	-		-	
Ergasilus chautauguaensis	560	0.56	4	0.03	3	0.03	0		0		-		-	
Ergasilus megaceros	302	0.30	0		3	0.03	0		0		-		-	
Ergasilus sp. (Imm.)	195	0.20	4	0.03	0		0		9	0.00	-		-	
Eucyclops agilis	0		0		0		23	0.05	28	0.01	-		-	
Eucyclops speratus	0		0		12	0.13	70	0.16	28	0.01	-		-	
Mesocyclops edax	12	0.01	0		0		0		51	0.02	-		-	
Tropcyclops prasinus mexicanus	0		0		0		47	0.11	5140	1.83	-		-	
Harpacticoida	0		0		16	0.17	70	0.16	355	0.13	-		-	
TOTAL COPEPODA	37643	37.74	154	1.26	275	2.89	7416	16.82	182335	64.81	-		-	
CLADOCERA														
Alona circumfimbriata	0		12	0.10	3	0.03	0		448	0.16	-		-	
Alona pulchella	0		0		3	0.03	0		944	0.34	-		-	
Alona spp. (Imm.)	0		0		20	0.21	0		2888	1.03	-		-	
Bosmina longirostris	5363	5.38	36	0.29	7	0.07	0		3383	1.20	-		-	
Ceriodaphnia lacustris	0		4	0.07	0		0		556	0.20	-		-	
Ceriodaphnia sp.	0		0		0		0		9	0.00	-		-	
Chydorus sphaericus	0		4	0.07	3	0.03	0		808	0.29	-		-	
Daphnia ambigua	0		0		0		0		906	0.32	-		-	
Daphnia parvula	2283	2.29	0		0		0		631	0.22	-		-	
Diaphanosoma leuchtenbergianum	605	0.61	0		0		0		364	0.13	-		-	
Disparalona rostrata	0		9	0.07	228	2.40	0		0		-		-	
Ilyocryptus sordidus	0		0		9	0.09	178	0.40	0		-		-	
Kurzia latissima	0		0		0		0		103	0.04	-		-	
Leydigia acanthocercoides	0		0		0		0		9	0.00	-		-	
Leydigia leydigi	0		0		0		23	0.05	224	0.08	-		-	
Macrothrix laticornis	0		0		134	1.41	9	0.02	1766	0.63	-		-	
Moina micrura	6	0.01	0		0		0		0		-		-	
Pleuroxus denticulatus	0		0		3	0.03	0		201	0.07	-		-	
Pleuroxus hamulatus	0		4	0.07	16	0.17	0		495	0.18	-		-	
Scapholeberis kingi	0		0		0		0		65	0.02	-		-	
Simocephalus serrulatus	6	0.01	0		0		0		0		-		-	
TOTAL CLADOCERA	8263	8.28	69	0.56	426	4.48	210	0.48	13800	4.90	-		-	

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Table 5.8. Continued.

Taxa	Neosho River 1 No./m³	Neosho River 1 %	Neosho River 10 No./m³	Neosho River 10 %	Neosho River 4 No./m³	Neosho River 4 %	Wolf Creek 7 No./m³	Wolf Creek 7 %	Wolf Creek 2 No./m³	Wolf Creek 2 %	Wolf Creek 3 No./m³	Wolf Creek 3 %	Wolf Creek 5 No./m³	Wolf Creek 5 %
ROTIFERA														
Anuraeopsis spp.	0		0		0		4159	9.44	131	0.05	-[b]		-	
Bdelloid Rotifera spp.	410	0.41	116	0.95	458	4.81	467	1.06	734	0.26	-		-	
Brachionus spp.	3853	3.86	384	3.14	458	4.81	0		2869	1.02	-		-	
Cephalodella spp.	30	0.03	32	0.26	251	2.64	1963	4.45	332	0.12	-		-	
Collotheca spp.	60	0.06	72	0.59	41	0.43	0		0		-		-	
Conochiloides spp.	0		82	0.67	187	1.96	0		6472	2.30	-		-	
Euchlanis spp.	0		32	0.26	0		0		0		-		-	
Filinia spp.	0		0		0		93	0.21	0		-		-	
Hexarthra spp.	1329	1.33	40	0.33	0		0		266	0.09	-		-	
Itura spp.	0		0		0		748	1.70	0		-		-	
Keratella spp.	23044	23.10	3077	25.17	2024	21.26	234	0.53	63785	22.67	-		-	
Lecane spp.	0		0		0		0		266	0.09	-		-	
Lepadella spp.	0		16	0.13	0		1589	3.60	332	0.12	-		-	
Lophocharis spp.	0		0		0		4626	10.50	201	0.07	-		-	
Monostyla spp.	0		16	0.13	0		0		65	0.02	-		-	
Mytilina spp.	0		0		0		0		266	0.09	-		-	
Platylas spp.	0		0		0		234	0.53	65	0.02	-		-	
Polyarthra spp.	2760	2.77	436	3.57	813	8.54	11589	26.29	402	0.14	-		-	
Pompholyx spp.	0		0		0		0		1598	0.57	-		-	
Rotaria spp.	0		0		0		7103	16.12	1131	0.40	-		-	
Synchaeta spp.	22036	22.09	7222	59.07	3734	39.23	1402	3.18	0		-		-	
Testudinella spp.	0		82	0.67	20	0.21	47	0.11	196	0.07	-		-	
Trichocerca spp.	186	0.19	248	2.03	438	4.60	888	2.01	3804	1.35	-		-	
Trichotria spp.	0		66	0.54	41	0.43	93	0.21	668	0.24	-		-	
Wolga spp.	0		0		146	1.53	0		1603	0.57	-		-	
Unidentified Rotifera spp.	144	0.14	82	0.67	207	2.17	1215	2.76	0		-		-	
TOTAL ROTIFERA	53852	53.98	12003	98.18	8818	92.64	36450	82.70	85186	30.28	-		-	
TOTAL ZOOPLANKTON	99758		12226		9519		44076		281321		-		-	

[a] Mean of two replicates.
[b] Location dry.

NALCO ENVIRONMENTAL SCIENCES

Table 5.9. Zooplankton collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 13 December 1976.

	Sampling Locations													
	Neosho River						Wolf Creek							
	1		10		4		7		2		3		5	
Taxa	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%	No./m³	%
COPEPODA														
Nauplii	35954[a]	33.90	27180	29.06	27934	40.97	-[b]		-		-		-	
Calanoid copepodites	695	0.66	422	0.45	344	0.50	-		-		-		-	
Cyclopoid copepodites	9010	8.50	4784	5.11	4577	6.71	-		-		-		-	
Cyclops bicuspidatus thomasi	487	0.46	148	0.16	20	0.03	-		-		-		-	
Cyclops vernalis	974	0.92	67	0.07	18	0.03	-		-		-		-	
Diaptomus clavipes	0		0		7	0.01	-		-		-		-	
Diaptomus pallidus	516	0.49	371	0.40	70	0.10	-		-		-		-	
Diaptomus siciloides	1041	0.98	702	0.75	161	0.24	-		-		-		-	
Ergasilus chautauquaensis	6	0.00	0		0		-		-		-		-	
Ergasilus megaceros	42	0.04	7	0.01	13	0.02	-		-		-		-	
Eucyclops agilis montanus	0		7	0.01	0		-		-		-		-	
TOTAL COPEPODA	48725	45.95	33688	36.02	33144	48.61	-		-		-		-	
CLADOCERA														
Alona circumfimbriata	0		6	0.01	0		-		-		-		-	
Bosmina longirostris	15506	14.62	18011	19.26	9050	13.27	-		-		-		-	
Chydorus sphaericus	0		12	0.01	6	0.01	-		-		-		-	
Daphnia parvula	1191	1.12	279	0.30	132	0.19	-		-		-		-	
Disparalona rostrata	0		14	0.01	0		-		-		-		-	
Macrothrix laticornis	0		13	0.01	6	0.19	-		-		-		-	
Simocephalus sp.	6	0.00	0		0		-		-		-		-	
TOTAL CLADOCERA	16703	15.75	18335	19.60	9194	13.48	-		-		-		-	
ROTIFERA														
Brachionus spp.	64	0.06	0		221	0.32	-		-		-		-	
Cephalodella spp.	64	0.06	70	0.07	91	0.13	-		-		-		-	
Euchlanis spp.	0		0		30	0.04	-		-		-		-	
Keratella spp.	11974	11.29	16276	17.40	9084	13.32	-		-		-		-	
Notommatid Rotifera spp.	0		0		34	0.05	-		-		-		-	
Polyarthra spp.	4332	4.08	5804	6.20	4664	6.84	-		-		-		-	
Synchaeta spp.	24180	22.80	17316	18.51	10416	15.28	-		-		-		-	
Trichotria spp.	0		1906	2.04	1309	1.92	-		-		-		-	
TOTAL ROTIFERA	40614	38.30	41510	44.38	25849	37.91	-		-		-		-	
TOTAL ZOOPLANKTON	106042		93533		68187		-		-		-		-	

[a] Mean of two replicates.
[b] Location dry.

NALCO ENVIRONMENTAL SCIENCES

Table 5.10. Mean densities of major zooplankton groups collected in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1975-1976.

Taxa and Location	April		June		September — August		December	
	No./m^3 (1975)	No./m^3 (1976)	No./m^3 (1975)	No./m^3 (1976)	No./m^3 (1975)	No./m^3 (1976)	No./m^3 (1975)	No./m^3 (1976)
COPEPODA								
John Redmond Reservoir	20003[a]	185665[b]	65687	130598	122795	41475	55218	48725
Neosho River[c]	8384	248	13250	76756	920	342	32072	33416
Wolf Creek	4930	512067	16770	102303	154708	239286	11900	-[d]
CLADOCERA								
John Redmond Reservoir	1349	46385	23304	91164	77309	15037	22024	16703
Neosho River	514	58	2127	53094	87	16	14406	13764
Wolf Creek	106	36764	4522	93617	21198	6839	22129	-
ROTIFERA								
John Redmond Reservoir	398123	1937	286128	385879	290486	141471	43516	40614
Neosho River	207792	20268	22968	335208	1932	10288	84968	33680
Wolf Creek	4247	376822	41358	46959	285203	1074636	5087	-
TOTAL ZOOPLANKTON								
John Redmond Reservoir	419475	233987	375119	607641	490590	197983	120758	106042
Neosho River	216692	20574	38390	465058	2939	10646	131465	80860
Wolf Creek	9283[e]	925653[f]	62650[e]	242879[f]	461109[f]	1320761[f]	39116[f]	-

[a] Samples collected at Location 1 within reservoir (1975).
[b] Samples collected at Location 1 in reservoir discharge (1976).
[c] Locations 10 and 4.
[d] All Wolf Creek locations dry.
[e] Flow present in Wolf Creek.
[f] Flow absent in Wolf Creek (isolated pools).

NALCO ENVIRONMENTAL SCIENCES

Chapter 6

MACROINVERTEBRATE STUDY

By

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I. Introduction

Benthic macroinvertebrate communities have been monitored on the Wolf Creek Generating Station (WCGS) site and in the surrounding environs as part of an environmental evaluation to assess and minimize the effects of construction and operation of this facility. Species composition and relative abundance data on the benthic fauna in John Redmond Reservoir, the Neosho River, and Wolf Creek have been collected quarterly since March 1973 (Kansas Gas and Electric Company 1974; Nulty 1975; Andersen 1976).

Objectives of this first construction phase monitoring study were:

1. To provide additional baseline data on the benthic macroinvertebrate fauna of the WCGS site and immediate environs;

2. To document the naturally occurring temporal and spatial variability of benthic populations in the area; and

3. To provide information for use in the formulation of management programs to minimize effects of construction and operation on the environment.

II. Field and Analytical Procedures

Duplicate samples of drifting benthic macroinvertebrates were collected from the tailwaters of John Redmond Dam (Location 1) on 24 February, 5 April, 14 June, 9 August, 4 October, and 13 December 1976 (Figure 6.1). Collections were made using a 0.75 m diameter plankton net of no. 0 mesh Nitex (0.571 mm), equipped with an internally mounted flowmeter (Model 2030, General Oceanics, Inc.). Duplicate Ponar dredge samples and single qualitative samples were collected on 25 February, 6 April, 15 June, 10 August, 5 October, and 14 December 1976 from Locations 10 and 4 in the Neosho River and Locations 7, 2, 3, and 5 in Wolf Creek (Figure 6.1). Due to the lack of water, no samples were collected at Locations 3 and 5 in October or December. Samples were collected from a different, slightly larger pool at Location 7 in October. Ice cover prevented qualitative sampling at Locations 7 and 2 in December.

All samples were sieved in the field using U. S. Standard no. 30 mesh (0.595 mm) screen. The retained material was transferred to appropriately labeled containers and fixed with a rose bengal staining solution of 10% formalin (Mason and Yevich 1967). After exposure to the staining solution for a minimum of 24 hr, samples were rewashed at the laboratory in a no. 60 mesh (0.250 mm) sieve and preserved in 70% ethanol. Organisms were hand-picked from debris with the aid of a stereozoom microscope, identified to the lowest positive taxonomic level, and enumerated. Aerial and terrestrial specimens collected in drift samples were not analyzed. Taxonomic keys used in identifications included Andersen (1973), Beck and Beck (1966), Beck and Beck (1969), Borror and DeLong (1964), Brinkhurst (1964, 1968), Burch (1972), Burks (1953), Cook (1956), Edmondson (1959), Flint (1964), Hamilton and Saether (1970), Harden and Mickel (1952), Hilsenhoff (1970), Hiltunen (1973), Hobbs (1972), Holsinger (1972), Klemm (1972), Leonard and Leonard (1962), Lewis (1969, 1974), Needham et al. (1935), Needham and Westfall (1955), Pennak (1953), Roback (1957, 1962,

1969, 1971, 1974), Ross (1944), Sperber (1950), Usinger (1971), and Williams (1972).

Diversity indices for all quantitative samples were calculated using the log base 2 in Shannon's (1948) equation as discussed by Wilhm and Dorris (1968). A one-way analysis of variance was used to test for differences in densities and diversity values among sampling dates and locations (Steel and Torrie 1960).

III. Results and Discussion

A. Habitat Characterization

John Redmond Reservoir was built by the U. S. Army Corps of Engineers in 1965 to provide flood control and streamflow regulation on the upper Neosho (Grand) River. Flow of the Neosho River in the study area is primarily dependent upon the midwater discharge from the dam, and is subject to extreme fluctuations according to priorities established in the Tulsa District Office of the Corps. The small amount of rainfall in the upper watershed during 1976 necessitated that the discharge from the dam be maintained at minimal levels (about 50 cfs) throughout most of the study period (Figure 6.2). Discharge rates encountered during macroinvertebrate drift samplings exceeded this minimum only on 14 June when 760 cfs were being released (Table 6.1).

The substrate at Location 1, where the drift samples were collected, was a layered bedrock of limestone, shale and some sandstone. The shallow riffle sampled at Location 10 contained gravel and larger rubble, whereas the gravel bar at Location 4 consisted primarily of sandy gravel.

Wolf Creek is subject to extended periods of pooling without flow during drought as well as brief periods of high flow from snowmelt and rainfall runoff. Benthic macroinvertebrate communities usually increase in complexity and stability as stream order increases (Harrel and Dorris 1968). However, desiccation of Wolf Creek Locations 3 and 5 during the drought of 1976 upset this general relationship. Upstream sampling Locations 7 and 2 which are in third order sections of the watercourse were more stable than those downstream of the proposed dam (3 and 5) which are in a fourth order reach (Strahler 1957).

Substrates sampled at Locations 7, 2, and 5 in Wolf Creek were generally clay with some gravel overlaid with leaf litter, whereas Location 3 was primarily sand and gravel. Although gravel substrates have been sampled at all locations in previous studies, water levels were so reduced that only clay-bottomed pools held water throughout 1976. No water was in the creek bed at Locations 3 and 5 on 5 October or 14 December.

B. Aquatic Macroinvertebrate Communities

1. Neosho River

Discharge rates from John Redmond Dam were low on each sampling date of 1976 (Figure 6.2). Water temperatures at Location 1 displayed normal seasonal variations and ranged from 1.2C in December to 25.6C in August (Table 6.1).

a. Drift Samples

Seasonal variation in the composition of the drifting macroinvertebrate assemblage was substantial. Duplicate drift samples yielded macroinvertebrate densities ranging from 274 organisms/100 m^3 in August to 2702/100 m^3 in October (Table 6.1). Numbers of drifting macroinvertebrate taxa per collection ranged from 18 in August to 38 in October (Table 6.1), whereas a total of 66 taxa was recorded in 1976 (Table 6.2).

Hydroids represented over 25% of the density, except in the summer (14 June and 9 August). Lomnicki and Slobodkin (1966) suggested that populations of Hydra in tailwater areas often develop dense aggregations in response to the constant availability of planktonic food items. The summer decline in hydroid density was expected as a normal part of their seasonal cycle (Pennak 1953). The marked increase in the drift density of Hydra in October was probably associated with season change (declining water temperature and length of photoperiod) as suggested by Reisa (1973).

Naididae were of major numerical importance only in February when they accounted for approximately 14% of the total drift density (Table 6.1). Carter (1977) similarly reported that naidids were abundant (16%) in the Missouri River drift only during February of 1976. Ladle (1971) reported increased benthic densities of Nais elinguis during winter in Great Britain. The abundance of naidids in the drift as the water began to warm in February was probably related to an increase in activity of the benthic population and a resultant higher susceptibility to drifting.

Hydropsychidae representation followed a seasonal pattern similar to that of the Naididae, accounting for 28% of the total drift density in February and less than 10% in each succeeding sampling period (Table 6.1). Carter (1977) reported percent abundance and density of Hydropsychidae in the drift of the Missouri River were higher during winter months. Elliott (1968) also found higher hydropsychid drift density in a small stream in England during March. Substantially reduced densities of drifting Hydropsychidae found through the summer were caused by the emergence of adults (Fremling 1960; Modde and Schmulbach 1973). The increased density in October was attributed to recruitment of young larvae over the summer reproduction period (Fremling 1960; Elliott 1968). The proximity of John Redmond Dam precluded import from upstream areas so that all hydropsychids collected at Location 1 were tailwater residents.

Chaoborus punctipennis (Chaoboridae) was important in the drift at Location 1 in April, June, and August but was rare in February, October, and December (Table 6.1). Considering the midwater discharge from the dam, these data fit the seasonal pattern of Chaoborus migration. The regular diel vertical migration of Chaoborus larvae was well documented in spring and summer by La Row and Marzolf (1970) and Carter and Kwik (1977). However, Deevey (1941) and Stahl (1966) reported that the larvae inhabit benthic sediments during fall and winter and do not migrate.

Simuliidae were abundant in the drift at Location 1 on all sampling dates except February and August. No direct cause could be found for

the reduction in February, but the drop recorded in August was probably related to the different collection time (morning vs. evening). Hynes (1970) reported strong diel periodicity in the drift of several species of Simuliidae.

The percent abundance of Chironomidae in the drift at Location 1 was higher in summer with June and August values of 56 and 40%, respectively (Table 6.1). Members of the genus Cricotopus comprised a major portion of the chironomids drifting on all sampling dates probably due to their affinity for the Cladophora which was prevalent on the rocks at this sampling location (Mundie 1956). Procladius and Tanypus larvae were common benthic organisms within John Redmond Reservoir (Funk 1973; Andersen 1976). Their presence in the tailwater drift in April and June indicated that they had migrated off the bottom as suggested by Davies (1976) and had been drawn through the midwater discharge of the dam.

b. Benthos Samples

Quantitative Ponar samples collected at Locations 10 and 4 contained totals of 95 and 79 macrobenthic taxa, respectively, and when combined totaled 109 different taxa (Table 6.2). Twenty-eight taxa were found at Location 4 in the baseline study (Kansas Gas and Electric Company 1974). However, when Locations 10 and 4 were both sampled, totals of 36 and 72 taxa were reported in 1974 and 1975, respectively (Nulty 1975; Andersen 1976). Low river flows, increased taxonomic proficiency, and more frequent sampling contributed to the higher number of taxa reported in 1976.

Total benthic densities in 1976 ranged from 350 to 23795 organisms/m^2 at Location 10 and from 1890 to 9941 organisms/m^2 at Location 4 (Table 6.3). Species diversity indices were generally indicative of good water quality, and the reduction noted on 15 June (Table 6.3) probably reflected the stress exerted by the high water earlier in the month (Figure 6.2).

A summary of the data collected at the downstream locations showed appreciable seasonal variation in the benthic macroinvertebrate community of the Neosho River. Hydroids and tubificids did not exceed 10% of the total benthic density on any sampling date. Hydra were absent after the June collection, probably due to the normal decline of late summer populations (Pennak 1953). Although burrowing worms of the family Tubificidae were not expected to develop large populations in the sand and gravel substrates sampled, they probably were more numerous in the areas of sediment deposition at both locations (Hynes 1966). Tubificids were major components of the benthos collected in previous studies when soft sediments were sampled (Kansas Gas and Electric Company 1974; Nulty 1975; Andersen 1976).

Several macroinvertebrate families were of temporary numerical importance. Naididae accounted for over 20% of the benthic density only in April, whereas Ephemeridae abundance exceeded 20% only in the June sampling (Table 6.3). Perlidae and Elmidae were relatively abundant at Location 4 in February but were of minor importance in the remaining sampling periods.

Hydropsychidae populations approached 20% of the total benthic density at both downstream locations in June and exceeded that percentage at

Location 10 thereafter. These net-spinning caddisflies require specific combinations of solid silt-free substrate and swift current to develop large populations (Dodds and Hisaw 1925; Fremling 1960). The rocky riffle at Location 10 provided better habitat than the bar of fine gravel at Location 4.

The family Chironomidae was numerically predominant in the river during all sampling periods, except June, when the mayfly Ephoron album was prevalent at both locations and in August at Location 10 when hydropsychids were dominant. Midge densities ranged from 57 organisms/m^2 in June to 8533/m^2 in October at Location 10 and from 255/m^2 in June to 7475/m^2 in December at Location 4 (Table 6.4). The occurrence of scouring during high river flows with major emergence periods (Coffman 1973) probably accentuated the June decrease of larval densities. The genus Cricotopus, generally associated with Cladophora (Mundie 1956), was more abundant at Location 10 where this alga was common. The predatory Tanypodinae (Roback 1971) and slower water forms, Chironomus, Dicrotendipes, and Pseudochironomus (Hauber and Morrissey 1945; Hauber 1947; Curry 1962), were more common at Location 4 where currents slowed on the inside of the bend.

Densities of taxonomic groups representing >20% of the total benthic density on each sampling date were statistically tested to determine differences between Locations 10 and 4. Ten statistically significant ($P \leq 0.05$) differences were identified in the 1976 data; one in February, five in April, three in October, and one in December. These differences primarily reflected temporary fluctuations in abundances of individual species. Similar testing of diversity indices from these two locations detected no significant ($P \geq 0.05$) differences indicating a similarity in the benthic faunas. No effects from construction activity were identified in the Neosho River.

c. Qualitative Samples

Qualitative samples from the Neosho River locations yielded nine taxa not collected by quantitative methods (Tables 6.5 and 6.6). The qualitative samples were dominated by semiaquatic and highly mobile aquatic taxa not easily taken with quantitative gear.

2. Wolf Creek

Ponar samples collected at Locations 7, 2, 3, and 5 in Wolf Creek yielded totals of 65, 55, 50, and 39 macroinvertebrate taxa, respectively, which combined to a grand total of 94 taxa (Table 6.2). Previous studies have reported yearly totals of 61 taxa in 1973 from Locations 2 and 3; 65 in 1974 from Locations 2, 3, and 5; and 84 in 1975 from Locations 7, 2, 3, and 5 (Kansas Gas and Electric Company 1974; Nulty 1975; Andersen 1976).

Benthic densities ranged from 397 organisms/m^2 at Location 5 in August to 8949/m^2 at Location 2 in April. A density of 20667 organisms/m^2 was reported in October at Location 7; however, it was not included in the range because the sample was collected from a different pool (Table 6.7). Species diversity indices indicated that the benthic communities in the isolated pools along the creek reacted similarly when subjected to the stresses associated with the drouth conditions (Wilhm 1970; Weber 1973). The lack of statistically

significant ($P \geq 0.05$) differences in densities among locations further indicated that none of the pools sampled along the creek were unique.

Nematoda and Chaoboridae were present in low densities at all creek locations in 1976 (**Table** 6.7). Ceratopogonidae were represented by substantial numbers only in April at Location 3, whereas Sphaeriidae were important only at Location 5 in August (Table 6.7). Naididae were generally a minor constituent in the benthos of the creek. However, they did occur in substantial numbers at Location 2 in the first three sampling periods and at Location 7 in June (Table 6.7), where populations of the burrowing naidid Dero digitata essentially replaced tubificid populations in the niche of ingesting and turning over the substrate (Howmiller 1974).

Tubificidae were generally the most abundant group of benthic macroinvertebrates in the isolated pools sampled in 1976. Considerable variation in the predominant species was noted among locations, but all were indicative of enriched habitats (Hiltunen 1967; Aston 1973). Limnodrilus cervix was predominant at Location 7, whereas L. cervix and L. hoffmeisteri codominated at Location 2. In addition to Limnodrilus, substantial numbers of Branchiuria sowerbyi were also a major component of the benthic fauna at Location 3. At Location 5, B. sowerbyi dominated the tubificid assembleage (Appendix D).

Chironomidae populations made up a substantial portion of the benthos collected in the creek, representing from 6.0% of the total benthic density at Location 2 in April to 66.6% at Location 7 in June (Table 6.7). Hydrobaenus, formerly called Trissocladius, was predominant at all creek locations in February. Paratendipes albimanus type was abundant at Locations 7 and 2 in April, whereas Chironomus dominated in June. Polypedilum simulans type was temporarily important at these upstream locations in August but was replaced by Procladius and Chironomus as the drouth persisted. In April, Chironomus and the tribe Tanytarsini dominated at Location 3, whereas the subfamily Orthocladiinae dominated at Location 5. Stictochironomus was predominant at both downstream locations in June and August.

No adverse effects of construction activities on the benthic community were identified along Wolf Creek in 1976. However, effects from the construction of a bridge abutment immediately upstream of Location 3 were not noted due to lack of water after the August sampling period.

Qualitative sampling on Wolf Creek was hampered by the low water throughout 1976 and by ice cover in December. Twelve taxa, not collected in the Ponar samples, were noted along the creek (Tables 6.5 and 6.6).

IV. Summary and Conclusions

1. Because of the below normal rainfall in 1976, sampling of macroinvertebrate populations was conducted under minimal flow conditions in the Neosho River and in isolated pools in Wolf Creek.

2. The qualitative and quantitative samples of macroinvertebrates collected in 1976 reflected communities similar to those of previous years.

3. The drifting macroinvertebrate assembleage in the tailwaters of John Redmond Dam varied seasonally. Major components included Hydra, Chaoborus, and Cricotopus.

4. Macroinvertebrate densities, numbers of taxa, and diversity indices recorded at Locations 10 and 4 in 1976 were generally higher than in previous years. The stable minimal flow in the river contributed to the increases in these parameters.

5. Stress in the isolated pools of Wolf Creek during 1976 caused increases in benthic densities and decreases in diversity indices. Sporadic occurrence of lentic taxa and increased taxonomic proficiency were the primary reasons for the increased number of taxa recorded from the four creek locations.

6. Chironomidae were consistently prevalent in the benthos samples from the downstream locations in the river. Other taxonomic groups fluctuated in abundance among sampling dates and between locations.

7. Tubificidae predominated in most Wolf Creek samples. Chironomidae were also consistently present in substantial numbers.

8. No detrimental effects from construction activities were identified in the aquatic macroinvertebrate communities near WCGS.

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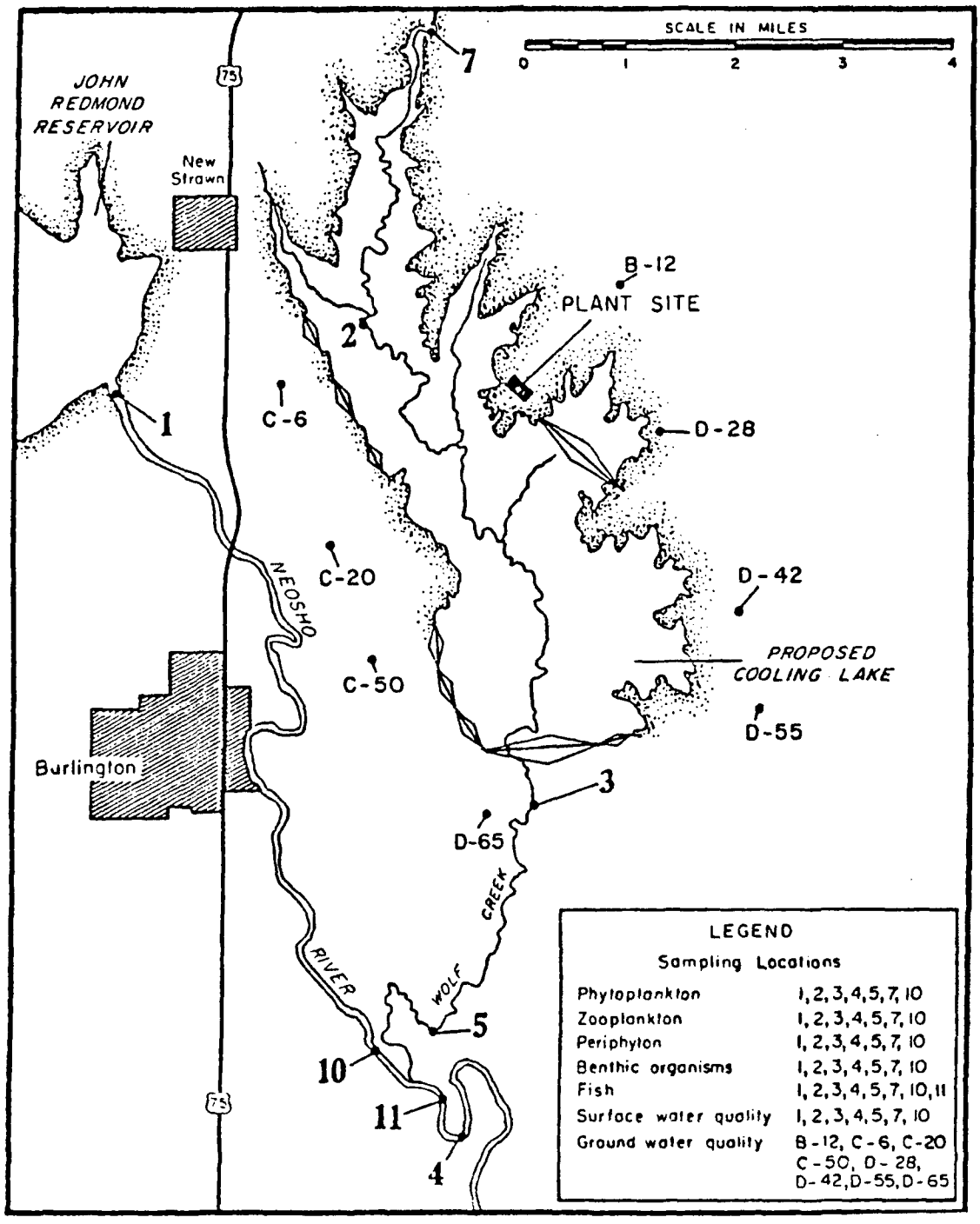

Figure 6.1. Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

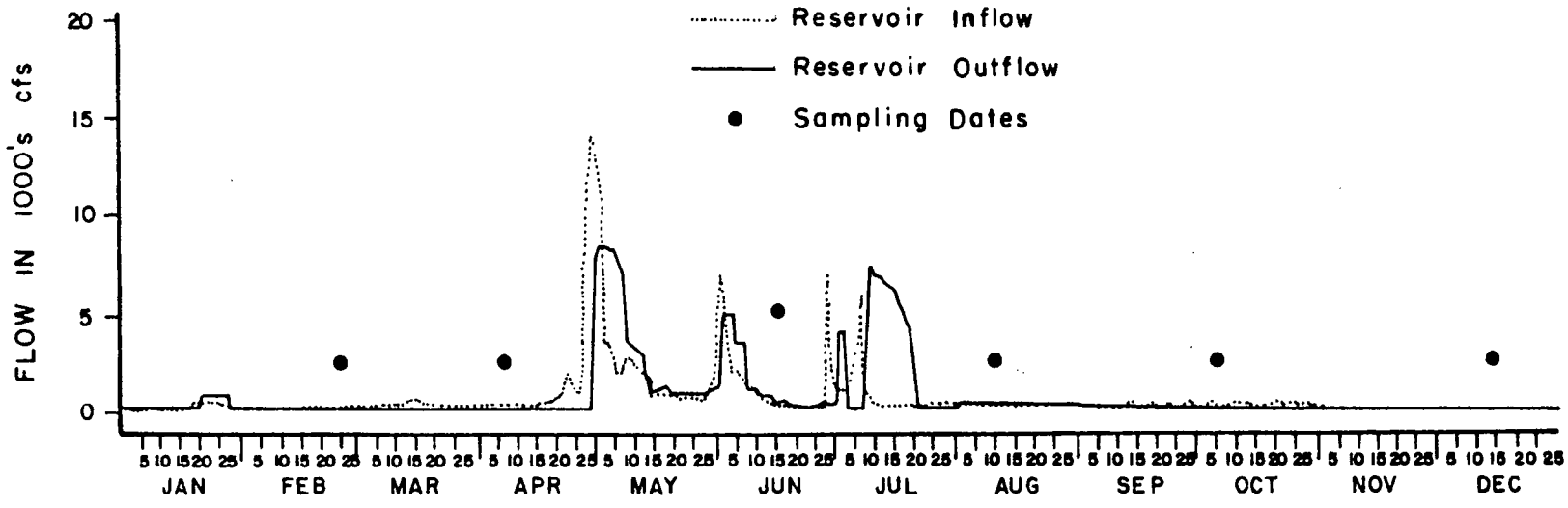

Figure 6.2. Inflow and outflow for John Redmond Reservoir, 1976.

Table 6.1. Summary of macroinvertebrate drift data collected from the tailwaters of John Redmond Dam on the Neosho River (Location 1) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

	Sampling Dates					
	24 February	5 April	14 June	9 August	4 October	13 December
Collection time	18:30	19:30	18:00	08:00	18:20	11:00
Water temperature (°C)	7.5	15.0	23.0	25.6	17.2	1.2
Discharge volume[a] (cfs)	54	54	760	50	50	50
Current velocity[b] (m/s)	0.30	0.48	0.18	0.62	0.33	0.62[c]
Drift density[b] (No./100m^3)	495	436	750	274	2702	375
Total taxa[d]	28	21	21	18	38	26
Shannon's diversity[e]	3.37	2.69	3.08	2.38	1.60	2.86
Percent abundance (%)						
Hydridae	29.6	25.3	2.5	0.5	78.4	42.9
Naididae	13.7	1.1	0.5	0.5	1.2	2.7
Hydropsychidae	28.0	7.5	6.1	8.2	4.0	7.9
Chaoboridae	1.1	38.7	21.2	45.3	1.3	1.6
Simuliidae	0.9	12.5	11.1	1.1	1.1	15.5
Chironomidae	13.3	9.3	55.8	39.5	8.9	11.9

[a] Cubic feet per second, U. S. Army Corps of Engineers, Tulsa District.
[b] Mean of two replicates.
[c] Based on only one replicate.
[d] Total of two replicates.
[e] Mean of two replicates, calculated using log base 2.

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Table 6.2. Benthic macroinvertebrate occurrence in quantitative collections in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

	Neosho River			Wolf Creek			
Taxon	1	10	4	7	2	3	5
Cnidaria							
Hydrozoa							
Hydroidea							
Clavidae							
Cordylophora lacustris Allman	+						
Hydridae							
Hydra sp. Linnaeus	+	+	+		+		
Platyhelminthes							
Turbellaria							
Tricladida							
Planariidae							
Dugesia sp. Girard	+		+				
Rhabdocoela							
Unidentified Rhabdocoela	+	+	+				+
Nematoda							
Unidentified Nematoda		+	+		+	+	+
Ectoprocta							
Phylactolaemata							
Fredericellidae							
Fredericella sultana (Bumenbach)	+	+					
Entoprocta							
Urnatellidae							
Urnatella gracilis Leidy	+						
Annelida							
Oligochaeta							
Plesiopora							
Enchytraeidae							
Unidentified Enchytraeidae						+	+
Naididae							
Chaetogaster diaphanus (Gruithuisen)			+		+		
Dero digitata (Muller)	+		+	+	+	+	+
D. dorsalis Ferrouniere				+	+		
Nais sp. (Muller)	+			+	+		
N. barbata Muller		+					
N. behningi Michaelsen	+	+	+				
N. bretscheri Michaelsen	+	+	+	+	+		
N. elinguis Muller		+					
Ophidonais serpentina (Muller)	+						
Paranais frici Hrabe	+				+		
P. simplex Hrabe			+				
Pristina foreli (Piquet)		+	+				
Stylaria lacustris (Linnaeus)		+	+		+		
Tubificidae							
Branchiura sowerbyi Beddard	+	+	+	+		+	+
Ilyodrilus templetoni (Southern)				+	+	+	+
Limnodrilus cervix Brinkhurst		+		+	+	+	+
L. claparedianus Ratzel				+	+	+	+
L. hoffmeisteri Claparede		+	+	+	+	+	+
L. udekemianus Claparede				+	+	+	+
Immature w/o cap. chaetae		+	+	+	+	+	+
Immature w/cap. chaetae		+	+	+	+	+	+
Prosopora							
Branchiobdellidae							
Cambarincola macrodonta Ellis	+						
Hirudinea							
Rhynchobdellida							
Glossiphoniidae							
Actinobdella sp. Moore		+	+				
Placobdella ornata (Verrill)				+		+	+
Piscicolidae							
Myzobdella sp. Leidy	+						
Pharyngobdellida							
Erpobdellidae							
Dina (*Mooreobdella*) *microstoma* Moore			+	+	+	+	+
Arthropoda							
Crustacea							
Amphipoda							
Talitridae							
Hyalella azteca (Saussure)				+	+		

Table 6.2. Continued.

Taxon	Neosho River			Wolf Creek			
	1	10	4	7	2	3	5
Decapoda							
Astacidae							
Unidentified Astacidae				+		+	+
Arachnida							
Acarina							
Unidentified Hydracarina	+			+	+		
Insecta							
Collembola							
Unidentified Collembola	+	+					
Ephemeroptera							
Ephemeridae							
Ephoron album (Say)		+	+				
Hexagenia sp. Walsh	+						
H. limbata (Serville)	+			+			
Potamanthus sp. Pictet	+	+	+				
Caenidae							
Caenis sp. Stephens	+	+	+	+	+		+
Tricorythodes sp. Ulmer	+	+	+	+	+		
Heptageniidae							
Unidentified Heptageniidae	+	+	+		+		
Heptagenia sp. Walsh		+	+				
Stenocron interpunctatum (Say)	+						
Stenonema sp. Traver	+	+	+	+			
S. ares Burks		+					
S. bipunctatum (McDunnough)		+	+				
S. femoratum (Say)	+						
S. integrum (McDunnough)		+					
S. pulchellum group (Walsh)		+					
S. terminatum (Walsh)		+					
S. tripunctatum (Banks)		+	+				
Baetidae							
Baetis sp. Leach	+	+			+		
Isonychia sp. Eaton		+					
Pseudocleon sp. Klapalek					+		
Odonata							
Gomphidae							
Gomphus sp. Leach		+	+				
Libellulidae							
Libellula luctuosa Burmeister						+	
Coenagrionidae							
Argia sp. Rambur		+	+	+			
Plecoptera							
Perlodidae							
Isoperla sp. Banks		+					
Perlidae							
Neoperla clymene (Newman)		+	+		+	+	+
Perlesta placida (Hagen)	+						
Hemiptera							
Corixidae							
Unidentified Corixidae	+	+	+	+	+	+	+
Megaloptera							
Sialidae							
Sialis sp. Latreille					+		+
Trichoptera							
Psychomyiidae							
Cyrnellus sp. Banks	+						
C. fraternus (Banks)	+						
Hydropsychidae							
Unidentified Hydropsychidae	+	+			+		
Cheumatopsyche sp. Wallengen	+	+	+				
Hydropsyche sp. Pictet	+	+	+				
H. frisoni Ross		+					
H. orris Ross	+	+	+				
H. simulans Ross	+						
Potamyia flava (Hagen)	+	+	+				
Hydroptilidae							
Unidentified Hydroptilidae	+	+					
Agraylea sp. Curtis	+	+	+			+	
Leptoceridae							
Ceraclea sp. (Billberg)		+		+			
Oecetis sp. McLachlan		+	+				
Coleoptera							
Dytiscidae							
Unidentified Dytiscidae		+		+		+	+
Eretes sp. Laporte					+		

Table 6.2. Continued.

Taxon	Neosho River 1	Neosho River 10	Neosho River 4	Wolf Creek 7	Wolf Creek 2	Wolf Creek 3	Wolf Creek 5
Hydrophilidae							
Unidentified Hydropilidae	+			+			
Elmidae							
Dubiraphia sp. Sanderson				+	+	+	
Stenelmis sp. Dufour	+	+	+	+		+	
Lepidoptera							
Pyralidae							
Paragyraetis sp. Lange		+					
Diptera							
Chaoboridae							
Chaoborus punctipennis (Say)	+		+	+	+		+
Simuliidae							
Unidentified Simuliidae	+	+		+			
Chironomidae							
Ablabesmyia mallochi (Walley)			+	+			
A. monilis (Linnaeus)		+	+				
Beckia tethys (Townes)	+						
Chironomus sp. (Meigen)		+	+	+	+	+	+
Cladotanytarsus sp. Kieffer		+	+	+			
Clinotanypus sp. Kieffer				+	+		
Corynoneura sp. Winner		+	+				
Cricotopus sp. (Wulp)	+	+	+		+		+
C. bicinctus (Meigen)	+	+	+				
C. sylvestris (Fabricius)		+	+				
C. tremulus (Linnaeus)	+	+	+	+	+		+
C. triannulatus Macquart	+	+	+				
C. vierriensis Goetghebuer		+					
Cryptochironomus sp. (Kieffer)	+	+	+	+			+
C. blarina (Townes)		+					
C. digitatus Malloch			+				
near Demicryptochironomus sp. Lenz			+				
Dicrotendipes sp. Kieffer		+	+	+	+		
Endochironomus sp. Kieffer				+			
Eukiefferiella sp. Thienemann	+	+	+			+	
E. claripennis Lundbeck			+				
Glyptotendipes (ss) sp. Kieffer		+		+	+	+	
G. (Phytotendipes) sp. Goetghebuer				+	+		
Hydrobaenus sp. Brundin	+	+	+	+	+	+	+
Kiefferulus dux Johannson					+		
Labrundinia sp. Fittkau	+						
Larsia sp. Fittkau		+	+	+	+	+	
Microchironomus sp. Kieffer			+				
Microtendipes pedellus type (DeGeer)							+
Micropsectra sp. Kieffer		+	+			+	+
Nanocladius sp. Kieffer	+	+	+				
N. distinctus (Malloch)	+						
Orthocladius (ss) sp. (Wulp)	+	+	+	+	+	+	+
Parachironomus sp. Lenz	+						
P. abortivus (Malloch)		+		+			
Paracladopelma sp. Harnisch					+		
Parakiefferiella sp. (Thienemann)	+	+	+				+
Paralauterborniella sp. Lenz			+				
Paratendipes near albimanus (Morgan)			+	+	+	+	
P. near connectens Lipina		+					
Phaenopsectra (Tribelos) sp. Townes					+		
Polypedilum (ss) "convictum" gr. (Walker)	+	+	+				
P. (ss) "scalaenum" gr. (Schrank)		+	+	+			
P. (ss) "simulans" gr. Townes		+	+	+	+	+	
Procladius (ss) sp. Skuse				+	+	+	+
P. (Psilotanypus) sp. (Kieffer)	+		+	+	+	+	+
Psectrocladius sp. (Kieffer)		+		+	+		
Psectrotanypus (ss) dyari (Coquillett)				+			
Pseudochironomus sp. Malloch	+	+	+	+			+
Rheotanytarsus sp. Bause	+	+	+				+
Saetheria tylus (Townes)		+					
Stenochironomus sp. Kieffer							+
Stictochironomus sp. Kieffer		+	+	+	+	+	+
Tanypus (ss) stellatus Coquillett	+						
Tanytarsus sp. Wulp	+	+	+	+	+	+	
Thienemanniella sp. Kieffer	+	+	+				
Thienemannimyia group Fittkau	+	+	+				
Ceratopogonidae							
Unidentified Ceratopogonidae		+	+	+	+	+	+

Table 6.2. Continued.

Taxon	Neosho River			Wolf Creek			
	1	10	4	7	2	3	5
Dolichopodidae							
Unidentified Dolichopodidae				+			
Empididae							
Hemerodromia sp. Meigen		+	+				
Muscidae							
Unidentified Muscidae						+	
Tabanidae							
Unidentified Tabanidae				+			
Tipulidae							
Unidentified Tipulidae		+		+			
Hexatoma sp. Latreille		+	+	+			
Pilaria sp. Sintenis		+					
Mollusca							
Gastropoda							
Pulmonata							
Physidae							
Physa sp. Draparnaud		+	+	+		+	
Planorbidae							
Helisoma antrosa (Conrad)				+			
H. trivolvis (Say)				+			
Ancylidae							
Ferrissia fragilis (Tryon)						+	
F. rivularis (Say)		+	+	+	+	+	+
Pelecypoda							
Heterodonta							
Spaeriidae							
Pisidium sp. Pfeiffer					+		
Sphaerium sp. Scopoli	+	+					
S. transversum (Say)		+	+	+	+	+	+
Eulamellibranchia							
Unionidae							
Unidentified Unionidae		+		+			
Lampsilis anodontoides fallaciosa (Smith)		+					
Total	66	95	79	65	55	50	39
Grand Total		109			94		

Table 6.3. Summary of macroinvertebrate data from Ponar samples from the Neosho River (Locations 10 and 4) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

	Sampling Dates/Locations											
	25 February		6 April		15 June		10 August		5 October		14 December	
	10	4	10	4	10	4	10	4	10	4	10	4
Benthic density[a] (No./m^2)	4366	3657	13098	8496	350	1890	23795	7560	16282	4328	16084	9941
Total taxa[b]	46	29	52	43	14	18	45	29	42	21	53	42
Shannon's diversity[c]	3.78	3.30	4.32	3.76	2.31	2.10	3.38	2.92	4.05	2.62	4.27	3.58
Percent abundance[d] (%)												
Hydridae	1.1	2.6	5.6	2.4	5.4	1.0	-	-	-	-	-	-
Naididae	8.7	0.5	21.9	30.8	-	-	<0.1	0.1	0.5	0.2	0.6	1.0
Tubificidae	0.4	5.4	0.1	0.7	8.1	-	0.1	3.3	-	9.2	1.8	7.2
Ephemeridae	0.2	-	-	0.2	37.8	57.0	<0.1	4.7	1.2	4.1	1.2	5.4
Perlidae	0.9	32.0	5.9	7.9	-	3.5	3.1	1.1	1.6	0.9	6.3	0.1
Hydropsychidae	6.1	1.0	7.9	0.2	18.9	17.0	79.5	0.3	20.5	-	24.7	-
Elmidae	4.3	14.0	4.7	1.4	-	-	0.8	1.7	3.5	-	5.6	3.5
Chironomidae	72.1	35.1	51.2	54.1	16.2	13.5	9.4	43.7	52.4	78.4	30.3	75.2

[a] Mean of two replicates.
[b] Total of two replicates.
[c] Mean of two replicates, calculatyd using log base 2.

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Table 6.4. Summary of quantitative macroinvertebrate data from the Neosho River (Locations 10 and 4) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-76.

Sampling Date	Discharge Volume cfs	Total Density (No./m²)[a]		Total Taxa		Diversity Index[a]		Mean Density (No./m²)[a] Naididae		Tubificidae		Ephemeroptera		Plecoptera		Trichoptera		Chironomidae	
		10	4	10	4	10	4	10	4	10	4	10	4	10	4	10	4	10	4
25 February 1976	45	4366	3657	46	29	3.78	3.30	378	19	19	198	57	132	38	1172	283	38	3147	1285
27 March 1973	6950	-[b]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26 March 1974	5450	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17 April 1975	3820	340	388	10	14	1.90	2.23	0	10	218	28	0	19	0	0	0	114	86	104
6 April 1976	57	13098	8496	54	43	4.32	3.76	2873	2618	19	57	142	160	775	671	1105	19	6709	4593
11 June 1973	3740	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 June 1974	3260	38	142	4	6	*[c]	*	0	0	9	0	0	38	0	0	0	0	9	38
10 June 1975	1010	2646	2174	29	22	2.05	2.67	28	0	0	10	264	567	19	0	1200	1163	1012	369
15 June 1976	416	350	1890	14	18	2.31	2.10	0	0	28	0	151	1200	0	66	66	321	57	255
10 September 1973	61	-	1598	-	19	-	*	-	0	-	0	-	906	-	0	-	38	-	416
9 September 1974	4420	265[d]	463	10[d]	7	*	*	0[d]	0	0[d]	350	113[d]	85	0[d]	0	57[d]	0	38[d]	28
9 September 1975	395	974	1257	11	18	1.01	2.41	0	0	19	28	19	76	56	454	832	520	10	57
9 August 1976	48	23795	7560	45	29	3.38	2.92	19	9	28	246	1624	3676	737	85	18919	19	2240	3307
5 October 1976	60	16282	4328	42	21	4.05	2.62	85	9	0	397	2930	312	255	38	3496	0	8533	3393
10 December 1973	3920	-	143	-	9	-	*	-	0	-	76	-	20	-	0	-	38	-	19
10 December 1974	1240	189	1370	13	25	*	*	0	9	19	728	19	19	0	0	19	19	94	576
3 December 1975	73	567	2438	19	36	3.36	2.70	19	57	19	180	57	227	10	10	19	57	246	1664
14 December 1976	42	16084	9941	53	42	4.27	3.58	94	104	293	718	3827	672	1011	9	4403	75	4876	7475

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Table 6.5. Macroinvertebrates collected qualitatively in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, February-June 1976.

Taxon	Sampling Date/Location: 25 February							6 April							15 June						
	1	10	4	7	2	3	5	1	10	4	7	2	3	5	1	10	4	7	2	3	5
Cnidaria																					
Hydrozoa																					
Hydroidea																					
Hydidae																					
Hydra sp.		0[a]	0																	R[b]	
Platyhelminthes																					
Turbellaria																					
Tricladida																					
Planaridae																					
Dugesia sp.	R								R	R											
Ectoprocta																					
Phylactolaemata																					
Plumatellina																					
Plumatellidae																					
Fredericella sultana		+[c]																		+	
Plumatella sp.																					
Annelida																					
Oligochaeta																					
Plesiopora																					
Naididae																					
Dero digitata																		R	R		R
Nais sp.																0	0				
N. behningi		R																			
N. bretscheri									R	R											
N. elinguis		R	R																		
Stylaria lacustris																				R	
Tubificidae																					
Branchiura sowerbyi		0	R																		
Limnodrilus claparedianus			R																		
L. hoffmeisteri			R																		
L. udekemianus			R																		
Immature with cap. chaetae			R																		
Immature w/o cap. chaetae			R																R		
Prosopora																					
Branchiobdellidae																					
Cambarincola chirocephala																			0	R	R
C. macrodonta																				0	0
C. vitrea																			R	0	0
Hirudinea																					
Rhynchobdellida																					
Glossiphoniidae																					
Helobdella lineata																		R			
Placobdella ornata																					R
P. parasitica																R					R
Piscicolidae																					
Myzobdella lugubris																	R				
Pharyngobdellida																					
Erpobdellidae																					
Dina microstoma											R							R		R	
Arthropoda																					
Crustacea																					
Decapoda																					
Astacidae																					
Unidentified Astacidae				R		R			R			R		R		R	R	R	0	R	
Orconectes sp.			R		0		0					R		R				R	0		0
O. nais						R						R									R
Insecta																					
Collembola																					
Unidentified Collembola									R												
Ephemeroptera																					
Ephemeridae																					
Hexagenia limbata																			R		
Potamanthus sp.															R						
Caenidae																					
Caenis sp.																	0				
Tricorythodes sp.		0																			

Table 6.5. Continued.

Taxon	Sampling Date/Location: 25 February 1	25 February 10	25 February 4	25 February 7	25 February 2	25 February 3	25 February 5	6 April 1	6 April 10	6 April 4	6 April 7	6 April 2	6 April 3	6 April 5	15 June 1	15 June 10	15 June 4	15 June 7	15 June 2	15 June 3	15 June 5
Heptageniidae																					
Unidentified Heptageniidae																R					
Heptagenia maculipennis																O					
Stenacron interpunctatum	R	O	R							R											
Stenonema sp.			R																		
S. ares									R												
S. bipunctatum									O	O											
S. integrum		R																			
S. pulchellum									R												
S. terminatum			R																		
S. tripunctatum	O	C[d]	R												R				R		
Baetidae																					
Baetis sp.	R	O																			
Isconychia sp.		C														O					
Leptophelebia sp.			R																		
Odonata																					
Coenagrionidae																					
Argia sp.		O	R						R	O											
Aeshnidae																					
Nasiaeschna pentacantha													R								
Lidellulidae																					
Macromia taeniolata																R					
Plecoptera																					
Perlidae																					
Neoperla clymene		R														R				R	
Perlesta sp.																				R	
Hemiptera																					
Corixidae																					
Unidentified Corixidae			R			R					O	R		R				R	R		
Gerridae																					
Gerris sp.						R					R	R	R					O	O	R	
Rheumatobates sp.																O	R				
Veliidae																					
Rhagovelia sp.																C	R				
Megaloptera																					
Corydalidae																					
Corydalus cornutus									R												
Trichoptera																					
Psychomyiidae																					
Cyrnellus sp.	R																				
Hydropsychidae																					
Unidentified Hydropsychidae																	R				
Cheumatopsyche sp.	R	O							R							O				R	
Hydropsyche frisoni																R					
H. orris		O																			
Potamyia flava	R	O							R												
Hydroptilidae																					
Agraylea sp.		O							R												
Leptoceridae																					
Ceraclea sp.		O														R					
Coleoptera																					
Dytiscidae																					
Unidentified Dytiscidae										R	R										
Hydrophilidae																					
Unidentified Hydrophilidae																			R	R	
Gyrinidae																					
Dineutus sp.												O	O	O				R	R	R	
Elmidae																					
Stenelmis sp.									R											R	

Table 6.5. Continued.

Taxon	Sampling Date/Location																					
	25 February							6 April							15 June							
	1	10	4	7	2	3	5	1	10	4	7	2	3	5	1	10	4	7	2	3	5
Diptera																						
Simuliidae																						
Unidentified Simuliidae		O							R													
Chironomidae																						
Chironomus sp.		R	R																R			
Cladotanytarsus sp.																	R					
Cricotopus sylvestris										R												
C. tremulus		O	R																			
Dicrotendipes sp.			R																	R		
Eukiefferiella sp.		O																				
Larsia sp.																R	R					
Microcricotopus sp.																	R					
Parakiefferiella sp.										R												
Polypedilum (ss) *convictum* type									R	O						O	O					R
P. (ss) *simulans* type										R												
Pseudochironomas sp.			R																			
Strictochironomus sp.			R																			
Thienemannimyia Group			R																			
Trissocladius sp.		R																				
Tipulidae																						
Unidentified Tipulidae									R													
Mollusca																						
Gastropoda																						
Pulmonata																						
Physidae																						
Physa sp.			R	O	O	O					R	R						C	O	O		
Planorbidae																						
Helisoma trivolvis					R							R						O	O			
Ancylidae																						
Ferrissia rivularis																			O	R		
Pelecypoda																						
Heterodonta																						
Sphaeriidae																						
Sphaerium transversum							R		R													

[a] O = Occasional (5-25).
[b] R = Rare (1-4).
[c] + = Present in colonies.
[d] C = Common (26-99).
[e] A = Abundant (100 +).

Table 6.6. Macroinvertebrates collected qualitatively in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, August-December 1976.

	Sampling Date/Location																							
	10 August							4 October							14 December						
Taxon	1	10	4	7	2	3	5	1	10	4	7	2	3	5	1	10	4	7	2	3	5
Arthropoda																					
Crustacea																					
Decapoda																					
Astacidae																					
Unidentified Astacidae		R[a]	R	O[b]	O	O	O		R			R	R								
Orconectes nais	R		O	O	O	R	R		R		R	R									
Insecta																					
Ephemeroptera																					
Ephemeridae																					
Hexagenia limbata						R															
Potamanthus sp.																R	R				
Heptageniidae																					
Stenonema tripunctatum												R									
Baetidae																					
Baetis sp.																R					
Isconychia sp.									O												
Odonata																					
Coenagrionidae																					
Argia sp.									R												
Lidellulidae																					
Macromia sp.										R											
Hemiptera																					
Corixidae																					
Unidentified Corixidae									R							O					
Gerridae																					
Gerris sp.				O	R							O									
Rheumatobates sp.	R	R	R	R					R			R									
Veliidae																					
Rhagovelia sp.	R	O							R												
Trichoptera																					
Hydropsychidae																					
Cheumatopsyche sp.									R							O	R				
Hydropsyche frisoni									R			R									
H. orris									R												
Potamyia flava									R												
Gyrinidae																					
Dineutus sp.		R			R	O	R														
Mollusca																					
Gastropoda																					
Pulmonata																					
Physidae																					
Physa sp.				R	R				O	O							O				
Planorbidae																					
Helisoma trivolvis				R	R																
Pelecypoda																					
Heterodonta																					
Sphaeriidae																					
Sphaerium transversum									O							R					

[a] R = Rare (1-4).
[b] O = Occasional (5-25).

Table 6.7. Summary of macroinvertebrate data from Ponar samples collected from Wolf Creek (Locations 7, 2, 3 and 5) in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

	Sampling Dates/Locations											
	25 February				6 April				15 June			
	7	2	3	5	7	2	3	5	7	2	3	5
Benthic density[a] (No./m^2)	1663	2788	4413	1125	964	8949	2807	1266	7437	3440	1635	1805
Total taxa[b]	21	29	26	12	19	28	21	20	23	21	17	21
Shannon's diversity[c]	2.85	2.91	2.74	2.54	2.40	1.34	2.94	2.85	1.89	1.97	2.62	2.39
Percent abundance[a] (%)												
Nematoda	0	0.7	0.9	6.7	0	0.1	0	0	0	0	0	0.5
Naididae	0	42.7	1.3	0	4.9	80.1	17.8	1.5	22.1	50.3	2.9	0.5
Tubificidae	61.4	22.0	64.7	66.4	62.7	9.3	34.0	68.7	0.4	25.0	69.4	48.7
Chaoboridae	0.6	1.7	0	0	13.7	0.2	0	0	0	0	0	0.5
Chironomidae	29.5	26.4	24.4	23.5	9.8	6.0	18.5	17.2	66.6	11.0	21.4	44.0
Ceratopogomidae	0	0.7	0.4	0	0	0	20.2	0.7	0.4	1.1	2.3	0.5
Sphaeriidae	1.1	2.0	4.7	1.7	0	0	6.4	6.7	0	2.2	0.6	2.6

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Table 6.7. Continued.

	Sampling Dates/Locations											
	10 August				5 October				14 December			
	7	2	3	5	7	2	3	5	7	2	3	5
Benthic density[a] (No./m^2)	435	1758	898	397	20667[d]	6020	-[e]	-	4319	2523	-	-
Total taxa[b]	14	22	16	12	42	20	-	-	15	19	-	-
Shannon's diversity[c]	2.48	2.74	2.70	2.34	3.09	2.50	-	-	2.48	1.99	-	-
Percent abundance[a] (%)												
Nematoda	0	0	0	2.4	0	0	-	-	0	0	-	-
Naididae	8.7	3.2	3.2	0	1.5	17.7	-	-	0.9	3.7	-	-
Tubificidae	13.0	66.1	82.1	28.6	29.5	29.7	-	-	64.6	54.7	-	-
Chaoboridae	0	0.5	0	2.4	0	0	-	-	2.0	0	-	-
Chironomidae	15.2	14.5	6.3	14.3	25.8	41.0	-	-	31.3	38.6	-	-
Ceratopogonidae	2.2	0.5	1.1	0	4.7	0.2	-	-	0.9	0	-	-
Sphaeriidae	4.3	9.1	1.1	23.8	1.4	6.6	-	-	0	0	-	-

[a] Mean of two replicates.
[b] Total of two replicates.
[c] Mean of two replicates, calculated using log base 2.
[d] Collected from a larger pool
[e] Not collected.

Chapter 7

FISHERIES STUDIES

By

Quentin P. Bliss

I. Introduction

A study of adult, juvenile, and larval fish was conducted from February through December 1976 in the Neosho River and Wolf Creek near Wolf Creek Generating Station (WCGS). Similar studies were conducted for the baseline assessment in 1973 (Kansas Gas and Electric Company 1974) and in two subsequent yearly construction monitoring studies (Szmania and Johnson 1975; Szmania 1976).

Specific objectives of this study were:

1. To determine the species composition, relative abundance, and seasonal distribution of fish in the Neosho River and Wolf Creek near WCGS;

2. To establish the food habits and age distribution of selected game species; and

3. To determine the species composition and abundance of the larval fish drift in the Neosho River immediately downstream of John Redmond Dam near the proposed WCGS make-up water intake structure.

II. Field and Analytical Procedures

A. Sampling Locations

The Neosho River and Wolf Creek were each sampled at four locations to characterize the resident fish community in both streams (Figure 7.1). A description of the physical characteristics associated with each location is presented below.

1. Neosho River

Location 1 was in the tailwaters of John Redmond Dam near the proposed WCGS make-up water intake structure. The substrate was bed rock and rock rip-rap lined the banks. Flow was entirely dependent on releases from John Redmond Reservoir.

Pools and riffles characterized Location 10 which was 0.7 km upstream of the confluence with Wolf Creek. Riffles had substrates of rock, rubble, and gravel, whereas the bottoms in the pools were bed rock overlaid with a layer (15-30 cm) of silt.

A riffle located approximately 0.5 km below the confluence with Wolf Creek constituted Location 11. The riffle consisted of small rubble, gravel, and sand swept by swift current. During periods of low flow, the water depth was 5-25 cm.

Location 4, 1.3 km downstream of the confluence with Wolf Creek, was comprised of deep pools and a shallow gravel bar. The bottom of the pools was silt and sand, whereas the gravel bar consisted of sand and gravel.

2. Wolf Creek

Location 7 was upstream of the area to be inundated by the proposed cooling lake. Due to the low amount of precipitation during 1976, this location was restricted to an isolated pool that contained leaf litter over a substrate of gravel, sand, and clay.

A large isolated pool located in the northernmost portion of the proposed cooling lake constituted Location 2. The substrate was rock overlaid with clay, silt, and leaf litter.

Location 3 was a clay and silt bottomed pool located approximately 1.7 km downstream of the proposed cooling lake dam site. During the October and December sampling periods this location was completely dry. Construction activities during the fall altered the physical features of a portion of this location.

Location 5 was approximately 1.6 km upstream from the mouth of Wolf Creek and consisted of an isolated pool with a hardpan clay bottom. During the October and December sampling periods the entire location was dry.

B. Sampling Methods

Fish were collected in February, monthly April through August, October, and December 1976.

1. Hoop Netting

Hoop nets, 2.4 m long, 0.8 m in diameter with 1.9 cm bar mesh, were used to collect fish in the Neosho River at Locations 1, 10, and 4. Three hoop nets were fished overnight (≈18 hr) at each Neosho River location during alternate months from February through December. In addition, three hoop nets were fished overnight only at Location 1 during May and July.

2. Seining

A seine, 4.6 m long, 1.8 m deep with 0.3 cm Ace mesh, was used to collect forage-size fish from the shallow areas at all locations. When physical conditions permitted, two to four seine hauls were taken per location during each sampling period.

3. Larval Fish Sampling

Larval fish were collected at Location 1 twice monthly April through July 1976. Duplicate fish larvae samples were collected by towing a 0.75 m diameter no. 0 mesh Nitex plankton net for 2-3 minutes. The net was equipped with a General Oceanics flowmeter (Model 2030) to quantify the volume of water sampled. During April, May, and June diurnal and nocturnal samples were taken, whereas in July only diurnal samples were collected. Each sample was preserved separately in 10% formalin.

D. Data Collection

Fish collected by hoop netting were identified, measured (total length in mm), and weighed (g) in the field. Forage-sized fish collected by seining were identified and measured either in the field or laboratory depending on the number of individuals collected. Fish to be identified and measured in the laboratory were preserved in 10% formalin. Taxonomic keys used to identify fish included Eddy (1953), Cross (1967), and Pfleiger (1971).

Larval fish were separated from the detritus in the laboratory and preserved in 4% formalin for later identification. Fish larvae were identified to the lowest positive taxonomic level using keys by Fish (1932), Mansueti and Hardy (1967), May and Gasaway (1967), Nelson et al. (1967), Nelson (1968), and Taber (1969). Larval fish densities were expressed as the number of larvae per 100 cubic meters (no./100 m^3).

Stomach samples were taken from selected game fish and preserved in 95% ethanol in the field. The contents of individual stomachs were analyzed in the laboratory with the aid of a binocular dissecting scope and food items were identified, enumerated, and volumetrically measured to the nearest 0.1 ml by water displacement. Taxonomic keys used to identify food organisms included Burks (1953), Pennak (1953), Needham and Needham (1962), Hilsenhoff (1970), and Usinger (1971).

Scale samples were obtained from a representative number of individuals of selected game fish species. Scale impressions were made on cellulose acetate slides, and the number of annuli was determined with the aid of a microprojector. Age was determined for individual fish and mean lengths were calculated for each age group represented.

Surface water temperatures were recorded in conjunction with each fish collection using a calibrated thermometer.

III. Results and Discussion

A. Physical Conditions

In general, surface water temperatures were similar among locations during each sampling period of 1976 (Table 7.1). Water temperatures ranged from 1.2C (34.2F) in the Neosho River on 13 December to 31.1C (88.0F) in the Neosho River and Wolf Creek on 9-10 August.

The flow rate and water level of the Neosho River were primarily dependent upon the release rate from John Redmond Reservoir (Figure 7.2). Minimal flow conditions existed in the Neosho River during all sampling periods except May and July when flows were higher (Figure 7.2). No flow was encountered in Wolf Creek during 1976 and sampling was restricted to isolated pools. Water levels in 1976 were lower than during previous studies.

B. Species Composition and Relative Abundance

1. General

Scientific and common names of fish collected during the

monitoring studies (1973-76) are listed according to Bailey (1970) in Table 7.2. Since 1973, 44 species have been collected in the study area near WCGS, including longnose gar, blue sucker, Neosho madtom, and stonecat which were collected for the first time during 1976. Of the species collected during 1976, the blue sucker, bluntnose darter, and Neosho madtom are considered threatened species in Kansas (Cross and Collins 1975).

Number and size distribution of fish collected with hoop nets and seine in each sampling period are presented by location in Appendix E, Tables E.1 through E.6. Total catch during 1976 consisted of 6759 individuals representing 38 species (Table 7.3). Numerically predominant species were red shiner (45.2%) and gizzard shad (24.9%).

2. Neosho River

Hoop netting at three locations in the Neosho River during 1976 yielded 180 fish, representing 12 species (Table 7.4). Although no fish were collected in May or December, the total hoop net catch in 1976 increased appreciably over prior years (1973-75). The increase was partly due to increases in the number of sampling locations and the number of hoop nets per location. Even with the higher catch, total hoop net catch accounted for only 2.7% of the total catch. White crappie (53.9%) and blue sucker (10.0%) were the most abundant species collected by hoop netting. Longnose gar, blue sucker, largemouth bass, and longear sunfish were taken for the first time in hoop nets.

Three longnose gar were collected at Location 10 (Table 7.4). Longnose gar are common in large rivers in eastern Kansas (Cross 1967) and generally occupy the less turbulent parts of these streams.

Blue sucker was the second most abundant species collected by hoop netting (Table 7.4); all of the 18 individuals collected were large (adult) fish. During the April sampling period blue suckers were observed on and below the riffle area near the upstream end of Location 10. These fish were believed to be a spawning concentration as Cross (1967) reported that blue suckers spawn in Kansas during April at water temperatures between 10C (50F) and 15.5C (60F). Water temperature in the Neosho River during the April sampling period ranged between 13.0C (55.4F) and 16.6C (61.9F) (Table 7.1). Blue suckers were collected in the study area throughout 1976. Blue suckers migrate upstream to spawn (Cross 1967; Cross and Collins 1975), and the blockage of this movement by John Redmond Dam probably increases their number in the study area during the early spring. The blue sucker is considered rare in Kansas, occurring only in the Missouri, Kansas, and Neosho rivers (Platt et al. 1974; Cross and Collins 1975). Of these three rivers, the blue sucker is probably most abundant in the Neosho River (Cross 1967; Cross and Collins 1975).

The majority of the fish collected with hoop nets were caught in the tailwaters of John Redmond Dam (Location 1). Hoop nets were set on eight sampling dates at Location 1 and on only six dates at the other two locations. Even allowing for the additional sampling effort, the catch rate was appreciably higher at Location 1. The entrainment and/or impingement rate of the WCGS makeup water structure could be affected if the fish populations remain higher in this area.

A total of 5944 individuals of 27 species was collected by seining in the Neosho River at Locations 1, 10, 11, and 4 (Table 7.5). Red shiner was the predominant species collected composing 49.3% of the total catch. Other abundant species collected included gizzard shad (28.1%) and ghost shiner (10.2%). Prior to 1976 only one location (Location 4) was seined in the Neosho River. Sampling at the three additional stations resulted in the collection of numerous gizzard shad (Location 1) and the stonecat and Neosho madtom (Locations 10 and 11). In general, reduced flows and stable water levels provided sampling conditions similar to 1975 and better than 1973 or 1974. Species composition and relative abundance of fish collected by seining were similar from 1974 to 1976.

The red shiner and ghost shiner are both common in the Neosho River (Cross and Collins 1975). Both species are prolific spawners and their populations usually are predominated by yearling and YOY individuals.

The majority of the gizzard shad (97.2%) collected by seining were taken at Location 1 during a period of high water releases from John Redmond Reservoir (13 July). Because the gizzard shad collected were YOY individuals, they probably had been discharged from the reservoir.

Eleven Neosho madtoms were collected at Location 11 and one at Location 10. These fish are noteworthy because their range is smaller than that of any other fish in Kansas (Cross 1967). They are confined to the mainstream of Spring River, Neosho River, and the lower course of Cottonwood River (Cross 1967). Neosho madtoms inhabit shallow gravel bars that are swept by swift current. Because of their rigid habitat requirements and restricted distribution, the Neosho madtom is vulnerable to the effects of pollution and drought (stream dewatering). Deacon (1961) reported that the range of the Neosho madtom in the Neosho River was appreciably reduced by the intermittent flow during the drought of the mid-1950's. In addition, he found that the rate at which the species regained abundance, when stable water conditions returned, was slow. Miller (1972) listed the Neosho madtom as an endangered species and Cross and Collins (1975) listed it as a threatened species in Kansas. Platt et al. (1974) considered the Neosho madtom the most endangered species in Kansas and stated that it was being considered for placement on the Federal Register of endangered species.

Stonecat, which had not been previously collected, was collected by seining at Locations 10 and 11. The stonecat is the largest and most widespread of the madtoms in Kansas (Cross 1967).

During 1976, 12 slenderhead darters were collected by seining in the Neosho River at Locations 10, 11, and 4; only two individuals were collected in 1975. The preferred habitat of this species is usually swiftly flowing water over a bottom of loose gravel or bedrock littered with stones (Cross 1967). The slenderhead darter is not classified as rare or endangered; however, special attention is required to assure its continued survival in Kansas (Platt et al. 1974).

Young-of-the-year white bass were numerous in seine collections at Location 1 on 13 July. On this date the water release rate from John Redmond Reservoir was high and the YOY white bass were probably discharged from the reservoir.

Few YOY channel catfish, largemouth bass, bluegill, and white crappie were present in the 1976 seine collections. These species were also scarce in seine collections of prior years (1973-75).

3. Wolf Creek

A total of 633 fish, representing 25 species, was collected by seining at Locations 7, 2, 3, and 5 in Wolf Creek (Table 7.6). Due to the low water level in Wolf Creek during 1976, sampling was restricted to isolated pools.

No fish were collected at Location 7 during the February and April sampling periods indicating that the fish population at this location probably winterkilled. Prior to 15 June, fish had repopulated Location 7 indicating that there has been flow in Wolf Creek since 6 April. During the October and December sampling periods, Locations 3 and 5 were completely dry. Field observations during the December sampling period indicated a major fish kill had occurred under the ice at Locations 7 and 2.

Fish collected in Wolf Creek were forage species and juveniles of game and commercial species. Species composition was similar to prior years (1973-75) and all species had been collected previously. Red shiner and orangespotted sunfish were the predominant species collected. The red shiner's capacity to tolerate changes in temperature, salinity, pH, and dissolved oxygen has made it particularly adaptable to habitats with variable or intermittent flow (Matthews and Hill 1977). Cross and Collins (1975) reported that red shiners were abundant in Kansas especially where habitats are unstable due to irregular flow and turbidity.

Species collected previously in Wolf Creek, but not during the present study, included sand shiner, river carpsucker, smallmouth buffalo, golden redhorse, shorthead redhorse, yellow bullhead, and channel catfish. The intermittent flow in the creek during 1976 probably prevented commercial and game species from utilizing it as a spawning and nursery area.

The rosyface shiner was collected only at Location 2 in Wolf Creek during 1974, 1975, and 1976. Deacon (1961) reported that the rosyface shiner is found in tributary streams of the Neosho River but rarely in the mainstream.

Two bluntnose darters were collected at Location 2 during 1976. In Kansas, the distribution of the bluntnose darter is limited to the Spring and Neosho river basins (Cross and Collins 1975). Unlike most darters, the bluntnose darter inhabits sluggish streams that have bottoms of mud and clay and will tolerate intermittent flow during periods of drought (Cross 1967). Platt et al. (1974) listed the bluntnose darter as rare in Kansas.

C. Age Analysis

A total of 93 individuals of three species (white crappie, longear sunfish, and freshwater drum) was aged by scale analysis (Table 7.7). White crappie was represented by Age Groups I, II, and III with Age Group I being the most abundant. The three freshwater drum aged were of Age Groups I and II, whereas the only longear sunfish aged was Age Group II.

The size distribution of white crappie indicated that there was considerable overlap in size between the different age groups. Kansas Forestry, Fish and Game Commission personnel attributed this overlap to mixing of fish from upstream reservoirs (J. Ray, Kansas Forestry, Fish and Game Commission, Chanute, Kansas, personal communication).

D. Food Habits

Twelve channel catfish and 36 white crappie stomachs were analyzed (Table 7.8). Major food items of channel catfish were crayfish (50.2%), fish larvae (22.2%), plant fragments (15.2%), and aquatic insects (11.3%). Principal food items in the diet of white crappie were fish (80.6%) and aquatic insects (14.1%).

Seasonally, channel catfish utilized aquatic insects in February, and crayfish and fish larvae in June (Appendix E, Table E.7). Fish were the major food item of white crappie during all sampling periods (February, April, July, August, and October), and aquatic insects were of secondary importance during all sampling periods except July.

E. Fish Larvae

A total of 4578 larval fish, representing eight taxa, was collected during 1976 (Table 7.9). Gizzard shad was predominant and comprised 98% of the total catch. Game fish larvae that were collected included 2 white crappie, 1 white bass, 1 *Lepomis* sp., and 9 freshwater drum which collectively comprised less than 0.3% of the total catch.

No fish larvae were collected on 5 and 19 April and 3 May 1976. Larval fish were first collected on 17 May when densities were 41.3/100 m^3 and 69.3/100 m^3 during the diurnal and nocturnal periods, respectively. Peak larval fish densities during diurnal (14222.6/100 m^3) and nocturnal (5607.2/100 m^3) periods occurred on 14 June. Fish larvae densities were low ($\leq$15.0/100 m^3) during the remaining sampling periods (28 June, 12 and 28 July).

On 17 May, most of the larval fish collected were catostomids (sucker family). Gizzard shad was the predominant fish larvae collected during both sampling periods in June, whereas Cyprinidae (carp and minnows) were the most abundant larvae collected during both July sampling dates.

IV. Summary and Conclusions

1. A total of 6759 fish, representing 38 species, was collected in the Neosho River and Wolf Creek during 1976. Species collected in 1976 which had

not been collected in prior monitoring studies included longnose gar, blue sucker, Neosho madtom, and stonecat.

2. Blue sucker, bluntnose darter, and Neosho madtom, rare or endangered species in Kansas, were collected during the 1976 study.

3. White crappie and blue sucker were the predominant species in the hoop net catch from the Neosho River.

4. Seining in Wolf Creek in 1976 yielded similar total catch and species composition to that reported in previous years. Flow was intermittent in Wolf Creek during 1976 and Locations 3 and 5 were dry during the October and December sampling periods.

5. Field observations during the December sampling period indicated that a major fish kill (winterkill) had occurred under the ice at Locations 7 and 2.

6. A total of 93 individuals, representing three species, was aged during 1976. There was a considerable overlap in size between Age Groups of white crappie which was attributed to mixing of fish from upstream reservoirs.

7. Analyses were performed on 12 channel catfish and 36 white crappie stomachs. Major food items in the diet of channel catfish were crayfish, fish larvae, plant fragments, and aquatic insects. Principal food items of white crappie were fish and aquatic insects.

8. A total of 4578 fish larvae, representing eight taxa, was collected during 1976, and the peak fish larvae density was encountered on 14 June (14222.6/100 m^3) during diurnal sampling. Gizzard shad comprised 98% of the total catch and game fish less than 0.3%.

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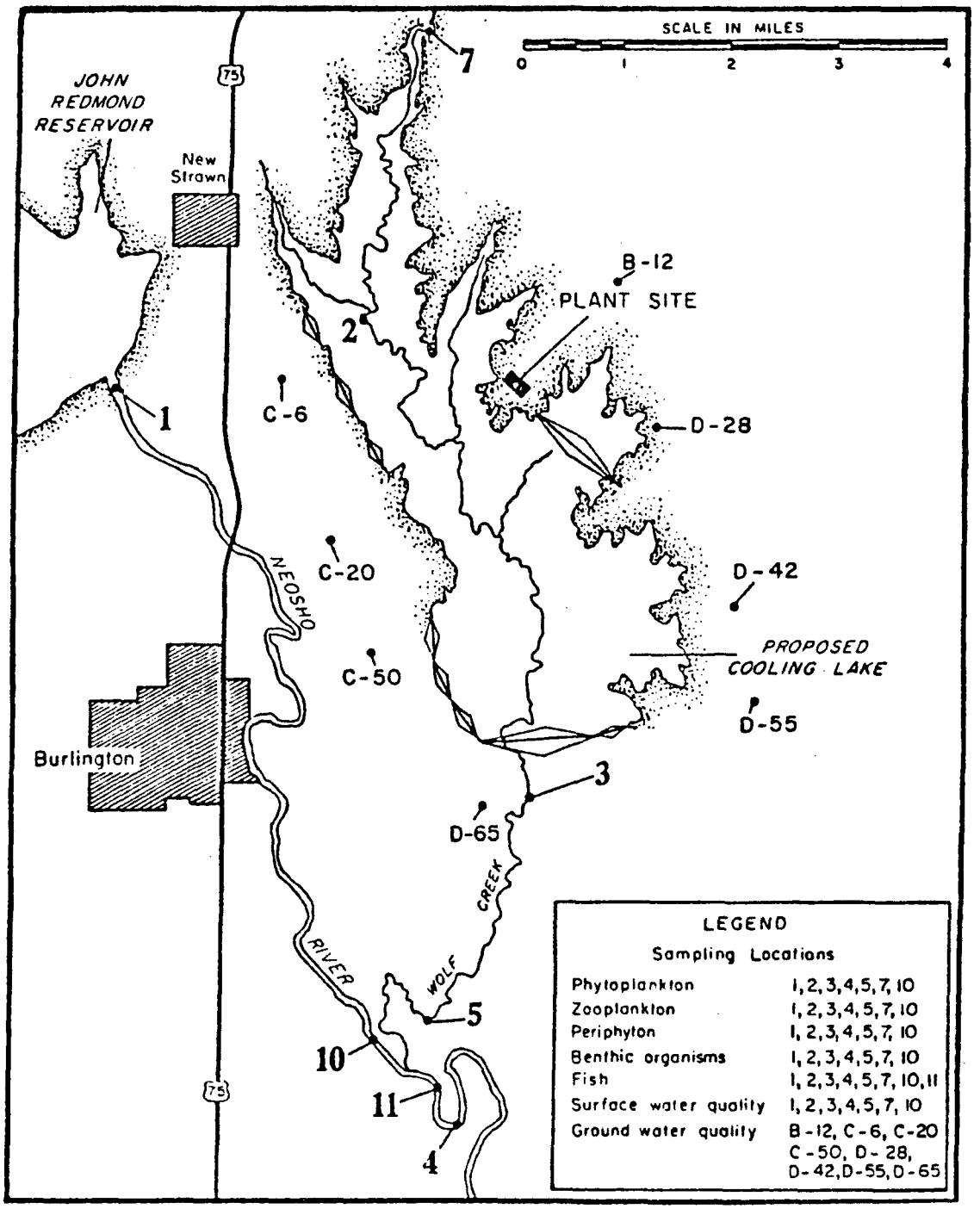

Figure 7.1. Sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

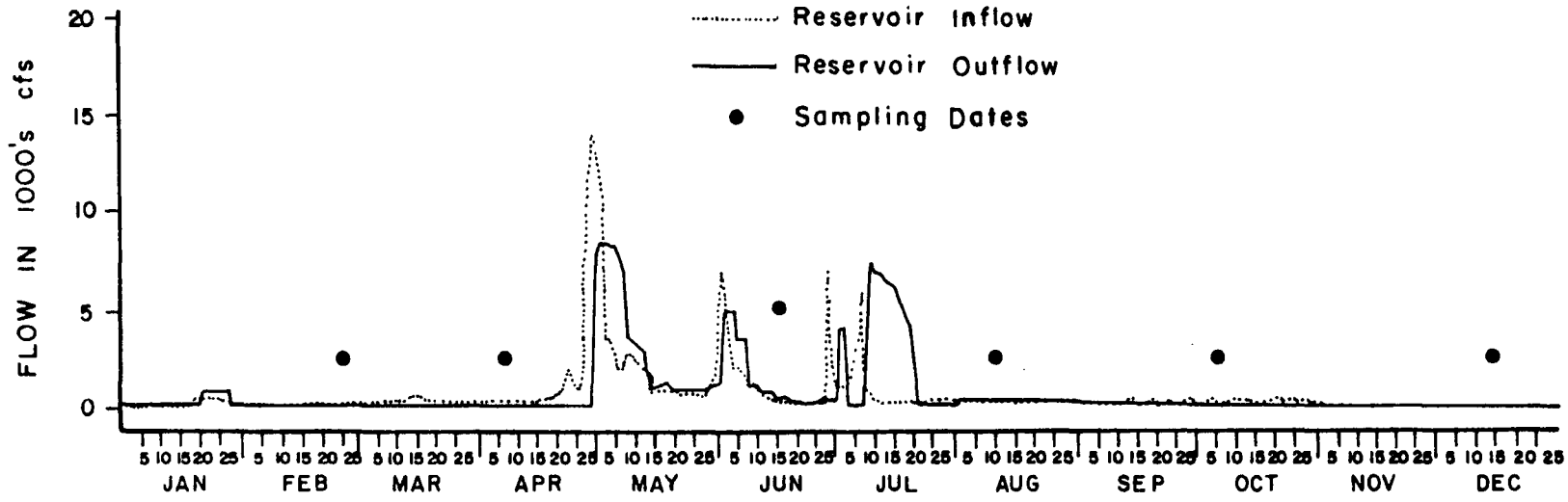

Figure 7.2. Inflow and outflow data for John Redmond Reservoir, 1976.

Table 7.1. Water temperature (°C) measured at fish sampling locations in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

	Neosho River				Wolf Creek			
Date	1	10	11	4	7	2	3	5
24-25 February	7.5	9.1	9.3	9.1	*[a]	5.5	6.3	6.5
5-6 April	13.0	16.0	15.8	16.6	13.1	12.4	11.8	11.4
3-4 May	11.3	-[b]	*	-	-	-	-	-
14-15 June	22.0	22.0	22.0	22.0	22.0	21.0	23.0	21.0
13 July	23.5	-	*	-	-	-	-	-
28 July	-	-	26.0	-	-	-	-	-
9-10 August	30.0	30.0	30.0	31.1	31.1	31.1	31.1	31.1
4-5 October	15.9	17.4	17.4	17.4	13.3	14.0	*	*
13-14 December	1.2	1.3	1.2	2.7	*	*	*	*

[a] Not measured.
[b] Sampling not scheduled.

Table 7.2. Checklist of fish species collected by all sampling methods in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1973-76.

Family and Scientific Name	Common Name	Year Collected 1973	1974	1975	1976
Lepisosteidae (gars)					
Lepisosteus platostomus	Shortnose gar	X		X	X
Lepisosteus osseus	Longnose gar				X
Clupeidae (herrings)					
Dorosoma cepedianum	Gizzard shad	X	X	X	X
Cyprinidae (carps and minnows)					
Campostoma anomalum	Stoneroller	X		X	X
Cyprinus carpio	Carp	X	X	X	X
Notemigonus crysoleucas	Golden shiner	X	X	X	X
Notropis buchanani	Ghost shiner	X	X	X	X
Notropis lutrensis	Red shiner	X	X	X	X
Notropis rubellus	Rosyface shiner		X	X	X
Notropis stramineus	Sand shiner		X	X	X
Notropis umbratilis	Redfin shiner		X	X	X
Phenacobius mirabilis	Suckermouth minnow	X	X	X	X
Pimephales notatus	Bluntnose minnow	X	X	X	X
Pimephales promelas	Fathead minnow	X	X		X
Pimephales tenellus	Slim minnow		X	X	X
Pimephales vigilax	Bullhead minnow	X	X	X	X
Catostomidae (suckers)					
Carpiodes sp.	YOY[a] carpsucker			X	
Carpiodes carpio	River carpsucker	X	X	X	X
Ictiobus sp.	YOY Buffalo			X	
Ictiobus bubalus	Smallmouth buffalo	X	X	X	X
Moxostoma erythrurum	Golden redhorse	X			
Moxostoma macrolepidotum	Shorthead redhorse	X		X	
Cycleptus elongatus	Blue sucker				X
Ictaluridae (freshwater catfishes)					
Ictalurus melas	Black bullhead	X	X	X	X
Ictalurus natalis	Yellow bullhead		X	X	
Ictalurus punctatus	Channel catfish	X	X	X	X
Pylodictis olivaris	Flathead catfish	X			
Noturus flavus	Stonecat				X
Noturus placidus	Neosho madtom				X
Cyprinodontidae (topminnows)					
Fundulus notatus	Blackstripe topminnow	X	X	X	X
Poeciliidae (livebearers)					
Gambusia affinis	Mosquitofish		X	X	X
Atherinidae (silversides)					
Labidesthes sicculus	Brook silversides		X		X
Percichthyidae (temperate basses)					
Morone chrysops	White bass	X	X	X	X
Centrarchidae (sunfishes)					
Lepomis cyanellus	Green sunfish	X	X	X	X
Lepomis humilis	Orangespotted sunfish	X	X	X	X
Lepomis macrochirus	Bluegill	X	X	X	X
Lepomis megalotis	Longear sunfish		X	X	X
Micropterus punctulatus	Spotted bass	X			
Micropterus salmoides	Largemouth bass	X	X	X	X
Pomoxis annularis	White crappie	X	X	X	X
Percidae (perches)					
Etheostoma chlorosomum[b]	Bluntnose darter		X		X
Etheostoma spectabile	Orangethroat darter	X			X
Percina caprodes	Logperch	X	X	X	X
Percina phoxocephala	Slenderhead darter			X	X
Stizostedion vitreum	Walleye	X			
Sciaenidae (drums)					
Aplodinotus grunniens	Freshwater drum	X	X	X	X
Total no. of species		30	31	31	38
Accumulated total no. of species		30	39	40	44

[a] Young-of-the-year.

[b] Bluntnose darter (*Etheostoma chlorosomum*) formerly identified as johnny darter (*E. nigrum*) by Kansas Gas and Electric Company (1974).

Table 7.3. Number of adult and juvenile fish collected by all sampling methods in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, February-December 1976.

Species	24-25 February	5-6 April	14-15 June	13 & 28 July	9-10 August	4-5 October	13-14 December	Total
Longnose gar	-[a]	2	-	-	1	-	-	3
Shortnose gar	1	-	4	-	-	1	-	6
Gizzard shad	1	35	3	1617	22	1	5	1684
River carpsucker	1	2	3	3	1	4	-	14
Smallmouth buffalo	-	2	3	1	-	4	-	10
Blue sucker	-	11	1	-	6	-	-	18
Carp	-	-	45	-	4	-	-	49
Red shiner	1051	321	614	66	431	551	19	3053
Ghost shiner	340	102	81	-	24	59	1	607
Rosyface shiner	1	-	-	-	-	-	-	1
Redfin shiner	-	1	-	-	11	-	-	12
Sand shiner	5	1	-	4	-	-	-	10
Fathead minnow	1	-	1	-	23	2	-	27
Bluntnose minnow	53	16	20	-	-	8	-	97
Bullhead minnow	126	2	4	1	17	90	2	242
Slim minnow	3	18	6	-	14	6	-	47
Suckermouth minnow	4	1	6	1	3	-	1	16
Golden shiner	2	-	2	-	3	16	-	23
Stoneroller	2	4	1	1	11	4	-	23
Channel catfish	5	21	12	1	9	5	-	53
Black bullhead	2	1	-	-	59	1	-	63
Stonecat	1	2	-	-	-	4	1	8
Neosho madtom	2	3	-	1	3	1	2	12
Brook silversides	-	-	-	-	15	21	-	36
Blackstripe topminnow	21	16	5	-	18	3	-	63
Mosquitofish	1	-	-	-	15	38	-	54
White bass	-	15	3	164	2	1	-	185
Largemouth bass	3	1	-	1	8	3	-	16
Bluegill	-	-	1	-	1	-	-	2
Green sunfish	8	4	5	-	-	5	-	22
Orangespotted sunfish	27	13	2	-	78	24	-	144
Longear sunfish	-	-	7	-	-	1	-	8
White crappie	2	10	1	33	60	6	-	112
Log perch	4	-	-	-	-	-	-	4
Slenderhead darter	1	4	-	-	4	2	1	12
Orangethroat darter	6	1	1	-	-	-	-	8
Bluntnose darter	2	-	1	-	-	-	-	2
Freshwater drum	-	1	9	1	2	-	-	13
Total	1676	610	840	1895	845	861	32	6759

[a] Not collected.

Table 7.4. Number of fish collected by hoop netting in the Neosho River in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, February-December 1976.

Species	1[a]	10[b]	4[b]	Total	Percent of Total
Longnose gar	0	3	0	3	1.7
Shortnose gar	0	2	4	6	3.3
Gizzard shad	6	0	0	6	3.3
River carpsucker	7	2	4	13	7.2
Blue sucker	13	2	3	18	10.0
Smallmouth buffalo	6	0	4	10	5.6
Carp	0	0	1	1	0.6
Channel catfish	9	0	4	13	7.2
Largemouth bass	1	0	0	1	0.6
Longear sunfish	0	1	1	2	1.1
White crappie	81	6	10	97	53.9
Freshwater drum	3	2	5	10	5.6
Total	126	18	36	180	
Percent of total	70.0	10.0	20.0		

[a] Fish were collected during eight sampling periods.
[b] Fish were collected during six sampling periods.

Table 7.5. Number of fish collected by seining at each location in the Neosho River in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, February-December 1976.

Species	Sampling Locations 1	10	11	4	Total	Percent of Total
Gizzard shad	1664	4	0	1	1669	28.1
River carpsucker	1	0	0	0	1	<0.1
Carp	0	0	2	0	2	<0.1
Ghost shiner	422	87	20	77	606	10.2
Red shiner	49	433	1224	1222	2928	49.3
Bullhead minnow	0	8	124	106	238	4.0
Slim minnow	0	3	8	21	32	0.5
Bluntnose minnow	0	7	25	11	43	0.7
Fathead minnow	1	0	0	1	2	<0.1
Sand shiner	9	0	1	0	10	0.2
Golden shiner	2	1	0	0	3	0.1
Suckermouth minnow	2	1	1	0	4	0.1
Stoneroller	0	1	5	2	8	0.1
Channel catfish	5	11	23	1	40	0.7
Black bullhead	1	0	0	0	1	<0.1
Stonecat	0	7	1	0	8	0.1
Neosho madtom	0	1	11	0	12	0.2
Brook silversides	20	13	0	3	36	0.6
Blackstripe topminnow	0	2	0	2	4	0.1
Mosquitofish	5	10	5	34	54	0.9
White bass	180	2	1	2	185	3.1
Largemouth bass	0	0	1	0	1	<0.1
Orangespotted sunfish	1	0	0	21	22	0.4
White crappie	8	0	0	5	13	0.2
Orangethroat darter	2	0	4	1	7	0.1
Slenderhead darter	0	7	2	3	12	0.2
Freshwater drum	1	0	2	0	3	0.1
Total	2373	598	1460	1513	5944	
Percent of total	39.9	10.1	24.6	25.5		

Table 7.6. Number of fish collected by seining at each location in Wolf Creek in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, February-December 1976.

Species	Sampling Locations 7	2	3	5	Total	Percent of Total
Gizzard shad	0	0	4	0	4	0.6
Red shiner	1	46	42	36	125	19.7
Ghost shiner	0	0	1	0	1	0.2
Bullhead minnow	0	0	0	4	4	0.6
Slim minnow	0	5	6	4	15	2.4
Bluntnose minnow	0	39	14	1	54	8.5
Fathead minnow	18	2	1	4	25	4.0
Rosyface shiner	0	1	0	0	1	0.2
Redfin shiner	8	2	2	0	12	1.9
Golden shiner	4	15	0	4	23	3.6
Suckermouth minnow	0	4	5	0	9	1.4
Stoneroller	3	10	3	0	16	2.5
Carp	0	3	19	24	46	7.3
Black bullhead	1	2	56	3	62	9.8
Blackstripe topminnow	3	17	29	10	59	9.3
Mosquitofish	0	0	0	1	1	0.2
Largemouth bass	0	11	3	0	14	2.2
Bluegill	0	0	2	0	2	0.3
Longear sunfish	0	1	5	0	6	0.9
Green sunfish	2	11	8	1	22	3.5
Orangespotted sunfish	47	42	20	13	122	19.3
Bluegill - green sunfish hybrid	0	0	1	0	1	0.2
White crappie	0	0	2	0	2	0.3
Log perch	0	4	0	0	4	0.6
Bluntnose darter	0	2	0	0	2	0.3
Orangethroat darter	0	0	1	0	1	0.2
Total	87	217	224	105	633	
Percent of total	13.7	34.3	35.4	16.6		

Table 7.7. Age determinations of selected fish collected in the Neosho River in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, April-October 1976.

Date	Sampling Location	Species	Age Group	Number of Individuals	Total Length (mm) Mean	Total Length (mm) Range
6 April	10	White crappie	3	1	170	-[a]
			2	1	180	-
	4	White crappie	2	4	206	150-305
			3	3	203	160-230
			4	1	290	-
15 June	10	White crappie	2	1	240	-
		Longear sunfish	2	1	120	-
		Freshwater drum	1	1	150	-
			3	1	490	-
13 July	1	White crappie	1	11	165	120-190
			2	11	169	150-190
			3	4	179	165-195
9 August	1	White crappie	1	32	152	125-185
			2	14	192	150-230
		Freshwater drum	1	1	155	-
	10	White crappie	1	2	126	122-130
			2	2	176	167-185
	4	White crappie	3	1	265	-
5 October	4	White crappie	1	1	170	-

[a] Not applicable.

NALCO ENVIRONMENTAL SCIENCES

Table 7.8. Relative importance of major food items found in the stomachs of selected fish collected in the Neosho River in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

Species (size range in mm)	No. of Stomachs		Food Item	Frequency of Occurrence	Volume	
	With Food	Empty			ml	Percent of Total
Channel catfish (175-430)	12	1	Cladocera	8.3	0.3	1.2
			Copepoda	8.3	<0.1	Tr[a]
			Aquatic Insects			
			Odonata	8.3	0.1	0.4
			Chironomidae	25.0	<0.1	Tr
			Simuliidae	41.7	1.6	6.2
			Hydropsychidae	8.3	1.2	4.7
			Fish larvae	41.7	5.7	22.2
			Crayfish	25.0	12.9	50.2
			Plant fragments	33.3	3.9	15.2
White crappie (112-210)	36	8	Cladocera	13.9	<0.1	Tr
			Copepoda	5.6	<0.1	Tr
			Aquatic Insects			
			Hydropsychidae	52.8	0.2	2.2
			Heptageniidae	8.3	0.2	2.2
			Chironomidae	30.6	<0.1	Tr
			Trichoptera	8.3	<0.1	Tr
			Ephemeridae			
			Ephoron sp.	5.6	<0.1	Tr
			Hexagenia sp.	16.7	0.4	4.3
			Caenidae	13.9	<0.1	Tr
			Corixidae	2.8	<0.1	Tr
			Chaoboridae	38.9	0.5	5.4
			Gerridae	2.8	<0.1	Tr
			Fish	41.7	7.5	80.6
			Unrecognizable	11.1	0.5	5.4

[a] Trace.

NALCO ENVIRONMENTAL SCIENCES

Table 7.9. Number, density and taxa of fish larvae collected at Location 1 in the Neosho River in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

	Diurnal Sample					Nocturnal Sample				
Date	Volume of Water Sampled (m^3)	Number of Larvae	Density per $100m^3$ [a]	Taxa Collected	Percent of Total	Volume of Water Sampled (m^3)	Number of Larvae	Density per $100m^3$ [a]	Taxa Collected	Percent of Total
5 April	52.4	0	- [b]	-		74.9	-	-	-	
19 April	44.0	0	-	-		97.8	-	-	-	
3 May	238.2	0	-	-		98.1	-	-	-	
17 May	61.1	25	41.3	Catostomidae (suckers)	68.0	55.4	36	69.3	Catostomidae (suckers)	88.9
				Gizzard shad	12.0				Gizzard shad	5.6
				Carp	16.0				Carp	5.6
				White bass	4.0					
14 June	23.3	3475	14222.6	Catostomidae (suckers)	0.1	18.1	1020	5607.2	Catostomidae (suckers)	0.4
				Gizzard shad	99.6				Gizzard shad	99.4
				Carp	0.1				White crappie	0.1
				Cyprinidae (carp and minnows)	<0.1				Freshwater drum	0.1
				White crappie	<0.1					
				Freshwater drum	0.1					
28 June	103.9	3	2.8	Gizzard shad	33.3	76.8	9	13.7	Gizzard shad	66.7
				Cyprinidae (carp and minnows)	33.3				Cyprinidae (carp and minnows)	11.1
				Unidentified larvae	33.3				Freshwater drum	22.2
12 July	60.7	9	15.0	Gizzard shad	11.1					
				Cyprinidae (carp and minnows)	55.6					
				Lepomis sp. (sunfish)	11.1					
				Freshwater drum	22.2					
28 July	66.4	1	1.5	Cyprinidae (carp and minnows)	100.0					

[a] Mean of two replicates.
[b] Not applicable.

NALCO ENVIRONMENTAL SCIENCES

Chapter 8

VEGETATION MONITORING

By

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and
Cynthia J. Talaber

I. Introduction

Construction phase monitoring of vegetation in the vicinity of Wolf Creek Generating Station (WCGS), Burlington, Kansas, was conducted in April, June, and September 1976.

Two of the representative community types sampled have been monitored since 1974; an additional sampling location was established during the 1976 program for permanent monitoring. These three monitoring locations provide comparative data intended to reveal evidence of community change. Two mudflat communities on John Redmond Reservoir were also sampled in 1976 for predictive purposes.

The objectives of the construction phase monitoring program were:

1. To evaluate vegetational changes since the preconstruction monitoring studies;

2. To supplement previous data to provide additional bases of comparison for subsequent monitoring studies;

3. To determine the relationship between intra-community phytosociological variance and an intra-community environmental gradient;

4. To evaluate any relationships between phytosociological changes and construction activities; and

5. To predict possible phytosociological changes which may result from construction activity and operation.

Community composition, structure, productivity, and biomass were quantified in two floodplain woods and an abandoned railroad right-of-way. Detailed analyses were made of the phytosociology of the floodplain woods communities to determine the relationship between intra-community phytosociological variance and intra-community environmental variance. The composition of two mudflat areas on John Redmond Reservoir was also determined (Figure 8.1).

The hypothesis that operation of the cooling lake will affect composition and production of adjacent plant communities prompted collection of additional baseline data. Tree cores were collected from both floodplain woods communities, and annual increments were measured for the past 10 years to provide a basis for evaluation of future changes in growth. Dendrometer bands were installed on the same trees to provide future increment data. Phytosociological data were subjected to gradient analysis to delineate the existing vegetational continuum. Future monitoring will examine shifts along the continuum caused by water status alterations.

II. Field and Analytical Procedures

A. Study Area

Fourteen separate vegetation stands, representative of floodplain woods,

open pastures, mixed shrub-grass pastures, abandoned railroad rights-of-way, and reservoir mudflats, have been sampled during baseline and monitoring studies. Locations of the five communities sampled in 1976 are shown in Figure 8.1. The north and south stands of floodplain woods (Communities 1 and 8), and the abandoned railroad right-of-way (Community 2) are permanent monitoring locations. The two mudflat areas on John Redmond Reservoir, a wet mudflat (Community 9) and a dry mudflat (Community 10), were sampled to determine probable vegetation types, should mudflats occur at the WCGS cooling lake.

B. Field Procedures

All vegetational strata within the five plant communities were sampled by the quadrat method (Oosting 1956; Wiegert 1962). Six permanent 400 m^2 circular plots were systematically distributed in each stand of floodplain woods to sample trees (stems greater than 10 cm dbh) and saplings (stems 2.5-10.0 cm dbh). Five circular plots, each 10 m^2, were nested at the center and tangent to the four cardinal compass points within the circumference of each 400 m^2 plot to sample the shrub stratum (Figure 8.2). Herbaceous vegetation and woody seedlings less than 30 cm tall were sampled with 1 m^2 plots centered within each 10 m^2 plot.

The ground layers in the abandoned railroad right-of-way and the wet mudflat were sampled using 25, 0.1 m^2 circular plots distributed at 10 m intervals along one transect; the dry mudflat was sampled using 10, 0.1 m^2 plots distributed along one transect. The abandoned railroad right-of-way was also sampled using the point-quadrat method; 200 point-quadrats were used to determine cover by species (Mueller-Dombois and Ellenberg 1974).

Twenty representative saplings and trees were selected in each wooded community to determine biomass and monitor productivity. Height and diameter were measured, and tree cores were extracted from each to provide a record of past and current production. Permanent dendrometer bands (Bormann and Kozlowski 1962) were installed on the trees in March 1976 to monitor future production; they were marked and read in September to determine circumference increase. These bands will be read each September to provide an annual index of bole-wood and subsequent community production. Productivity in the abandoned railroad right-of-way was determined by the harvest method (Ovington et al. 1963).

C. Analytical Procedures

Community composition and structure were quantified for each of the six plots in the two floodplain woods, and by community for each of the five sampling locations. Productivity was calculated for the two floodplain woods and the abandoned railroad right-of-way. Absolute and relative values of frequency, density, and dominance were computed for species in the overstory, understory, and shrub strata. Importance values were determined as the sum of the relative indices (Curtis and McIntosh 1951). Absolute and relative frequency and community ground layer coverage were calculated for ground layer vegetation in each community sampled. In addition, percent cover by species was calculated for the abandoned railroad right-of-way (Mueller-Dombois and Ellenberg 1974). Densities of trees and saplings were calculated for nine stem size classes. All data summaries were performed on a Data General NOVA computer using standard formulas (Curtis and Cottam 1962).

Community biomass and primary productivity were calculated using equations of Whittaker et al. (1974), Kelly et al. (1974), and Whittaker and Marks (1975). The increment, diameter, and height of representative saplings and trees were used to estimate their above-ground biomass and annual productivity using allometric regressions derived from empirical data gathered in a mesic woods by Whittaker et al. (1974). The biomass and productivity values for each sapling and tree were multiplied by the density of their respective size classes and summed to obtain biomass and productivity estimates for the stand in kilograms per hectare.

Plant voucher specimens were collected, dried, processed for permament preservation, and deposited in the NALCO ES herbarium for future reference. Botanical nomenclature followed Gleason and Cronquist (1963). A phylogentic list of species sampled during 1976 was compiled (Appendix F, Table F-1).

The coefficient of community (2a/b) was used to quantify similarity between 1975 and 1976 community data; "a" is the number of recorded species common to both years of sampling and "b" is the collective sum of species found each year. Cox (1972) indicated that the coefficient of community for replicate samples in a plant community does not usually exceed 0.85. When comparing yearly data from the communities near Wolf Creek, a coefficient greater than 0.75 was considered very similar, a coefficient between 0.60 and 0.74 was considered moderately similar, and dissimilarity was indicated by coefficients less than 0.60.

A flood susceptibility continuum index representative of the flooding gradient for each of the six plots in the wooded communities was established through analysis of combined tree and sapling compositional and structural data. Flood susceptibility numbers, as established by Lindsey et al. (1961) for floodplain tree species, were assigned to each tree species and the mean-sum of relative density and dominance was multiplied by the species' respective flood susceptibility number. These values were summed to yield the plot's flood susceptibility continuum index. Flood susceptibility numbers range from 1 (flood-tolerant) to 10 (flood-intolerant) thus yielding stand continuum indices from 100 (flood-tolerant stand) to 1000 (flood-intolerant stand). Vegetation of the shrub and ground layer strata was individually compared; absolute frequencies of species in the ground layer and importance values of species in the shrub stratum were used in the determination of Kulczynski's "degree of floristic resemblance" (Kulczynski 1928). Matrices of these values were prepared to simplify the identification of vegetation patterns within the community. Community ordination, based upon the "degree of floristic resemblance", was calculated using the method of ordination described by Bray and Curtis (1957).

III. Results and Discussion

A. North Floodplain Woods (Community 1)

1. *Present Status*

The north floodplain woods is subject to periodic flooding, but the soil of this slight south facing slope is well-drained most of the year.

a. Composition

Composition of the overstory was codominated by bur oak (Quercus macrocarpa), hackberry (Celtis occidentalis), and black walnut (Juglans nigra); these species had importance values of 75.7, 59.5, and 43.2, respectively (Table 8.1). The occurrence of a few large bur oak (relative dominance of 43.2%) and numerous small hackberry (relative density of 32.8%) accounted for their importance. These two species had 100% frequency. Bitternut hickory (Carya cordiformis), Shumard's oak (Quercus shumardii), and redbud (Cercis canadensis) were intermediates, of which bitternut had the greatest density (relative density of 14.1%) and Shumard's oak the largest individuals (relative dominance of 17.1%). Lesser components were green ash (Fraxinus pennsylvanica), Kentucky coffee-tree (Gymnocladus dioica), slippery and American elm (Ulmus rubra and U. americana), and red mulberry (Morus rubra).

Reproduction of most major overstory species was indicated in the understory, excepting bur oak, black walnut, and Shumard's oak (Table 8.2). Hackberry was most important of the nine sapling species (importance value of 156.6), and redbud was secondary (importance value of 48.9). Green ash, bitternut, American elm, osage orange (Maclura pomifera), red mulberry, slippery elm, and gray dogwood (Cornus racemosa) were also present.

The shrub stratum consisted of six shrub species and nine tree species, of which coralberry (Symphoricarpos orbiculatus) was most common (importance value of 140.1; Table 8.3). Hackberry and green ash were reproducing well. Other components included Missouri gooseberry (Ribes missouriense), seedlings of redbud and slippery elm, and grape vines (Vitis sp.).

The ground layer was composed of 17 identifiable species in April, 21 in June, and 22 in September (Table 8.4). Seven of these were found in all sampling periods. Seasonal variation was evidenced by the presence of cleavers (Galium aparine), spreading chervil (Chaerophyllum procumbens), spring avens (Geum vernum), onion (Allium sp.), common blue violet (Viola papilionacea), spring beauty (Claytonia virginica), nyctelea (Ellisia nyctelea), smooth yellow violet (Viola eriocarpa), and sweet cicely (Osmorhiza sp.) in April only. In June and September, Virginia wild rye (Elymus virginicus) dominated; wood nettle (Laportea canadensis), black snakeroot (Sanicula gregaria), Virginia creeper (Parthenocissus quinquefolia), wingstem (Verbesina alternifolia), violets, and sedge (Carex laxiflora) were also frequent.

b. Structure

Based on density analysis, floodplain tree species such as hackberry, redbud, and green ash were successionally increasing in the community; these species composed 88% of the saplings (Table 8.5). Shumard's oak and most bur oak were large trees of which reproduction was low. Hackberry will eventually dominate.

The shrub stratum covered 19.7% of the ground and consisted of 9000 stems/ha (Table 8.3). Coralberry had the greatest density (5833 stems/ha).

Ground layer coverage decreased from 53% in June to 34% in September (Table 8.4); this was probably due to suppression by shading and the reduction of ephemeral species.

c. Productivity and Biomass

Primary productivity for the north floodplain woods was estimated at 10523 kg/ha per year and community biomass was 209,670 kg/ha (Table 8.5). This biomass estimate was similar to that of an Illinois lowland woods (Uhlemann 1977).

Annual increment core data for the 20 trees and saplings sampled in the north floodplain woods are plotted in Figure 8.3 as Increment Index (width of individual annual ring increment as a percentage of the maximum ring for the 10-year period). These data are of limited current use but may provide valuable monitoring information when the moisture status of the site is altered due to filling of the reservoir. General trends, indicated by the plots as a whole, demonstrate above-average growth (and associated growing conditions) in the period 1969 to 1971 and average or slightly below average in the period 1972-76. Future growth of trees in the community may be increased by a raised water table or decreased by increased flooding frequency and duration which would subsequently reduce root uptake of water, nutrients, and oxygen.

Dendrometer band data for 1976 did not correlate well with annual increment core data for 1976 (Figure 8.3), due to problems associated with the first year of installation. The bands did not appear to function properly on the small diameter saplings (note zero readings), but should provide better data in future years on the larger trees. These data, as with those of the tree-ring analysis, provide additional baseline information and are not extensively discussed here.

2. Comparisons with Previous Studies

The north floodplain woods has been sampled for two years, providing a good basis for comparison.

a. Composition

The overall coefficient of community was 0.89, indicating a high degree of similarity between 1975 and 1976 data (Figure 8.4). Individual strata coefficients were also high; those of the overstory and understory were 0.92 and 0.89, respectively. The coefficient of the shrub stratum was 0.74, and 0.75 was calculated for the ground layer.

b. Structure

The structure of the upper strata in this community varied slightly between 1975 and 1976. In 1975, 275 trees/ha and 842 saplings/ha were estimated; in 1976, 267 trees/ha and 721 saplings/ha were found. Most of the reduction occurred in the smallest size class of hackberry. This may have been caused by insufficient water supply from the recent drought, although natural thinning often occurs in small size classes.

The shrub stratum was similar to that of 1975, with 9000 stems/ha in 1976 compared to 9041 in 1975 (Table 8.3). The reduction of shrub cover from 31.7 to 19.7% was probably due to the recent drought. Ground layer cover in September was very similar, with 40% coverage in 1975 and 34% in 1976.

c. Productivity and Biomass

Primary productivity was estimated at 10523 kg/ha per year and biomass at 209,670 kg/ha in 1976, compared to 8763 kg/ha per year and 186,116 kg/ha in 1975. The differences in these values, although not significant, were due primarily to the use of a more accurate method of analysis, and not to community dynamics.

B. Abandoned Railroad Right-of-Way (Community 2)

1. Present Status

The abandoned railroad right-of-way was representative of the potential prairie vegetation of the Osage Plains region in Kansas; such undisturbed bluestem prairies are unusual in the area. Weaver (1968) and Kuchler (1974) described prairies with composition similar to that of this community.

a. Composition

A total of 32 taxa was recorded in the abandoned right-of-way in 1976 (Table 8.6). Only five taxa were identifiable to the generic level in April; wood-sorrel (*Oxalis* sp.) was the most common. In June, panic grasses (*Panicum scribnerianum*, *P. virgatum*, and *P. lanuginosum*) were codominant with little bluestem (*Andropogon scoparius*). Indian grass (*Sorghastrum nutans*), red top (*Agrostis hyemalis*), Virginia wild rye, and Japanese brome (*Bromus japonicus*) were also common grasses. Three-seeded mercury (*Acalypha gracilens*), wood-sorrel, and flowering spurge (*Euphorbia corollata*) were among the forbs recorded. Dominants were essentially the same in September, except for the occurrence of heath aster (*Aster ericoides*) and mountain-mint (*Pycnanthemum flexuosum*) among the forbs. Little bluestem, switchgrass (*Panicum virgatum*), and Scribner panicum (*P. scribnerianum*) consistently formed the greatest cover by individual species (Table 8.7). Some native prairie species observed, although not sampled, were big bluestem (*Andropogon gerardi*), Illinois bundleflower (*Desmanthus illinoensis*), Pitcher's sage (*Salvia pitcheri*), blazing star (*Liatris pycnostachya*), and rattlesnake-master (*Eryngium yuccifolium*).

b. Structure

A dense community ground layer cover was present in September (92% by quadrat method and 98% by point-quadrat), consisting almost entirely of grasses. The mean canopy height increased rather slowly throughout the season, attaining only 3.1 dm in September (Table 8.7). Sunflowers, big bluestem, and Indian grass occasionally reached a height of approximately 1.5 m.

c. Productivity

The abandoned railroad right-of-way produced a standing crop of 7060 kg/ha per year. This value is high in comparison to prairies studied by Koelling and Kucera (1965) and Smeins and Olson (1970).

2. Comparisons with Previous Studies

This community has been sampled for three years, two of preoperation monitoring and one of construction phase monitoring. Drought conditions in 1976, though not as severe as those of 1974, resulted in relatively low structural and compositional development.

a. Composition

The coefficient of community was 0.64 between 1975 and 1976 (Figure 8.4). This was approximately the same as the similarity between 1974 and 1975 (0.65, Buchanan 1976). Compositional changes were typical of the changing nature of the prairie.

b. Structure

The canopy of the abandoned railroad right-of-way was only 75% as tall in 1976 as it was in 1975; this was likely an effect of drought. A dense ground cover was produced both years.

c. Productivity

The standing crop decreased about 5% from 1975 to 1976 (from 7446 to 7060 kg/ha per year) but was still much greater than that of 1974.

C. South Floodplain Woods (Community 8)

1. Present Status

The south floodplain woods is located about 6 km downstream of the main dam site on Wolf Creek. The woods slopes slightly southward toward the creek; topography is irregular and depressions are frequent.

a. Composition

The composition of the overstory in the south floodplain woods was codominated by American elm, silver maple (*Acer saccharinum*), pin oak (*Quercus palustris*), hackberry, and Shumard's oak (importance values of 54.1, 35.8, 33.0, 31.7, and 31.4, respectively; Table 8.8). Of these, American elm was the most numerous (relative density of 25.3%) and silver maple had the greatest dominance (16.9%). Green ash, bur oak, and shellbark hickory (*Carya laciniosa*) were of intermediate importance. Sycamore (*Platanus occidentalis*), red mulberry, black walnut, Kentucky coffee-tree, and redbud were minor constituents.

Of the five dominant species in the overstory, only hackberry and American elm were reproducing well in the understory as indicated by sapling importance values of 119.6 and 91.2, respectively (Table 8.9). Shellbark hickory, green ash, red mulberry, redbud, and Kentucky coffee-tree were minor components with importance values ranging from 8.4 to 21.5. One sapling each of honey locust (Gleditsia triacanthos) and silver maple was recorded.

Five shrub species, 11 tree species, and one woody herbaceous species were recorded in the shrub stratum (Table 8.10). Poison ivy (Rhus radicans) was codominant with coralberry (importance values of 65.5 and 61.4, respectively). Other species in order of decreasing importance, were hackberry seedlings, green ash seedlings, wahoo (Euonymus atropurpureus), American elm, slippery elm, shellbark hickory, bur oak, and greenbrier (Smilax hispida).

The ground layer was composed of 19 identifiable species in April, 23 in June, and 19 in September (Table 8.11). Eight were common to all sampling periods. The occurrence in April of spreading chervil, cleavers, smooth yellow violet, phlox, common blue violet, spring avens, onion and sweet cicely demonstrated seasonal variation. In June and September, Virginia wild rye, Virginia creeper, and poison ivy codominated the ground layer; wood nettle was also a codominant in June. Ruellia (Ruellia strepens), white avens (Geum canadense), black snakeroot, and greenbrier were frequent.

b. Structure

Hackberry and American elm were considerably more dense as saplings than as trees and constituted 77% of the saplings (Table 8.12). Silver maple, pin oak, Shumard's oak, and bur oak occurred mainly in the larger size classes and their production was negligible. As in the north floodplain woods, hackberry will be the dominant species in the future.

The shrub stratum included 8633 stems/ha, covering 18.6% of the ground (Table 8.10). Poison ivy and coralberry were almost equally dense (2533 and 2833 stems/ha, respectively).

The ground layer cover of the community was 20% in April, 37% in June, and 28% in September (Table 8.11).

c. Productivity and Biomass

The south floodplain woods was estimated to have a primary productivity of 17668 kg/ha per year and a biomass of 220,688 kg/ha in 1976 (Table 8.12). This biomass estimate was similar to that of the north floodplain woods and that of an Illinois lowland woods (Uhlemann 1977).

Annual increment core data for the 20 trees and saplings sampled in the south floodplain woods are plotted in Figure 8.5 as Increment Index (width of individual annual ring increment as a percentage of the maximum ring for the 10-year period). These data were collected as additional baseline information that will be used to assess effects of changes in the future moisture status. General trends indicated above average growth in the period 1969 to

1973, with below average growth in the few years before and after that period. Growth in 1976 was slightly below average.

Dendrometer band data demonstrated inconsistencies, similar to those noted in the north floodplain woods, in the first year and indicated that the bands do not operate accurately on the smaller saplings (Figure 8.5).

2. Comparisons with Previous Studies

Because the south floodplain woods was sampled only one year, it is discussed in comparison with 1976 data for the north floodplain woods, which had a very high similarity between 1975 and 1976 data.

a. Composition

The composition of the overstory differed between the two woods except in the presence of hackberry as a dominant; however, this species was the major component of both understories and will eventually dominate both stands. The abundance of American elm in the south woods indicates that this community may have a more favorable moisture regime than that of the north woods. Coralberry shrubs, hackberry seedlings, and green ash seedlings were common species of both shrub strata; the lush growth of poison ivy in the south woods also suggests a better water supply. Virginia wild rye, Virginia creeper, and wood nettle were frequent constituents of both ground layers.

b. Structure

The structure of the upper strata in the two woods varied considerably. The north floodplain woods had 267 trees/ha and 721 saplings/ha, whereas the south floodplain woods had 396 trees/ha and 358 saplings/ha. The representation of hackberry in the smaller size classes and lower strata of both woods indicated its potential for future prominence.

Cover values of the shrub stratum and ground layer were similar between the two stands; the shrub stratum covered 19.7% in the north woods and 18.6% in the south woods, and ground layer cover was 34% in the former and 28% in the latter.

c. Productivity and Biomass

Primary productivity in the south floodplain woods was estimated at 17688 kg/ha per yr (Table 8.12), compared to 10523 kg/ha per yr in the north floodplain woods (Table 8.5). Biomass was 220,688 kg/ha in the former and 209,670 in the latter. The difference may be attributed to greater densities in almost every tree size class in the south woods.

D. Mudflats on John Redmond Reservoir

1. Wet Mudflat (Community 9)

a. Composition

The wet mudflat community showed evidence of recent flooding

in June and has probably been inundated at least once a year. Major components in June were Pennsylvania smartweed (Polygonum pensylvanicum), cocklebur (Xanthium strumarium), and immature composites (Table 8.13). Development was much more advanced in September and composition was dominated by a mixture of annuals and weedy species common to such fluctuation zones. Fall panic grass (Panicum dichotomiflorum) and spurge (Euphorbia humistrata) dominated; amaranth (Amaranthus arenicola), flower-of-an-hour (Hibiscus trionum), lady's thumb (Polygonum persicaria), rough sumpweed (Iva ciliata), and lovegrass (Eragrostis pilosa) were also frequent.

b. Structure

The canopy of the mudflat was very irregular, due to clumping of individual species; maximum height was approximately 0.75 m. Many plants had the prostrate habit typical of mudflat vegetation, and thus contributed little to the canopy. Small groups of willows (Salix spp.) were scattered across the area. In drier areas, stands of tall coarse grasses such as barnyard grass (Echinochloa crusgalli) and Sudan grass (Sorghum sudanense) added structural complexity. Density also varied greatly across the sampling areas; dense, nearly homogeneous stands (especially of Polygonum spp.) alternated with virtually bare areas. Ground cover increased from 24 to 50% between June to Sepember (Table 8.13).

2. Dry Mudflat (Community 10)

a. Composition

Unlike the wet mudflat, the dry mudflat community has probably not been annually inundated, and consequently was codominated by perennials and annuals. The most important species were annual sunflower (Helianthus annuus), cocklebur, horse nettle (Solanum carolinense), and foxtail grass (Setaria geniculata), of which the latter two are perennials. Other common species were common ragweed (Ambrosia artemisiifolia), panic grasses, and smartweed (Polygonum lapathifolium) (Table 8.14).

b. Structure

Annual sunflower determined the height of the canopy at 2 m. The stand was much more continuous than that on the wet mudflat, with no areas of bare soil apparent. Ground cover was also greater, reaching 88% in September (Table 8.14).

E. Gradient Analysis of Floodplain Woods

Vegetation patterns along an environmental gradient tend to repeat themselves with great fidelity under similar conditions of stand age, topography, and soils (Rochow 1972); i.e., vegetation change is a manifestation of environmental change. The correlation of a vegetation gradient to the physical gradient of flood frequency and intensity is the required baseline data for monitoring or predicting vegetation alterations in a streamside forest ecosystem due to changes in the flooding regime resulting from the construction of an impoundment (Skip and Bell 1975). Gradient analysis was conducted in the north and south floodplain

woods to describe the range of hydric levels and the variance of the vegetation's flood susceptibility prior to the construction of the WCGS cooling lake. Normally, the environmental moisture gradient within a vegetation community may be objectively determined by the relative elevations of the sampling plots within that community. However, optimal utility of the application of gradient analysis techniques requires that a broad range of the environmental spectrum be represented within the community analyzed (Rochow 1972). The relative elevations of the plots in the south floodplain woods, and particularly in the north floodplain woods, varied so little and the degree of drainage varied so much that the use of elevation as the sole criterion for establishing the flooding gradient was not feasible. Therefore, rather than establish an ordination of vegetational plots along a predetermined flooding gradient, the relative intensity of flooding was ascertained from known species behavior in response to flooding (Lindsey et al. 1961).

1. South Floodplain Woods

Vegetation sampling plots in the south floodplain woods varied in elevation from 304.21 to 307.36 m. Analysis of combined tree and sapling data weighted by flooding susceptibility numbers yielded flooding susceptibility indices ranging from 511 to 782 (Table 8.15). The ranking of these values, rated from rather low to comparatively high (Lindsey et al. 1961), closely followed the plot order of increasing elevation, with one minor exception.

Tree species patterns representing the flooding gradient were as follows: green ash, silver maple and sycamore dominated and reached greatest importance at the wet end between continuum indices 511 and 545; pin oak and American elm dominated mid-gradient positions between indices 587 and 660; and, hackberry and Shumard's oak reached prominence at the dry end between indices 692 and 782 (Table 8.15).

The degree of floristic resemblance was calculated to compare shrub-stratum data from plot to plot (Table 8.16). Sixty-seven percent of plot-to-plot comparisons resulted in indices below 50% similarity, indicating the phytosociological heterogeneity of the shrub stratum within the stand. Plots were ordinated based upon the aforementioned degree of floristic resemblance; this ordination resulted in a plot sequence nearly identical to that established by the flooding susceptibility continuum indices. Inversions in the plot order of the two different sequences occurred only between plots of high similarity. The phytosociological variation within the shrub stratum, and the close correlation between the plot ordination based on the tree and sapling data and the ordination based on the shrub stratum data, demonstrates the sensitivity and adaptation of the shrub stratum to an environmental gradient.

In the shrub stratum, silver maple and green ash reached greatest importance and were dominant at the wet end between continuum indices 511 and 545. Poison ivy dominated between indices 511-587, hackberry between indices 545 and

660, slippery elm at index 660, and wahoo and coralberry at the dry end between indices 692 and 792 (Table 8.17).

All ground layer plot-to-plot comparisons in the computation of the degree of floristic resemblance resulted in values of higher than 50% similarity (Table 8.16); this indicated a much higher degree of stratum homogeneity than the analysis of the shrub stratum. As community homogeneity increases, the reliability of a calculated ordination lessens. Plot ordination developed from ground-layer plot phytosociology did not bear as close a resemblance to the ordination established from the flooding susceptibility continuum indices as did the plot ordination developed from shrub-stratum phytosociology. Species composition of the ground layer was such that very few species reached importance only in a low number of plots (Table 8.18). The relative evenness of the distribution of important ground layer species was due to their inherent broad amplitude of ecological tolerance.

2. North Floodplain Woods

Vegetation sampling plots in the north floodplain woods ranged in elevation from 332.06 to 333.70 m; these elevations are approximately 30 m higher and represent approximately half the elevational gradient recorded in the south floodplain woods. Flooding susceptibility continuum indices ranged from 672 to 760, a small range commensurate with the small elevational gradient (Table 8.19). Distribution of most tree species of community importance occurred more randomly along the elevational gradient in the north floodplain woods than in the south floodplain woods; however, the importance of green ash was limited to the plots of lower continuum indices and the importance of bitternut hickory and black walnut were limited to the plots of higher continuum indices.

Plot-to-plot comparisons of the shrub stratum vegetation showed a high degree of homogeneity; all indices of the degree of floristic resemblance were greater than 50% (Table 8.20). Shrub stratum plot ordination did not correspond well with the ordination developed from the flooding continuum indices; however, plot number two, the plot of lowest flooding susceptibility, was least similar to all other plots. The distribution of important shrub species was random (Table 8.21).

In the ground layer, the degree of floristic resemblance calculations, community ordination, and distribution of important species gave similar results (Tables 8.20 and 8.22). Community ground layer homogeneity was high, ground layer plot ordination did not correlate well with tree plot ordination, and the distribution of important ground layer species was random.

3. Conclusions

Construction of the WCGS lake will modify flooding intensity and periodicity. This environmental change will produce changes in community vegetation.

Gradient analysis of current tree and sapling data showed a distinct gradient of broad ecological amplitude in the south floodplain woods and a

more subtle gradient of smaller amplitude in the north floodplain woods. The degree of correlation between the ordination established by the flooding susceptibility indices and the phytsociological ordination of shrub stratum plots of the floodplain woods was related to the amplitude of the ecological gradient represented by the sampling plots. Shrub-plot ordination of the south floodplain woods correlated closely with a well established gradient, whereas the ordination of the north floodplain woods correlated less closely. The relationship between the degree of ordination correlation to an environmental gradient and the amplitude of the environmental gradient has been documented by Rochow (1972). Because the shrub stratum plot ordination follows the flood susceptibility continuum ordination, it may be assumed that the shrub stratum also varies along a continuum in response to the flooding gradient. Analysis of the ground layers of the woods showed a degree of community homogeneity too high for reliable ground layer plot ordination.

It is predicted that flooding intensity will decrease in the south floodplain woods and increase in the north floodplain woods when the cooling lake is constructed. Should this occur, vegetation of the south floodplain woods will shift up the gradient and become more similar to the current vegetation of the north floodplain woods. The vegetation of the north floodplain woods will shift down the gradient and become more similar to the current vegetation of the south floodplain woods. Data in Table 8.23 show the current degree of floristic resemblance between plots of the south and north floodplain woods. Data presented in Tables 8.15 through 8.2.3 will serve as baseline information for future community environmental impact analysis.

F. Anticipated Construction Impacts to Plant Communities

The sensitivity of major vegetation communities to the environmental changes resulting from construction of Wolf Creek Generating Station were assessed and the possible resultant vegetation changes postulated.

1. North Floodplain Woods (Community 1)

The north floodplain woods will be affected by construction and operation more than other terrestrial communities because of its close physiographic association with Wolf Creek and its proximity to the projected shorelines of the WCGS cooling lake. Most woods in the vicinity are located within Wolf Creek's floodplain and are subjected to periodic flooding; however, the elevation of the north floodplain woods above the normal creek levels provides fairly well-drained conditions between inundations. The character of the floodplain woods is largely controlled by the fluctations in moisture conditions. Gradient analyses of this woods showed the vegetation to be fairly flood susceptible relative to other woods along Wolf Creek.

The monitoring plots in the north floodplain woods are located just above the proposed northern perimeter of the cooling lake. Conversion of Wolf Creek to a cooling lake will probably increase the incidence of flooding and the local moisture regime. Increases in the moisture regime (raising the water table) can interfere with reproductive strategies or edaphic requirements of present plant species (Johnson and Bell 1975). Due to the relatively high flood

susceptibility of the vegetation, it is expected that some changes in community composition may occur along with physiological changes in remaining species. Vegetation of the north floodplain woods will more closely resemble the current vegetation of the south floodplain woods. Low tolerance species such as walnut, bitternut hickory, and Shumard's oak will give way to high-tolerance species such as green ash, silver maple, and sycamore.

2. Abandoned Railroad Right-of-Way (Community 2)

The abandoned railroad right-of-way represented native bluestem prairie of the region. A moisture gradient will be created along this right-of-way ranging from inundated conditions to normal dry conditions beyond the influence of the WCGS lake level. In segments of the abandoned railroad right-of-way nearer the lake edge, marsh vegetation may develop. Intermediate moisture levels may promote the increase of slough grass (*Spartina pectinata*) or perhaps encroachment by woody species which may ultimately develop into a floodplain woods. Areas which are periodically inundated may develop vegetation similar to the wet or dry mudflat communities of John Redmond Reservoir.

The abandoned railroad right-of-way sampling plots are elevated about 8 m above the proposed level of the cooling lake. Root systems of prairie species seldom exceed 8 m (Weaver 1968); however, capillary action could make additional soil moisture available. Species requiring more moisture than is presently available in Community 2, such as big bluestem, could be locally favored by creation of the cooling lake.

3. South Floodplain Woods

The south floodplain woods, due to its close association with Wolf Creek, will experience the effects of the cooling lake. The character of this floodplain woods has largely evolved under the influence of periodic flooding. Gradient analysis conducted in Community 8 revealed that the arboreal vegetation is relatively flood tolerant. Construction of the WCGS cooling lake is expected to alter the hydric regime by reducing flooding frequency and intensity. This environmental change will allow the invasion of less flood-tolerant species such as black walnut and bitternut hickory, reduction in importance of such tolerant species as green ash, silver maple, and sycamore, and will ultimately result in community vegetation more strongly resembling the current vegetation of the north floodplain woods.

IV. Summary and Conclusions

1. The north floodplain woods (Community 1) was dominated by bur oak, hackberry, and black walnut. Hackberry and other lowland species were reproducing well; oaks and black walnut were lacking in the smaller size classes.

2. Compositional and structural data in the north floodplain woods were similar between 1975 and 1976. Differences in production estimates due to the introduction of a new sampling technique were slight.

3. The abandoned railroad right-of-way (Community 2) was composed of native prairie grasses and forbs. The mean height of the canopy was 3.1 dm and the area was highly productive.

4. The decreased canopy height and slightly lower productivity in the abandoned railroad right-of-way were due to less favorable growing conditions in 1976.

5. The south floodplain woods (Community 8) was sampled for the first time in 1976. American elm, silver maple, oaks, and hackberry were dominant. Only hackberry and American elm were reproducing well.

6. The overstory composition of the south floodplain woods differed from that of the north floodplain woods, probably as a result of differences in the moisture regime. Hackberry dominated the understory and will eventually be the dominant, as in the north floodplain woods.

7. The wet mudflat on John Redmond Reservoir (Community 9) was vegetated by the predominantly annual species common to frequently inundated areas. Smartweeds, panic grass, and prostrate spurge were dominant. Ground cover was sparse.

8. The dry mudflat on John Redmond Reservoir (Community 10) was codominated by perennials and annuals. Sunflowers, cockleburs, horse nettles, and foxtail grass were major species; ground cover was nearly complete.

9. Tree ring analysis and dendrometer bands were introduced in the north and south floodplain woods to provide baseline data for future monitoring of growth alterations caused by changes in moisture status attributable to creation of cooling lake.

10. Gradient analysis demonstrated a well-defined vegetational gradient correlated to moisture status in the south floodplain woods and a very subtle gradient in the north floodplain woods.

11. Filling of the cooling lake is expected to cause a shift to flood-tolerant species in the north floodplain woods by raising the water table.

12. Filling of the cooling lake is expected to result in a shift to more flood-intolerant species in the south floodplain woods due to reduced flooding below the dam.

13. Filling of the cooling lake is expected to cause a shift to marsh and wet-prairie species, and possibly floodplain woody species, in lower elevations of the abandoned railroad right-of-way.

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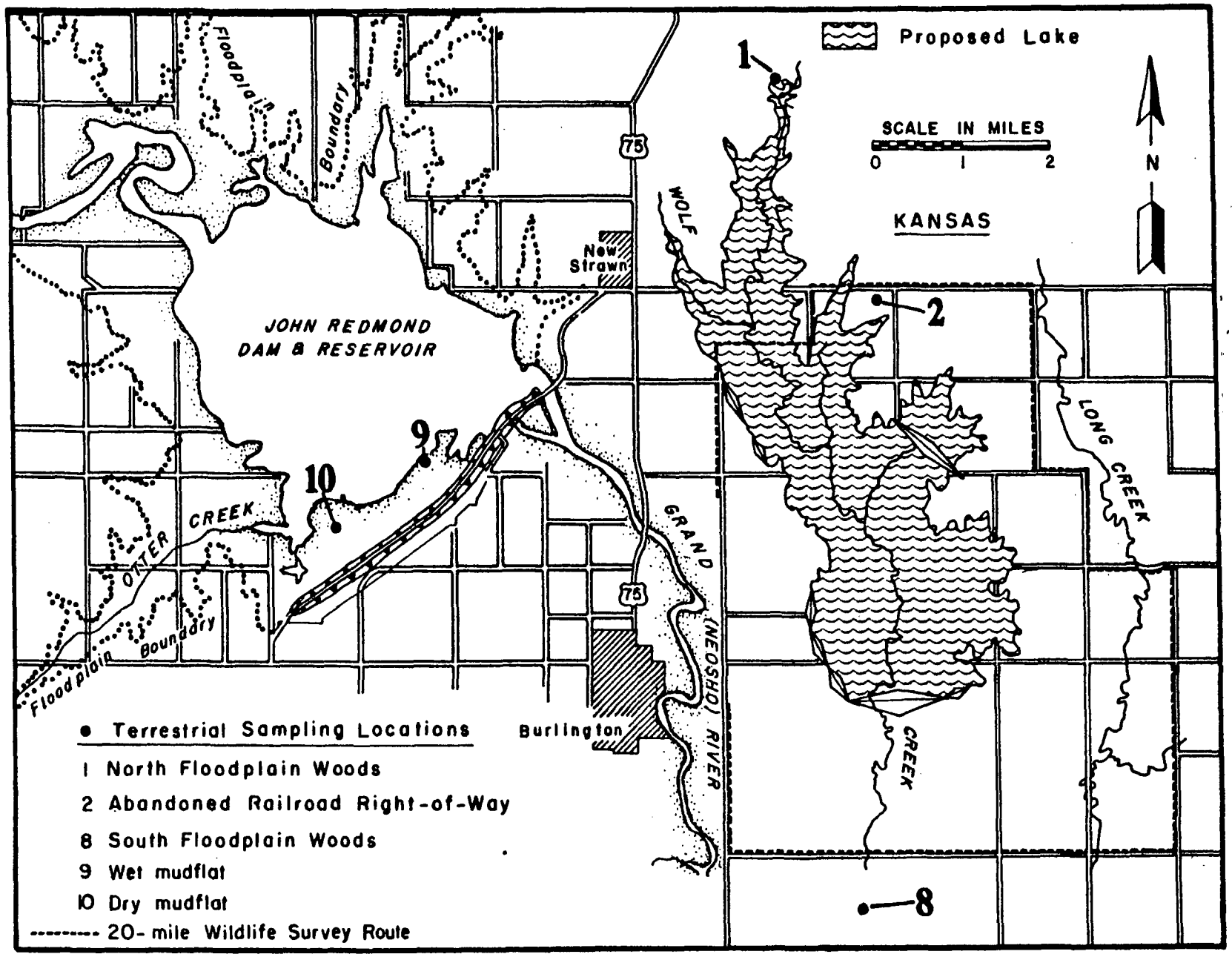


Figure 8.1. Vegetation sampling locations in the vicinity of the Wolf Creek Generating Station.

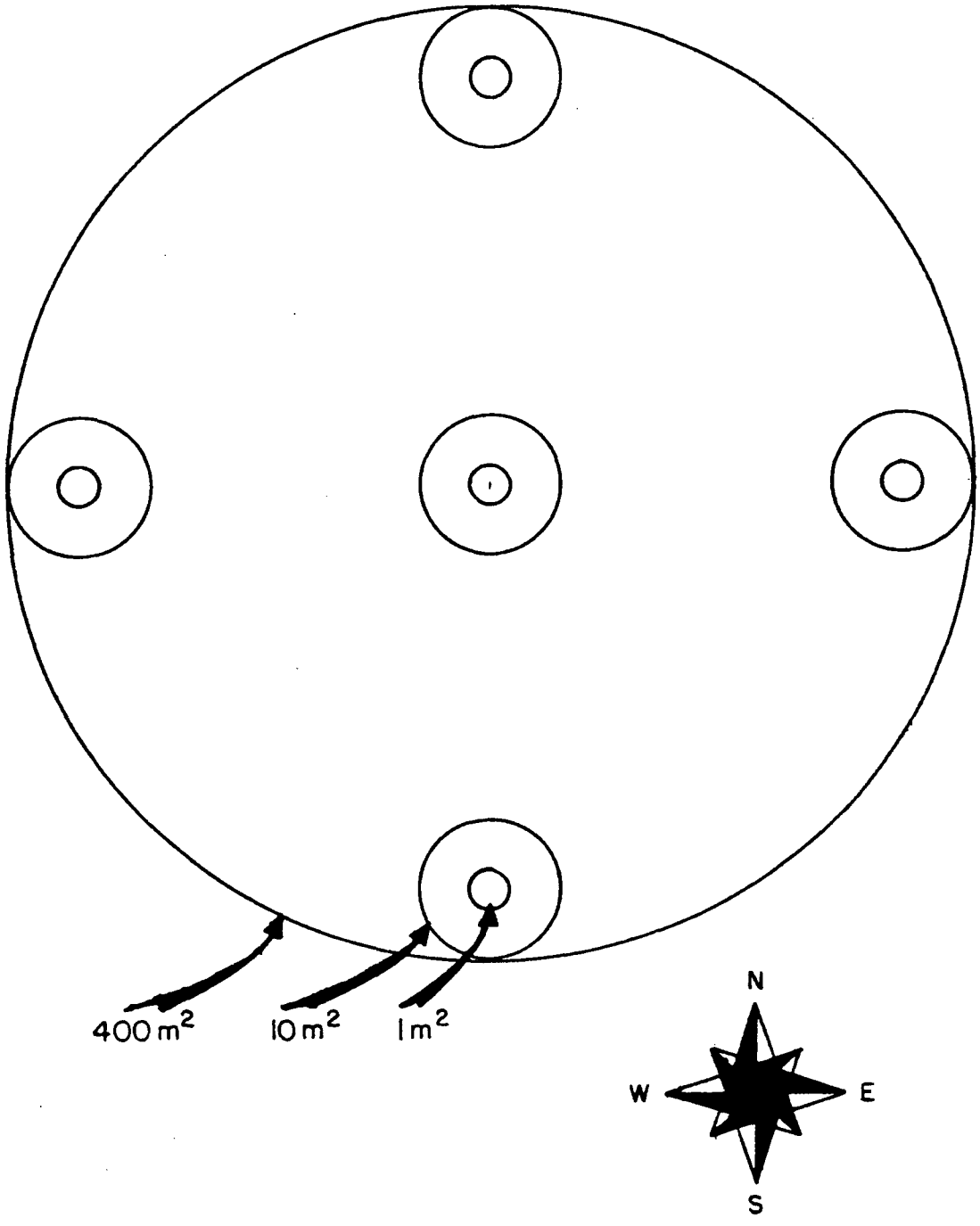


Figure 8.2. Schematic representation of nested quadrat layout for sampling vegetation in a floodplain woods in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

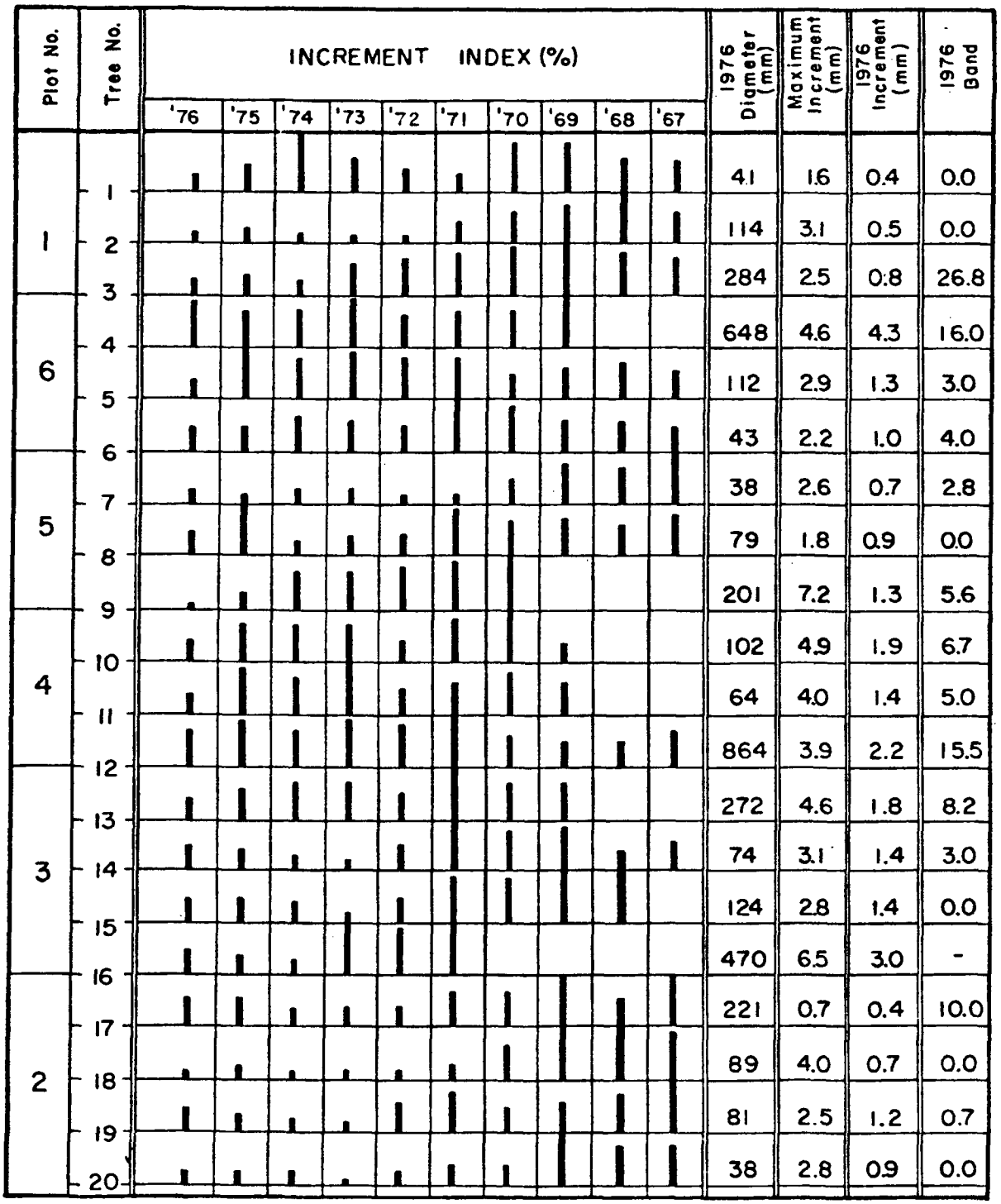


Figure 8.3. Tree ring and dendrometer band data from representative trees and saplings in the north floodplain woods, Community 2, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, September 1976.

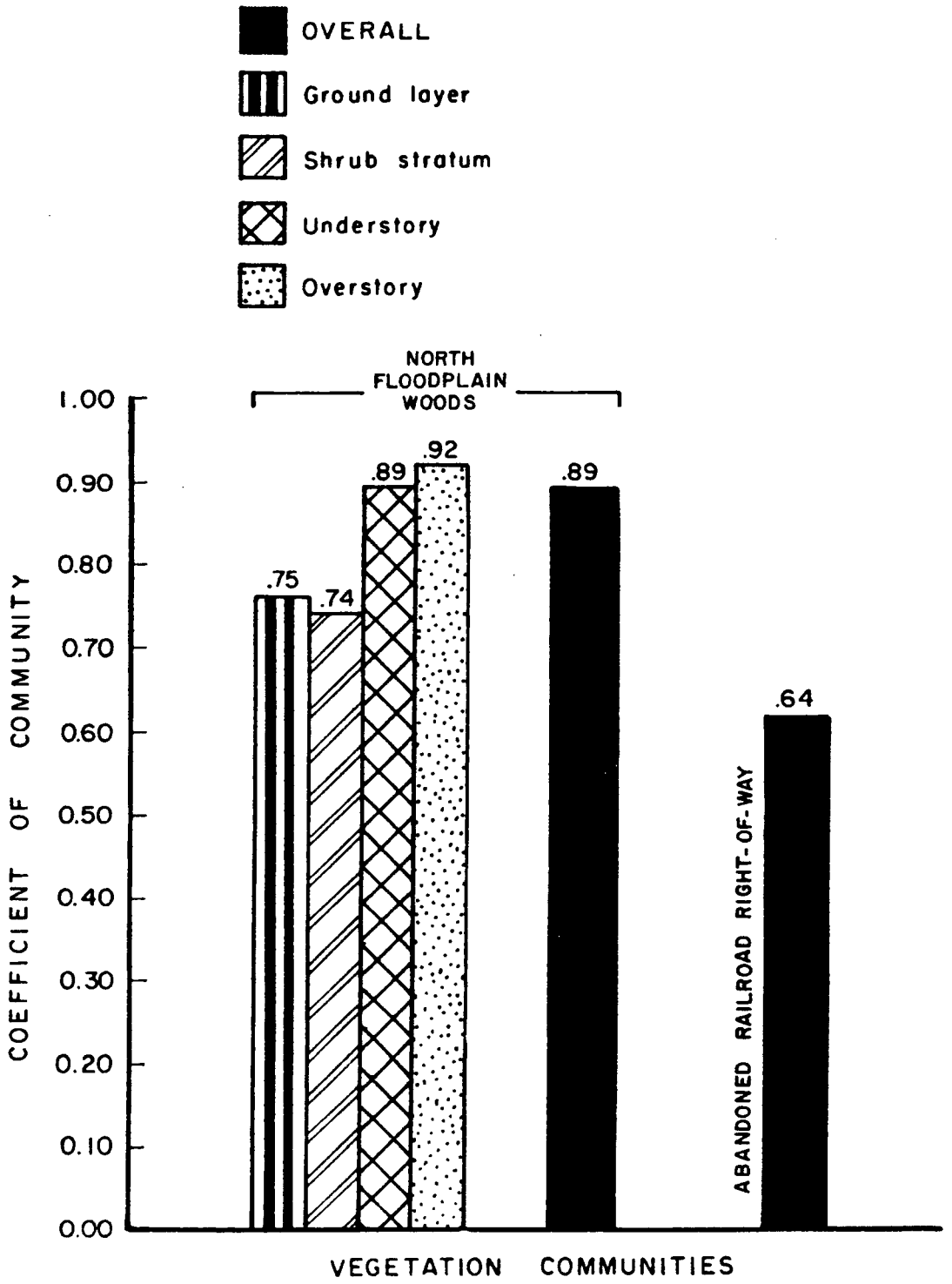
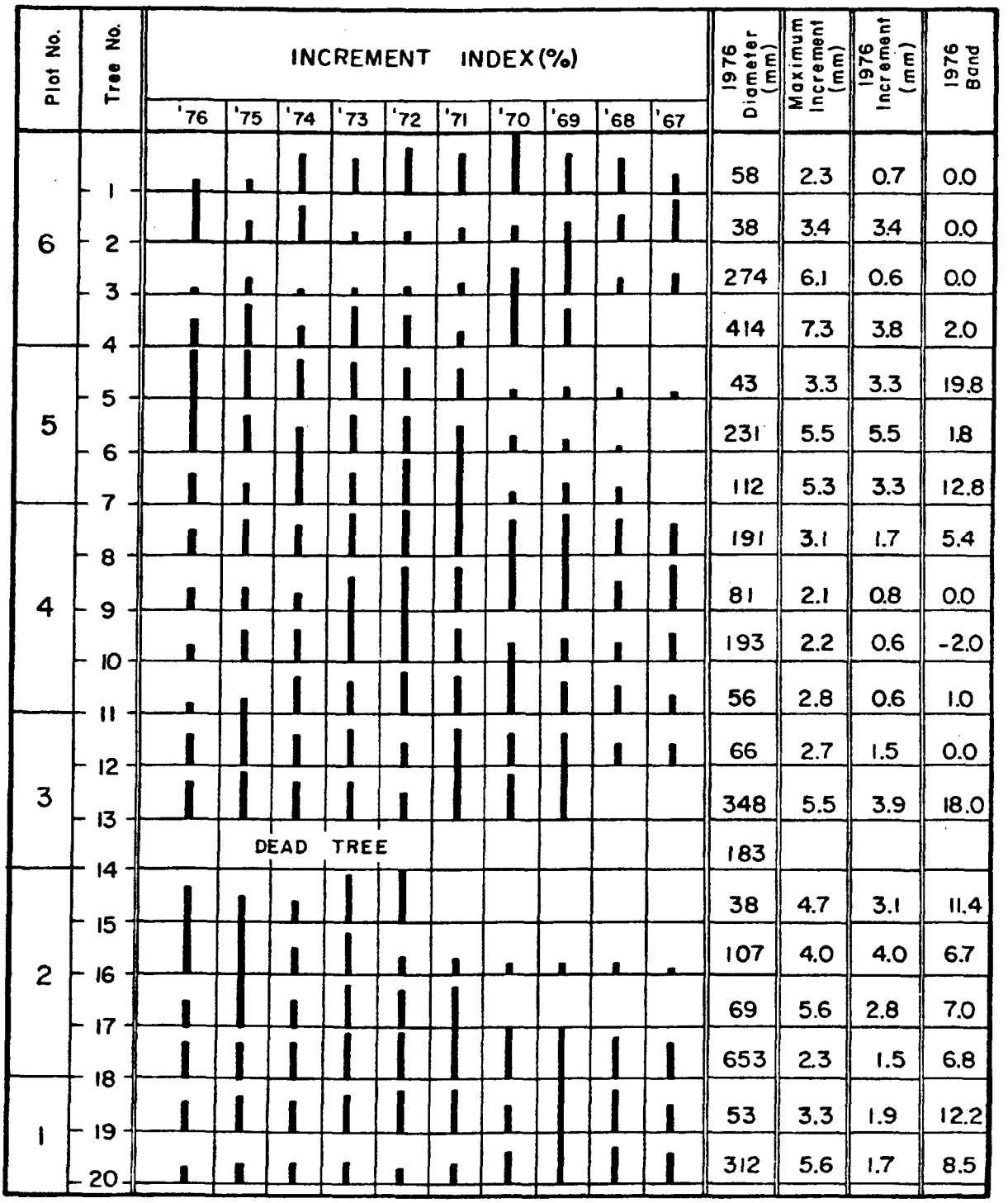


Figure 8.4. Similarity between 1976 and 1975 monitoring data for each plant community sampled for two years in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas.



Plot No.	Tree No.	1976 Diameter (mm)	Maximum Increment (mm)	1976 Increment (mm)	1976 Band
6	1	58	2.3	0.7	0.0
	2	38	3.4	3.4	0.0
	3	274	6.1	0.6	0.0
	4	414	7.3	3.8	2.0
5	5	43	3.3	3.3	19.8
	6	231	5.5	5.5	1.8
	7	112	5.3	3.3	12.8
4	8	191	3.1	1.7	5.4
	9	81	2.1	0.8	0.0
	10	193	2.2	0.6	-2.0
	11	56	2.8	0.6	1.0
3	12	66	2.7	1.5	0.0
	13	348	5.5	3.9	18.0
	14	183			
2	15	38	4.7	3.1	11.4
	16	107	4.0	4.0	6.7
	17	69	5.6	2.8	7.0
	18	653	2.3	1.5	6.8
1	19	53	3.3	1.9	12.2
	20	312	5.6	1.7	8.5

Figure 8.5. Tree ring and dendrometer band data from representative trees and saplings in the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, September 1976.

Table 8.1. Phytosociological data summary of trees in the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.

Species	Frequency	Relative Frequency	Trees/ Hectare	Relative Density	Basal Area (m^2/hectare)	Relative Dominance	Importance Value
Quercus macrocarpa	100.0	20.0	33.3	12.5	12.8	43.2	75.7
Celtis occidentalis	100.0	20.0	87.5	32.8	2.0	6.7	59.5
Juglans nigra	66.7	13.3	41.7	15.6	4.2	14.3	43.2
Carya cordiformis	66.7	13.3	37.5	14.1	2.4	8.1	35.5
Quercus shumardii	16.7	3.3	8.3	3.1	5.1	17.1	23.5
Cercis canadensis	50.0	10.0	20.8	7.8	0.4	1.3	19.1
Fraxinus pennsylvanica	33.3	6.6	16.7	6.2	1.5	4.9	17.8
Gymnocladus dioica	16.7	3.3	8.3	3.1	0.6	1.9	8.3
Ulmus rubra	16.7	3.3	4.2	1.6	0.4	1.4	6.2
Ulmus americana	16.7	3.3	4.2	1.6	0.3	0.8	5.8
Morus rubra	16.7	3.3	4.2	1.6	0.0	0.2	5.1
Totals			266.7		29.7		

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Table 8.2. Phytosociological data summary of saplings in the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.

Species	Frequency	Relative Frequency	Saplings/ Hectare	Relative Density	Basal Area (m^2/hectare)	Relative Dominance	Importance Value
Celtis occidentalis	100.0	20.0	462.5	64.2	1.4	72.5	156.6
Cercis canadensis	100.0	20.0	112.5	15.6	0.3	13.3	48.9
Fraxinus pennsylvanica	66.7	13.3	58.3	8.0	0.1	3.0	24.5
Carya cordiformis	66.7	13.3	20.8	2.9	0.0	4.3	20.5
Ulmus americana	50.0	10.0	33.3	4.6	0.0	2.3	16.9
Maclura pomifera	50.0	10.0	12.5	1.7	0.0	0.9	12.7
Morus rubra	33.3	6.6	8.3	1.2	0.0	1.4	9.2
Ulmus rubra	16.7	3.3	8.3	1.2	0.0	2.0	6.5
Cornus racemosa	16.7	3.3	4.2	0.6	0.0	0.1	4.0
Totals			720.8		1.9		

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Table 8.3. Phytosociological data summary of species in the shrub stratum of the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.

Species	Frequency	Relative Frequency	Stems/ Hectare	Relative Density	% Ground Cover	Relative Dominance	Importance Value
Symphoricarpos orbiculatus	86.7	31.3	5833	64.8	8.6	43.9	140.1
Celtis occidentalis	50.0	18.1	867	9.6	5.3	27.1	54.8
Fraxinus pennsylvanica	36.7	13.3	733	8.1	1.7	8.4	29.9
Ribes missouriense	23.3	8.4	467	5.2	0.4	2.2	15.8
Cercis canadensis	10.0	3.6	100	1.1	1.4	7.3	12.0
Ulmus rubra	13.3	4.8	300	3.3	0.6	3.4	11.5
Vitis sp.	16.7	6.0	233	2.6	0.3	1.5	10.1
Ulmus americana	6.6	2.4	100	1.1	0.6	3.2	6.7
Smilax hispida	10.0	3.6	100	1.1	0.0	0.3	5.1
Quercus macrocarpa	6.6	2.4	67	0.7	0.1	0.5	3.7
Morus rubra	3.3	1.2	33	0.4	0.2	1.1	2.7
Rhus radicans	3.3	1.2	67	0.7	0.0	0.2	2.2
Carya cordiformis	3.3	1.2	33	0.4	0.1	0.3	1.9
Cornus racemosa	3.3	1.2	33	0.4	0.1	0.3	1.9
Euonymus atropurpureus	3.3	1.2	33	0.4	0.0	0.1	1.7
Totals			9000		19.7		

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Table 8.4. Frequency of species in the ground layer and average ground layer cover in the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, April, June, and September 1976.

Species	April		June		September	
	Frequency	Relative Frequency	Frequency	Relative Frequency	Frequency	Relative Frequency
Chaerophyllum procumbens	83.3	12.5				
Galium aparine	76.7	11.5				
Gramineae	76.7	11.5			3.3	0.6
Sanicula gregaria	73.3	11.0	56.7	11.3	50.0	10.4
Laportea canadensis	60.0	9.0	66.7	13.2	56.7	11.8
Carex sp.	50.0	7.5				
Compositae	40.0	6.0				
Viola eriocarpa	36.7	5.5				
Symphoricarpos orbiculatus	30.0	4.5	23.3	4.6	20.0	4.2
Phlox divaricata	23.3	3.5	6.6	1.3		
Polygonum virginianum	23.3	3.5	10.0	2.0	26.7	5.6
Viola papilionacea	16.7	2.5				
Geum vernum	13.3	2.0				
Urtica dioica	10.0	1.5	6.6	1.3	13.3	2.8
Allium sp.	10.0	1.5				
Parthenocissus quinquefolia	10.0	1.5	56.7	11.3	50.0	10.4
Ribes missouriense	6.6	1.0			16.7	3.5
Ulmus americana	6.6	1.0				
Ellisia nyctelea	6.6	1.0				
Claytonia virginica	3.3	0.5				
Rhus radicans	3.3	0.5	6.6	1.3	3.3	0.6
Liliaceae	3.3	0.5				
Osmorhiza sp.	3.3	0.5				
Elymus virginicus			70.0	13.9	63.3	13.2
Verbesina alternifolia			43.3	8.6	43.3	9.0
Viola sp.			43.3	8.6	3.3	0.6
Carex laxiflora			40.0	7.9	43.3	9.0
Cercis canadensis			13.3	2.6		
Geum canadense			10.0	2.0	6.6	1.4
Ruellia strepens			10.0	2.0	16.7	3.5
Menisperum canadense			6.6	1.3	6.6	1.4
Parietaria pensylvanica			6.6	1.3		
Festuca obtusa			6.6	1.3		
Pilea pumila			6.6	1.3	3.3	0.6
Polygonum sp.			3.3	0.6		
Quercus shumardii			3.3	0.6		
Celtis occidentalis			3.3	0.6	3.3	0.6
Fraxinus pennsylvanica			3.3	0.6	3.3	0.6
Leersia virginica					10.0	2.1
Cinna arundinacea					6.6	1.4
Aster sp.					6.6	1.4
Polgonum punctatum					6.6	1.4
Carya sp.					6.6	1.4
Chenopodium hybridum					3.3	0.6
Quercus sp.					3.3	0.6
Smilax hispida					3.3	0.6
Average Community Ground Layer	37%		53%		34%	

Table 8.5. Density (stems per hectare) of saplings and trees by diameter classes in the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.

	Diameter Classes dbh (cm)											
	Sapling Class			Tree Class								
Species	2.5-6.2	6.3-10.0	Sub-Total	10.1-17.5	17.6-25.0	25.1-32.5	32.6-40.0	40.1-47.5	47.6-55.0	> 55.1	Sub Total	Totals
Density (stems/ha)												
Celtis occidentalis	275.0	187.5	462.5	66.7	8.3	8.3	4.2				87.5	550.0
Cercis canadensis	79.2	33.3	112.5	16.7	4.2						20.8	133.3
Fraxinus pennsylvanica	54.2	4.2	58.3	4.2	4.2	4.2			4.2		16.7	75.0
Carya cordiformis	12.5	8.3	20.8	12.5	4.2	12.5	4.2		4.2		37.5	58.3
Juglans nigra				8.3	4.2	8.3	4.2	12.5	4.2		41.7	41.7
Ulmus americana	33.3		33.3			4.2					4.2	37.5
Quercus macrocarpa					4.2		4.2		4.2	20.8	33.3	33.3
Morus rubra	4.2	4.2	8.3	4.2							4.2	12.5
Maclura pomifera	8.3	4.2	12.5									12.5
Ulmus rubra		8.3	8.3				4.2				4.2	12.5
Gymnocladus dioica				4.2			4.2				8.3	8.3
Quercus shumardii										8.3	8.3	8.3
Cornus racemosa	4.2		4.2									4.2
Totals	470.8	250.0	720.8	116.7	29.2	37.5	25.0	12.5	16.7	29.2	266.7	987.5
Biomass (kg/ha)	1745	3940		5662	5198	15298	19893	14671	28355	114908		209670
Productivity (kg/ha/yr)	393	625		679	242	741	1302	798	1294	4449		10523

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Table 8.6. Frequency of species in the ground layer and average ground layer cover in the abandoned railroad right-of-way, Community 2, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, April, June, and September 1976.

	April		June		September	
Species	Frequency	Relative Frequency	Frequency	Relative Frequency	Frequency	Relative Frequency
Gramineae	96.0	49.0	20.0	4.9	76.0	21.6
Oxalis sp.	56.0	28.6	36.0	8.8	4.0	1.1
Achillea millefolium	16.0	8.1	8.0	2.0		
Claytonia virginica	12.0	6.1				
Compositae	8.0	4.1	16.0	3.9		
Vitis sp.	4.0	2.0	4.0	0.9		
Galium aparine	4.0	2.0				
Panicum scribnerianum			44.0	10.8	68.0	19.3
Andropogon scoparius			44.0	10.8	72.0	20.5
Panicum virgatum			40.0	9.8	44.0	12.5
Acalypha gracilens			36.0	8.8	40.0	11.4
Panicum lanuginosum			24.0	5.9		
Sorghastrum nutans			20.0	4.9	4.0	1.1
Agrostis hyemalis			16.0	3.9		
Elymus virginicus			12.0	2.9		
Bromus japonicus			12.0	2.9		
Euphorbia corollata			12.0	2.9		
Viola pedatifida			8.0	2.0		
Tradescantia ohiensis			8.0	2.0		
Koeleria cristata			8.0	2.0		
Physalis sp.			8.0	2.0		
Petalostemum sp.			4.0	0.9		
Scutellaria parvula			4.0	0.9		
Viola sp.			4.0	0.9		
Prunus sp.			4.0	0.9	4.0	1.1
Helianthus maximiliani			4.0	0.9	4.0	1.1
Helianthus laetiflorus			4.0	0.9		
Solanum carolinense			4.0	0.9		
Parietaria pensylvanica			4.0	0.9		
Aster ericoides					16.0	4.5
Pycnanthemum flexuosum					8.0	2.3
Solidago canadensis					4.0	1.1
Eragrostis spectabilis					4.0	1.1
Sporobolus asper					4.0	1.1
Average Community Ground Layer Cover	20%		54%		92%	

Table 8.7. Percent cover of species in the ground layer, community ground layer cover, and mean canopy height in the abandoned railroad right-of-way, Community 2, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, April, June and September 1976.

	April		June		September	
Species	% Cover	Relative Dominance	% Cover	Relative Dominance	% Cover	Relative Dominance
Gramineae	13.0	74.3				
Oxalis sp.	2.5	14.3	1.0	2.1		
Compositae	1.5	8.6	2.5	5.3		
Claytonia virginica	0.5	2.9				
Andropogon scoparius			15.5	32.6	53.0	54.1
Panicum virgatum			7.0	14.7	34.5	35.2
Panicum scribnerianum			6.5	13.7	5.0	5.1
Sorghastrum nutans			5.0	10.5	0.5	0.5
Panicum lanuginosum			3.0	6.3		
Achillea millefolium			1.5	3.2		
Bromus japonicus			1.0	2.1		
Euphorbia corollata			1.0	2.1		
Koeleria cristata			1.0	2.1		
Agrostis hyemalis			0.5	1.1		
Elymus virginicus			0.5	1.1		
Viola pedatifida			0.5	1.1		
Psoralea tenuiflora			0.5	1.1		
Petalostemum sp.			0.5	1.1		
Pycnanthemum flexuosum					3.0	3.1
Sporobolus asper					1.0	1.0
Acalypha gracilens					0.5	0.5
Aristida oligantha					0.5	0.5
Community Ground Layer Cover						
	17.5%		47.5%		98%	
Mean Canopy Height						
	1.1 dm		2.0 dm		3.1 dm	

Table 8.8. Phytosociological data summary of trees in the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.

Species	Frequency	Relative Frequency	Trees/ Hectare	Relative Density	Basal Area (m^2/hectare)	Relative Dominance	Importance Value
Ulmus americana	83.3	15.6	100.0	25.3	4.2	13.2	54.1
Acer saccharinum	33.3	6.2	50.0	12.6	5.3	16.9	35.8
Quercus palustris	33.3	6.2	45.8	11.6	4.8	15.1	33.0
Celtis occidentalis	83.3	15.6	45.8	11.6	1.4	4.5	31.7
Quercus shumardii	33.3	6.2	41.7	10.5	4.6	14.6	31.4
Fraxinus pennsylvanica	66.7	12.5	37.5	9.4	2.2	6.8	28.8
Quercus macrocarpa	50.0	9.3	29.2	7.3	2.6	8.3	25.1
Carya laciniosa	66.7	12.5	25.0	6.3	0.8	2.6	21.4
Platanus occidentalis	16.7	3.1	4.2	1.1	4.0	12.7	16.9
Morus rubra	16.7	3.1	4.2	1.1	0.7	2.1	6.2
Juglans nigra	16.7	3.1	4.2	1.1	0.5	1.6	5.8
Gymnocladus dioica	16.7	3.1	4.2	1.1	0.4	1.3	5.5
Cercis canadensis	16.7	3.1	4.2	1.1	0.0	0.1	4.3
Totals			395.8		31.6		

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Table 8.9. Phytosociological data summary of saplings in the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.

Species	Frequency	Relative Frequency	Saplings/ Hectare	Relative Density	Basal Area (m^2/hectare)	Relative Dominance	Importance Value
Celtis occidentalis	100.0	27.3	162.5	45.3	0.5	46.9	119.6
Ulmus americana	100.0	27.3	112.5	31.4	0.3	32.6	91.2
Carya laciniosa	33.3	9.0	16.7	4.7	0.0	7.7	21.5
Fraxinus pennsylvanica	16.7	4.5	29.2	8.1	0.1	5.2	17.9
Morus rubra	33.3	9.0	12.5	3.5	0.0	3.5	16.1
Cercis canadensis	33.3	9.0	8.3	2.3	0.0	1.7	13.1
Gymnocladus dioica	16.7	4.5	8.3	2.3	0.0	1.5	8.4
Gleditsia triacanthos	16.7	4.5	4.2	1.2	0.0	0.4	6.2
Acer saccharinum	16.7	4.5	4.2	1.2	0.0	0.3	6.0
Totals			358.3		1.0		

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Table 8.10 Phytosociological data summary of species in the shrub stratum of the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.

Species	Frequency	Relative Frequency	Stems/ Hectare	Relative Density	% Ground Cover	Relative Dominance	Importance Value
Rhus radicans	33.3	13.7	2533	29.3	4.2	22.4	65.5
Symphoricarpos orbiculatus	23.3	9.5	2833	32.8	3.5	19.0	61.4
Celtis occidentalis	36.7	15.1	700	8.1	4.3	22.9	46.1
Fraxinus pennsylvanica	36.7	15.1	800	9.2	1.7	9.3	33.7
Euonymus atropurpureus	23.3	9.5	700	8.1	1.7	9.1	26.8
Ulmus americana	13.3	5.5	133	1.5	0.6	3.4	10.4
Ulmus rubra	10.0	4.1	200	2.3	0.6	3.5	9.8
Carya laciniosa	10.0	4.1	133	1.5	0.6	3.2	8.8
Quercus macrocarpa	10.0	4.1	133	1.5	0.2	1.3	6.9
Smilax hispida	10.0	4.1	100	1.2	0.1	0.6	5.9
Morus rubra	6.6	2.7	67	0.7	0.2	0.8	4.3
Gymnocladus dioica	6.6	2.7	67	0.7	0.1	0.6	4.2
Acer saccharinum	3.3	1.4	33	0.4	0.4	2.1	3.8
Quercus shumardii	6.6	2.7	67	0.7	0.0	0.3	3.8
Sambucus sp.	3.3	1.4	33	0.4	0.2	0.8	2.6
Diospyros virginiana	3.3	1.4	33	0.4	0.1	0.3	2.1
Cercis canadensis	3.3	1.4	33	0.4	0.0	0.1	1.9
Menispermum canadense	3.3	1.4	33	0.4	0.0	0.1	1.9
Totals			8633		18.6		

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Table 8.11. Frequency of species in the ground layer and average ground layer cover in the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, April, June, and September 1976.

Species	April		June		September	
	Frequency	Relative Frequency	Frequency	Relative Frequency	Frequency	Relative Frequency
Galium aparine	96.7	18.4				
Chaerophyllum procumbens	93.3	17.7				
Gramineae	53.3	10.1				
Laportea canadensis	30.0	5.7	40.0	9.7	13.3	4.0
Geum vernum	30.0	5.7				
Compositae	26.7	5.1				
Allium sp.	23.3	4.4				
Parthenocissus quinquefolia	23.3	4.4	46.7	11.4	43.3	12.9
Symphoricarpos orbiculatus	20.0	3.8	6.6	1.6	6.6	2.0
Rhus radicans	20.0	3.8	40.0	9.7	36.7	10.9
Carex sp.	16.7	3.2				
Sanicula gregaria	13.3	2.5	20.0	4.9	16.7	5.0
Viola papilionacea	13.3	2.5				
Phlox divaricata	10.0	1.9				
Menispermum canadense	10.0	1.9	13.3	3.3	3.3	0.9
Viola eriocarpa	10.0	1.9				
Smilax hispida	6.6	1.3	20.0	4.9	30.0	8.9
Ranunculus abortivus	6.6	1.3				
Euonymus atropurpureus	6.6	1.3	3.3	0.8		
Celtis occidentalis	6.6	1.3	3.3	0.8	3.3	0.9
Gleditsia triacanthos	3.3	0.6				
Urtica dioica	3.3	0.6				
Fraxinus pennsylvanica	3.3	0.6	3.3	0.8	3.3	0.9
Elymus virginicus			60.0	14.6	36.7	10.9
Ruellia strepens			30.0	7.3	26.7	7.9
Geum canadense			30.0	7.3	13.3	4.0
Viola sp.			23.3	5.7	3.3	0.9
Ambrosia trifida			16.7	4.1	13.3	4.0
Carex laxiflora			13.3	3.3	30.0	8.9
Ulmus americana			3.3	0.8	3.3	0.9
Quercus macrocarpa			3.3	0.8		
Quercus sp.			3.3	0.8		
Polygonum sp.			3.3	0.8		
Cercis canadensis			3.3	0.8		
Latuca sp.			3.3	0.8		
Acer saccharinum			3.3	0.8		
Festuca obtusa			3.3	0.8		
Impatiens biflora			3.3	0.8		
Oxalis sp.			3.3	0.8		
Circaea quadrisulcata			3.3	0.8		
Pilea pumila			3.3	0.8	13.3	4.0
Polygonum punctatum					16.7	5.0
Parietaria pensylvanica					3.3	0.9
Quercus shumardii					3.3	0.9
Convolvulaceae					3.3	0.9
Panicum sp.					3.3	0.9
Average Community Ground Layer	20%		37%		28%	

Table 8.12. Density (stems per hectare) of saplings and trees by diameter classes in the south floodplain woods Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.

	Diameter Classes dbh (cm)											
	Sapling Class			Tree Class								
Species	2.5-6.2	6.3-10.0	Sub-Total	10.1-17.5	17.6-25.0	25.1-32.5	32.6-40.0	40.1-47.5	47.6-55.0	> 55.1	Sub-Total	Totals
Density (stems/ha)												
Ulmus americana	62.5	50.0	112.5	62.5	20.8		12.5			4.2	100.0	212.5
Celtis occidentalis	95.8	66.7	162.5	29.2	8.3	4.2	4.2				45.8	208.3
Fraxinus pennsylvanica	20.8	8.3	29.2	8.3	16.7	4.2	4.2		4.2		37.5	66.7
Acer saccharinum	4.2		4.2	4.2		12.5	12.5	20.8			50.0	54.2
Quercus palustris					16.7	16.7		4.2	4.2	4.2	45.8	45.8
Quercus shumardii				4.2		12.5	8.3	8.3	8.3		41.7	41.7
Carya laciniosa	4.2	12.5	16.7	16.7	4.2		4.2				25.0	41.7
Quercus macrocarpa					8.3	4.2	12.5	4.2			29.2	29.2
Morus rubra	8.3	4.2	12.5					4.2			4.2	16.7
Cercis canadensis	8.3		8.3	4.2							4.2	12.5
Gymnocladus dioica	8.3		8.3				4.2				4.2	12.5
Gleditsia triacanthos	4.2		4.2									4.2
Platanus occidentalis										4.2	4.2	4.2
Juglans nigra							4.2				4.2	4.2
Totals	216.7	141.7	358.3	129.2	75.0	54.2	66.7	41.7	16.7	12.5	395.8	754.2
Biomass (kg/ha)	783	1848		5298	18240	22357	55971	48305	27995	39891		220688
Productivity (hg/ha/yr)	409	726		1579	3648	960	5427	2872	1164	883		17668

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Table 8.13. Frequency of species in the ground layer and average ground layer cover on a wet mudflat on John Redmond Reservoir, New Strawn, Kansas, June and September 1976.

Species	June		September	
	Frequency	Relative Frequency	Frequency	Relative Frequency
Polygonum pensylvanicum	92.3	32.4		
Xanthium strumarium	61.5	21.6	12.0	3.4
Compositae	61.5	21.6		
Gramineae	46.2	16.2		
Ipomoea lacunosa	15.4	5.4	12.0	3.4
Solanum carolinense	7.6	2.7	12.0	3.4
Panicum dichotomiflorum			68.0	19.1
Euphorbia humistrata			64.0	18.0
Amaranthus arenicola			48.0	13.5
Hibiscus trionum			36.0	10.1
Polygonum persicaria			24.0	6.7
Iva ciliata			24.0	6.7
Eragrostis pilosa			24.0	6.7
Abutilon theophrasti			8.0	2.2
Polygonum lapathifolium			8.0	2.2
Euphorbia maculata			8.0	2.2
Sida spinosa			4.0	1.1
Leptochloa attenuata			4.0	1.1
	Average Community Ground Layer Cover			
	24%		50%	

Table 8.14. Frequency of species in the ground layer and average ground layer cover on a dry mudflat on John Redmond Reservoir, New Strawn, Kansas, September 1976.

Species	Frequency	Relative Frequency
Helianthus annuus	60.0	12.2
Solanum carolinense	60.0	12.2
Xanthium strumarium	50.0	10.2
Setaria geniculata	50.0	10.2
Gramineae	40.0	8.1
Ambrosia artemisiifolia	30.0	6.1
Panicum sp.	30.0	6.1
Polygonum lapathifolium	30.0	6.1
Asclepias sp.	20.0	4.1
Euphorbia preslii	20.0	4.1
Amaranthus sp.	20.0	4.1
Sida spinosa	20.0	4.1
Hibiscus trionum	20.0	4.1
Helianthus petiolaris	10.0	2.0
Echinochloa muricata	10.0	2.0
Strophostyles leiosperma	10.0	2.0
Compositae	10.0	2.0
	Average Community Ground Layer Cover	
	88%	

Table 8.15. Ordination of plots in the south floodplain woods (Community 8) based on flood susceptibility continuum index, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

Plot Number		3	6	2	5	1	4
Plot Eelevation (m)		304.21	305.53	305.33	305.84	306.80	307.36
Flood Susceptibility Continuum Index (Calculated from Tree and Sapling Data)		511	545	587	660	692	782
Species	Flood Susceptibility Number	(Relative Dominance & Relative Density)					
Fraxinus pennsylvanica	4	74.3	11.6	22.9		5.4	
Acer saccharinum	5	39.4	80.3				
Plantanus occidentalis	5		43.1				
Quercus palustris	6			63.4		49.2	
Gleditsia triacanthos	6	9.4				2.2	
Ulmus americana	6	76.9	28.9	42.2	120.1	16.4	29.6
Quercus macrocarpa	7		6.3	29.8		27.2	
Celtis occidentalis	7		29.9	28.3	21.0	53.3	43.2
Morus rubra	7				22.8	4.4	3.6
Gymnocladus dioica	7						18.2
Juglans nigra	8				19.4		
Caraya laciniosa	8			12.8	16.3	13.7	5.9
Cercis canadensis	8					2.1	7.6
Quercus shumardii	9					25.8	91.5

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Table 8.16. Plot-to-plot degree of floristic resemblance for shrub stratum and ground layer stratum data from the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

Shrub Stratum

Flood Susceptibility Continuum Index		511	545	587	660	692	782
	Plot Number	3	6	2	5	1	4
511	3	100[a]	55	52	48	9	22
545	6		100	54	59	20	39
587	2			100	42	31	41
660	5				100	24	41
692	1					100	58
782	4						100

Ground Layer Stratum

Flood Susceptibility Continuum Index		511	545	587	660	692	782
	Plot Number	3	6	2	5	1	4
511	3	100	67	71	57	51	54
545	6		100	55	54	48	45
587	2			100	65	61	62
660	5				100	57	59
692	1					100	51
782	4						100

[a] Percent similarity.

Table 8.17. Distribution of shrub-stratum species along the flood susceptibility continuum in the south floodplain woods, Community C, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

Plot Number	3	6	2	5	1	4
Plot Elevation (m)	304.21	305.53	305.33	305.84	306.80	307.36
Flood Susceptibility Continuum Index (Calculated from Tree and Sapling Data)	511	545	587	660	692	792
Species			Importance Value			
Acer saccharinum		39.3				
Fraxinus pennsylvanica	132.6	100.0	21.7	81.1	7.1	19.8
Smilax hispida	35.2			29.7	6.8	
Rhus radicans	132.6	64.3	141.1	33.9	12.0	46.1
Diospyros virginiana			9.1			
Ulmus americana		32.3	11.1			16.3
Celtis occidentalis		64.0	75.6	62.6	39.5	35.1
Quercus shumardii			9.1		7.3	
Quercus macrocarpa			9.1	53.4	7.3	
Sambucus sp.				39.3		
Ulmus rubra			11.1		32.8	
Menispermum canadense					7.3	
Morus rubra					17.4	
Euonymus atropurpureus			11.1		64.6	29.6
Cercis canadensis					7.3	
Symphoricarpos orbiculatus					78.1	121.5
Caraya laciniosa					12.4	18.3
Gymnocladius dioica						13.4

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Table 8.18. Distribution of ground-stratum species along the flood susceptibility continuum in the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

Plot Number		3	6	2	5	1	4
Plot Elevation (m)		304.21	305.53	305.33	305.84	306.80	307.36
Flood Susceptibility Continuum Index (Calculated from Tree and Sapling Data)		511	545	587	660	692	782
Species	Month of Maximum Occurrence	Frequency During Month of Maximum Occurrence					
Viola papilionacea	April	60	20				
Acer saccharinum	June		20				
Urtica dioica	April		20				
Gleditsia triacanthos	April		20				
Pilea pumila	September	20	20	20		20	
Polygonum punctatum	September	40		20		40	
Smilax hispida	September	20	60	40	20	40	
Ambrosia trifida	June	40		20	20		20
Quercus macrocarpa	June			20			
Cercis canadensis	June			20			
Rhus radicans	June	60	40	80	40	20	40
Laportea canadensis	June	20	60		100	20	40
Chaerophyllum procumbens	April	100	80	80	100	100	100
Galium aparine	April	80	100	100	100	100	100
Ranunculus abortivus	April			20		20	
Sanicula gregaria	June		20		60	40	
Festuca obtusa	June				20		
Ruellia strepens	June	40		40	20		80
Ulmus americana	June				20		
Carex laxiflora	September	40	20	40	40	20	20
Elymus virginicus	June	20		100	100	60	80
Geum canadense	June	20		40	20	80	20
Geum vernum	April			20	80	60	20
Euonymus atropurpureus	April				20	20	
Parthenocissus quinquefolia	June	20	20	40	20	80	100
Fraxinus pennsylvanica	June				20		
Impatiens biflora	June				20		
Celtis occidentalis	April					40	

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Table 8.19. Ordination of plots in the north floodplain woods, Community 1, based on flood susceptibility continuum index, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

Plot Number		2	4	6	1	5	3
Plot Elevation (m)		333.06	332.72	332.66	333.70	332.99	333.27
Flood Susceptibility Continum Index (Calculated from Tree and Sapling Data)		672	715	722	740	751	760
Species	Flood Susceptibility Number	(Relative Dominance & Relative Density)					
Fraxinus pennsylvanica	4	35.0	23.7	2.3		10.5	2.9
Ulmus americana	6	2.5	9.5		15.3		
Maclura pomifera	6	2.6		2.4			2.9
Gymnocladus dioica	7						
Celtis occidentalis	7	63.4	54.1	80.0	68.9	91.3	57.9
Quercus macrocarpa	7	53.0	44.2	69.0	41.0	16.1	35.8
Morus rubra	7		2.5		3.8		2.9
Ulmus rubra	8	5.5			10.5		
Juglans nigra	8			14.3	44.0	18.7	49.2
Cercis canadensis	8	26.6	2.5	28.0	6.3	16.7	14.7
Cornus racemosa	8			2.3			
Carya cordiformis	9	11.4		2.6		47.4	33.3
Quercus shumardii	9		53.8				

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Table 8.20. Plot-to-plot degree of floristic resemblance for shrub stratum and ground layer stratum data from the north floodplain woods, Community 1, in the vicinity of Wolf Creek Generating Station, Burlington, Kansas, 1976.

Shrub Stratum

Flood Susceptibility Continuum Index		672	715	722	740	751	760
	Plot Number	2	4	6	1	5	3
672	2	100[a]	69	86	47	66	71
715	4		100	74	77	71	69
722	6			100	56	72	75
740	1				100	66	52
751	5					100	76
760	3						100

Ground Layer Stratum

Flood Susceptibility Continuum Index		672	715	722	740	751	760
	Plot Number	2	4	6	1	5	3
672	2	100	64	76	49	72	73
715	4		100	59	58	58	64
722	6			100	53	67	62
740	1				100	53	47
751	5					100	78
760	3						100

[a] Percent similarity.

Table 8.21. Distribution of shrub-stratum species along the flood susceptibility continuum in the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

Plot Number	2	4	6	1	5	3
Plot Elevation (m)	333.06	332.72	332.66	333.70	332.99	333.27
Flood Susceptibility Continuum Index (Calculated from Tree and Sapling Data)	672	715	722	740	751	760
Species	Importance Value					
Ulmus americana	31.6					
Morus rubra	13.2					
Rhus radicans			15.7			
Euonymus atropurpureus			11.7			
Cornus racemosa			13.0			
Ribes missouriense		33.1		51.3		
Ulmus rubra		26.9		44.4		
Cercis canadensis	19.5		20.1			24.8
Symphoricarpos orbiculatus	120.1	141.4	145.4	162.2	177.4	120.6
Fraxinus pennsylvanicus	34.9	15.1	27.3	14.2	37.5	50.5
Caraya cordiformis				8.5		
Celtis occidentalis	80.8	70.6	66.8	7.6	44.1	58.1
Vitis sp.		12.9		7.6	26.1	19.0
Smilax hispida				7.0	14.9	8.1
Quercus macrocarpa						18.8

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Table 8.22. Distribution of ground-stratum species along the flood susceptibility continuum in the north floodplain woods, Community 1, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

Plot Number		2	4	6	1	5	3
Plot Elevation (m)		333.06	332.72	332.66	333.70	332.99	333.27
Flood Susceptibility Continuum Index (Calculated from Tree and Sapling Data)		672	715	722	740	751	760
Species	Month of Maximum Occurrence	Frequency During Month of Maximum Occurrence					
Fraxinus pennsylvanica	June	20					
Smilax hispida	September	20					
Ruellia strepens	September	20	60				
Phlox divaricata	April	80		60			
Cinna arundinacea	September	20		20			
Celtis occidentalis	June		20				
Ellisia nyctelea	April		40				
Leersia virginica	September	20		20	20		
Verbesina alternifolia	June	40	80	60	80		
Polygonum punctatum	September			40			
Urtica dioica	April		40			20	
Rhus radicans	June			20			
Ribes missouriense	April			40			
Claytonia virginica	April			20			
Menispernum canadense	June		20		20		
Carex laxiflora	September	40	60	40	80	20	20
Cercis canadense	June		40		20	20	
Viola eriocarpa	April	40		60	80	40	
Sanicula gregaria	April	60	80	80	100	60	60
Chaerophyllum procumbens	April	100	80	80	60	100	100
Symphoricarpos orbiculatus	April	20		20	80	40	20
Elymus virginicus	June	80	60	80	20	100	80
Parthenocissus quinquefolia	June	60	40	20	100	60	60
Laportea canadensis	June	80	40	100		100	80
Galium aparine	April	80	80	80	20	100	100
Polygonum virginianum	April	20	20	20	20	40	20
Viola papilionacea	April			20	60	20	
Geum vernum	April			20	40	20	
Geum canadense	April		20		20		20

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Table 8.22. (continued)

Plot Number		2	4	6	1	5	3
Plot Elevation (m)		333.06	332.72	332.66	333.70	332.99	333.27
Flood Susceptibility Continuum Index (Calculated from Tree and Sapling Data)		672	715	722	740	751	760
Species	Month of Maximum Occurrence	Frequency During Month of Maximum Occurrence					
Chenopodium hybridum	September				20		
Quercus shumardii	June				20		
Pilea pumila	June				20	20	
Festuca obtusa	June			20			20
Ulmus americana	April				20		20
Parietaria pennsylvanica	June				20		20

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Table 8.23. Plot-to-plot degree of floristic resemblance for shrub stratum data from the north floodplain woods, Community 1, and the south floodplain woods, Community 8, in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

		North Floodplain Woods						
		Flood Susceptibility Continuum Index						
			672	715	722	740	751	760
		Plot Number	2	4	6	1	5	3
South Floodplain Woods	511	3	12[a]	5	14	7	13	20
	545	6	44	26	36	7	27	36
	587	2	40	32	38	11	27	30
	660	5	33	48	35	10	32	45
	692	1	48	51	52	44	44	49
	782	4	58	57	68	48	59	59

[a] Percent similarity.

Chapter 9

WILDLIFE MONITORING

By

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I. Introduction

Construction phase monitoring of terrestrial wildlife occurred in the vicinity of the Wolf Creek Generating Station (WCGS) on 12-13 May, 22-25 June, 21-24 September, and 8-10 November 1976 and 17-19 January 1977. Avifauna, medium and large-sized mammals, and herpetofauna were censused along a 20-mile wildlife survey route and within two communities (north floodplain woods and abandoned railroad right-of-way, Figure 9.1). Small mammals were sampled in two communities and on two mudflats at John Redmond Reservoir. The mudflats at John Redmond Reservoir were sampled in 1976 in response to a Nuclear Regulatory Commission (NRC) recommendation to study the effects of fluctuating water levels on the fauna. These data were used to predict the potential impact of fluctuating water levels on the fauna at the WCGS cooling lake. Two communities (open pasture and mixed shrub-grass pasture) and the squirrel census were deleted from the 1976 monitoring program in response to NRC recommendations.

The 1976 monitoring program was designed to determine:

1. Species composition and abundance of game and non-game wildlife;
2. Baseline data for communities not previously sampled;
3. Naturally occurring variations in species composition and abundance not related to construction or operation; and
4. Possible faunal changes that may result from construction activity and operation of WCGS.

II. Field and Analytical Procedures

A. Study Areas

Wildlife populations were censused in two communities near Wolf Creek Generating Station (WGGS), in two mudflat communities on John Redmond Reservoir, and along a 20-mile wildlife survey route during the 1976 monitoring study (Figure 9.1).

The north floodplain woods (Community 1) was initially sampled during the 1973 baseline study and during monitoring studies subsequent to November 1974. This wooded community was located along Wolf Creek and has not been recently logged.

The abandoned railroad right-of-way (Community 2) was selected in May 1974 and has been sampled during all subsequent monitoring studies. The community is typical of abandoned railroad rights-of-way, having relatively low areas scattered with debris parallel to the former track bed beyond which lies a generally flat sod of prairie grasses. The tenant of an adjacent farm pastured cattle to the perimeter of the community and during 1976 removed a fence row along one edge, thus reducing the extent of neighboring undisturbed habitat.

The wet mudflat (Community 9) was a relatively flat peninsula that is flooded several times per year. During the June sampling, many bare areas were noted and vegetation cover was only 24%; parts of the mudflat were inundated during a rainstorm. In September, no recent flooding was evident, the soil was dry, and vegetation cover had increased to 50%.

The dry mudflat (Community 10) was a slightly sloping area subject to less frequent flooding than Community 9. Development of vegetation in June was more advanced and few extensive bare areas existed. In September, vegetation cover increased to 88%, much greater than in Community 9.

B. Mammals

Mammal surveys conducted in 1976 included trapping studies at four communities, observations along the 20-mile wildlife survey route, pitfall trapping, and miscellaneous observations.

1. Small Mammal Trapping

A grid of 50 Sherman live traps (8 x 9 x 23 cm) was established in the abandoned railroad right-of-way and north floodplain woods communities (Figure 9.1) to determine species composition and abundance in June and September 1976. One trap was placed at each station, with stations spaced at 10 m intervals along lines 10 m apart (abandoned railroad right-of-way: two rows 12 traps each, two rows 13 traps each; north floodplain woods: five rows, 10 traps each). Traps were set and baited with a mixture of peanut butter and rolled oats for four consecutive nights and checked daily; captured animals were toe-clipped for identification and their sex, weight, and reproductive condition were noted. The modified Peterson index (Seber 1973) was used to calculate population estimates, and density estimates were determined by dividing the population estimates by the trapping grid's area of influence. This area equals the area of the trapping grid plus the area inside a line around the perimeter of the grid "n" meters from the grid boundary (where "n" equals the radius of a species mean home range).

Small mammal populations were sampled in Communities 9 and 10 using a line of 100 Museum Special snap traps with stations 10 m apart and 3 traps per station. Traps were set and baited for three consecutive nights at each community in June and September; captured animals were identified and their sex, weight, and reproductive condition were noted. Capture data were converted to number per 100 trap nights (TN) to facilitate comparison and analysis.

2. Eastern Cottontail Census

Eastern cottontails (*Sylvilagus floridanus*) were censused in June and September by standard roadside counts along the 20-mile wildlife survey route. Each cottontail observed was recorded and abundance indices calculated.

3. Supplemental Data

In addition to the described surveys, records were kept of all mammals and/or their signs noted during each field trip. These observations provided information on the species composition and relative abundance of larger mammals near the site.

4. Nomenclature

Identification and/or nomenclature followed Cockrum (1952), Murie (1954), and Jones et al. (1975).

C. Avifauna

Avifauna censuses were conducted seasonally to derive species lists and estimates of relative densities of game and nongame species that occur near WCGS. Seasons, for the purpose of this study, were defined as follows: spring-March, April, and May; summer-June, July, and August; fall-September, October, and November; and winter-December, January, and February.

1. Transect Counts

Relative population estimates of birds in the abandoned railroad right-of-way and north floodplain woods (Figure 9.1) were derived from transect counts (Kendeigh 1944); three counts were conducted in each community during each survey period. Both sight observations and songs were used for species identification. The species, numbers observed, and duration of each count were recorded. Raw data were converted to number of birds per hour to provide a basis for direct comparisons. Relative frequencies were calculated for each species.

The bird species diversity index (BSD), a derivation of the information theory (Shannon and Weaver 1949) and a measure of biotic diversity (MacArthur 1965), was calculated for avian species recorded within each community. The equation:

$$BSD = 1/N \left(N \log_e N - \sum_{i=1}^{s} n_i \log_e n_i\right)$$

(Lloyd et al. 1968), where N = total population, n_i = number of species observations, and s = total number of species in the aggregation, was used to calculate diversity.

2. 20-mile Wildlife Survey Route

A 20-mile wildlife survey route, established along roads near the site area (Figure 9.1), was driven twice during each survey period. All species of wildlife were recorded with observations listed by mile segment along the route.

Bobwhite (*Colinus virginianus*) were censused on two successive days in May and June at one-mile intervals along the 20-mile wildlife survey route. During each survey, the number of Bobwhite heard calling was counted for 2-minute periods at each stop during the early morning hours (Preno and Labisky 1971).

3. Supplemental Data

In addition to the described surveys, records were kept of birds observed during each field trip; a separate species list was kept for birds observed near John Redmond Reservoir. Additional observational data that were provided by personnel from Flint Hills National Wildlife Refuge and the U.S. Fish and Wildlife Service in past years have not been compiled for 1976.

4. Nomenclature

Nomenclature followed the American Ornithologists' Union (1957, 1973). Avian identification was aided by reference to Peterson (1947) and Robbins et al. (1966).

D. Reptiles and Amphibians

Reptiles and amphibians were qualitatively surveyed in May, June, and September by pitfall trapping, community inventories, a night driving survey, and searches in special habitats.

1. Community Studies

Pitfall traps consisting of two, one-gallon containers and a 3 m drift fence of hardware cloth were established in each community. Pitfall traps were checked for three nights and all captures recorded. Reptiles and amphibians were also surveyed through intensive community searches. An ecologist walked through each community turning over debris and examining appropriate habitat, and recorded all reptiles and amphibians observed.

2. 20-mile Wildlife Survey Route

The 20-mile wildlife survey route was driven after sunset to search for herptiles during May, June, and September. All herptiles observed or heard were recorded.

3. Supplemental Data

Additional herptile observations were obtained by searching aquatic habitats near the site. All species observed near John Redmond Reservoir were also recorded.

4. Nomenclature

Nomenclature and identifications followed Conant (1975).

E. Rare and Endangered Species

All species lists were checked against the official list of threatened and endangered species (U.S. Dep. Interior 1976).

III. Results and Discussion

A. Mammals

1. Small Mammals

a. Wolf Creek

Five species of small mammals were captured in 1976 from two grids during a 800 trapnight (TN) effort; two species were captured in the north floodplain woods and five species in the abandoned railroad right-of-way. Trap success was higher in the north floodplain woods than in the abandoned railroad right-of-way in 1976.

1) Community and Seasonal Analyses

North Floodplain Woods: The number of small mammal captures was greater in this community than in the abandoned railroad right-of-way (Table 9.1). The white-footed mouse and short-tailed shrew represented 76 and 24%, respectively, of the individuals captured in the community and were the only species present in 1976. Short-tailed shrew density increased between June (1.5/ha) and September (14.6/ha), whereas the white-footed mouse density decreased during this same period (34.0/ha to 26.0/ha).

Abandoned Railroad Right-of-way: The number of small mammal captures was lowest and species richness was highest in this community (Table 9.1). The hispid cotton rat was the prominent species, representing 64.8% of the captures; subordinate species included the short-tailed shrew (9.3%), deer mouse (13.0%), white-footed mouse (1.9%), and prairie vole (11.1%). Densities of all species, except the prairie vole, increased between June and September (Table 9.1).

2) Comparisons With Previous Studies

Data on white-footed mice from the north floodplain woods and hispid cotton rats from the abandoned railroad right-of-way were sufficient to compare from 1975 to 1976 and 1974 to 1976, respectively. Seasonal white-footed mouse densities were higher in June than in September, however; this difference was not as pronounced in 1976 as in 1975 (Table 9.2). The densities of white-footed mice in June (34.0/ha) and September (26.0/ha) 1976 were higher than comparable densities in June and September 1975, 23.0 and 7.0/ha, respectively (Table 9.2). Hispid cotton rat population data from June 1974 to September 1976 demonstrated a cyclic pattern. Populations were moderately dense in June 1974 but declined in September 1974 and continued to decline through June 1975 when no animals were captured. The hispid cotton rat population began to recover in September 1975 and continued to increase through 1976 (Table 9.2).

Numerous authors (Davis 1958; McCulloch 1959; Goertz 1964) have noted that the hispid cotton rat demonstrates extreme fluctuations in numbers. The causes of these fluctuations are not clear but reduction of food and cover in a given habitat is often cited as a cause for these declines. Goertz

(1964) trapped a field which was partially mowed during his study, a situation similar to that which occurred along the abandoned railroad right-of-way in late summer 1974, and concluded that mowing probably was the factor limiting the population. Goertz and others have noted that during periods of stress, e.g. food shortage, lack of cover, and drought, cotton rats retreat from marginal habitats to superior habitats. The cotton rat population crash noted in September 1974 and June 1975 was probably caused by stress conditions, possibly mowing and drought, whereas the population recovery in 1976 was probably in response to improved conditions.

b. John Redmond Reservoir

Traplines were established on annually inundated (wet) and occasionally inundated (dry) mudflats to document the effects of flooding on small mammal populations (Figure 9.1). Many plant species occurring on the wet mudflat (Community 9) had the prostrate habit typical of mudflat vegetation. Ground cover varied on the wet mudflat where dense, nearly homogeneous areas of smartweed (*Polygonum* spp.) alternated with areas of bare ground. Small groups of willows (*Salix* spp.) were scattered across the mudflat, and in drier areas stands of coarse grasses were evident.

The dry mudflat (Community 10) was codominated by perennials and annuals. The most important species were annual sunflower (*Helianthus annuus*), cocklebur (*Xanthium strumarium*), horse nettle (*Solanum carolinensis*), and foxtail grass (*Setaria geniculata*). Ground cover as a whole was more continuous than that on the wet mudflat, with no obvious areas of bare ground.

Six species of small mammals (116 individuals) were captured in traps from the two mudflats at John Redmond Reservior in 1976. The deer mouse and house mouse were the prominent species and accounted for 70.7 and 17.2%, respectively, of all captures (Table 9.3). Less abundant species included the western harvest mouse (*Reithrodontomys megalotis*, 1.0%), white-footed mouse (5.1%), hispid cotton rat (3.0%), and prairie vole (2.0%). In addition to those species captured in traps, three least shrews (*Cryptotis parva*) were captured in pitfall traps set for herptiles. The least shrew, deer mouse, white-footed mouse, prairie vole, and house mouse were common to both mudflats. The western harvest mouse was unique to the wet mudflat and the hispid cotton rat was unique to the dry mudflat; 47 animals were collected on the wet mudflat compared to 69 on the dry mudflat.

In June soil in the wet mudflat was saturated, standing water was noted in low areas, and the ground cover was only 24%. Corps of Engineers records indicate that the wet mudflat was inundated between 28 April and 14 July except for four consecutive days in May and 12 consecutive days in June just prior to the June sampling. The major portion of the dry mudflat was not inundated in 1976; therefore, ground cover was more developed than on the wet mudflat. The number of mice captured and the species richness in June were lower on the wet mudflat (1 species, 0.7/100TN) than on the dry mudflat (3 species, 15.7/100TN).

Drier conditions were noted in September and the ground cover increased on the wet and dry mudflats to 50 and 88%, respectively. In September

species richness increased on both mudflats and was higher on the wet mudflat (6 species) than on the dry mudflat (5 species). The relative abundance of mice increased on the wet mudflat to 15.0/100TN but decreased on the dry mudflat to 7.3/100TN (Table 9.3).

2. Eastern Cottontail Census

The number of eastern cottontails recorded along the 20-mile route in June 1976 was 0.40/mile, the highest number recorded since the baseline study in 1973. Numbers recorded during similar periods of 1973, 1974, and 1975 were 0.35, 0.20, and 0.05/mile, respectively. Counts of eastern cottontails by rural mail carriers in Coffey County for July 1973-75 were much lower (0.04, 0.04, and 0.03/mile, respectively) but indicated a stable year-to-year population (J. Norman, Kansas Forestry, Fish and Game Commission, Pratt, Kansas, personal communication).

3. Incidental Observations

a. Floodplain Woods

Six additional mammalian species were observed in the floodplain woods in 1976-77. The least shrew and eastern mole (*Scalopus aquaticus*) were noted in September and May, respectively, and the fox squirrel (*Sciurus niger*) was observed during all sampling months except June (Table 9.4). Larger species such as the coyote (*Canis latrans*), raccoon (*Procyon lotor*), and white-tailed deer (*Odocoileus virginianus*) were recorded infrequently. A greater number of species and individuals was noted in 1976-77 than in previous studies.

b. Abandoned Railroad Right-of-way

The eastern cottontail was a common species in the abandoned railroad right-of-way (Table 9.4). Coyote sign was noted in May 1976 and January 1977.

c. 20-Mile Wildlife Survey Route and Other Areas

Fox squirrels were common along the route in each study period and a coyote was observed in May (Table 9.4). A white-tailed deer was recorded 0.8 km south of Location 2 in May.

4. Rare and Endangered Species

No rare or endangered species of mammals were observed during this study.

B. Avifauna

Johnston (1965) summarized much of the information relating to the distribution of birds in Kansas and reported that 383 species (184 breeding species) have been recorded in the state. A list of 183 avian species has been compiled for the Flint Hills National Wildlife Refuge located several miles west of the

WCGS site, whereas 119 species have been observed during the three annual monitoring studies. Wetland habitat on the refuge attracts approximately 63 aquatic or semi-aquatic avian species. Appropriate wetland habitat for these species is absent on the WCGS site and this accounts for the lower number of species noted. Such habitat will be available when the cooling lake is filled and many of these species will utilize the new habitat. Seventy avian species were noted at John Redmond Reservoir during the 1976 monitoring program (Table 9.5).

A total of 99 avian species was observed during community surveys and along the 20-mile wildlife survey route in 1976-77. This included 16 migrant, 41 summer, 32 permanent, and 10 winter resident species (Table 9.6). Most species were recorded along the 20-mile wildlife survey route; however, several were only recorded in the north floodplain woods (Community 1). One species, the Barred Owl (Strix varia), was not recorded during any scheduled surveys but was observed in the south floodplain woods (Community 8) in January 1977.

1. Commmunity Surveys

Community surveys were conducted in the north floodplain woods (Community 1) and along the abandoned railroad right-of-way (Community 2). As expected, more species were recorded in the woodland community.

a. Transects

North Floodplain Woods (Community 1): Forty-three species of birds were recorded in the north floodplain woods during the 1976-77 monitoring study. The Red-bellied Woodpecker (Centurus carolinus), Downy Woodpecker (Dendrocopos pubescens), Black-capped Chickadee (Parus atricapillus), and Cardinal (Cardinalis cardinalis) were common permanent resident species (Table 9.7). The House Wren (Troglodytes aedon), Cardinal, and Eastern Wood Pewee (Contopus virens) were the three most abundant breeding species. Species characteristic of eastern deciduous woodlands such as the Wood Thrush (Hylocichla mustelina) and Great Crested Flycatcher (Myiarchus crinitus) were observed in this community. The number of observations was greatest in November (441.4/hr), when many American Robins were observed, and lowest in May (58.0/hr). The June population estimate was calculated to be 110.8/hr (Table 9.7).

Abandoned Railroad Right-of-Way (Community 2): Thirty avian species were recorded in this community (Table 9.8). The Eastern Meadowlark (Sturnella magna), Mourning Dove (Zenaida macroura), and Bobwhite were common resident species. The Eastern Meadowlark, Red-winged Blackbird (Agelaius phoeniceus), Common Grackle (Quiscalus quiscula), and Dickcissel (Spiza americana) were the most abundant breeding species noted in June (Table 9.8). The greatest number of individuals was recorded in November (139.0/hr) when a large number of meadowlarks was observed; a relatively high breeding population (122.0/hr) was recorded in June. The smallest number of birds was recorded in January 1977 (7.5/hr), when the area was snow covered and neither food nor cover were available to the birds. This number of birds was much lower than in January 1975 (274/hr) or 1976 (157/hr; Table 9.9). It is likely that the abnormally cold winter caused the low avian populations. Mike Long, Manager of the Flint Hills National Wildlife Refuge, indicated that the

1976-77 winter conditions at the refuge and vicinity were severe and that winter bird populations seemed to be lower than previous years.

b. Bird Species Diversity

Bird species diversity (BSD) reflects the total number of species in an area and the relative distribution of species within an aggregation. BSD is generally highest during the migratory periods when many species pass through an area, and lower during the summer and winter. Values are also higher in more complex vegetative associations.

Bird species diversity was calculated for each community and sampling period. BSD values ranged from 0.45 at the abandoned railroad right-of-way in January to 2.91 at the north floodplain woods in May (Table 9.9). BSD values from the north floodplain woods generally followed the expected seasonal pattern of high values in the spring and lower values in winter and summer. However, the low values reported in November were caused by the large number of American Robins recorded; a predominance of one species in a community lowers species diversity.

BSD values calculated for the abandoned railroad right-of-way showed a different pattern. The highest value occurred during June with progressively lower indices from September through January (Table 9.9). Lower fall values may have been caused by the unseasonally cold weather during those months; the 0.45 BSD calculated for January reflected the very low species richness and abundance at that time (Table 9.9).

More complex physiognomic communities have greater BSD values (Karr 1968), whereas grasslands are known for low BSD values (Shugart and James 1973). Structural and vegetational diversity in the wooded floodplain community were greater than in the grassland dominated abandoned right-of-way, and calculated BSD values followed this vegetation-complexity gradient.

c. Comparison with Previous Studies

Data collected prior to November 1974 in a floodplain woods community represented a different location and direct comparisons were not applicable; however, data subsequent to November 1974 for the north floodplain woods community and all data from the abandoned railroad right-of-way represent similar sampling locations and procedures, and were comparable.

Examination of these data shows that the number of species and individuals has generally increased in 1976 compared to 1974 and 1975 at both communities. Lower avian populations in 1975 were believed to be caused by drought conditions (Suchecki and Schamberger 1976), and it appears that populations have recovered during the past year.

2. 20-Mile Wildlife Survey Route

a. Seasonal Analysis

Eighty-three species were observed along the 20-mile wildlife

survey route during the 1976 monitoring study (Table 9.6). The number of species observed remained fairly constant throughout the study except for January 1977 (Table 9.10). Portions of the route were inaccessible during this month due to snow, and seven miles were not censused; therefore, the January data in Table 9.10 represent only a partial census. The number of individuals was also lowest in January and highest in November; approximately equal numbers of birds were observed in May and June (Table 9.10).

Avian species recorded along the route reflected the diversity of habitats and seasonal differences in avifauna composition. During the spring and fall, many migrant species were observed as were aquatic species such as the Double-crested Cormorant (Phalacrocorax auritus), Great Blue Heron (Ardea herodius), Canada Goose (Branta canadensis) and Mallard (Anas platyrhyncos). Large numbers of raptors were observed during the fall migratory period, including the Red-tailed Hawk (Buteo jamaicensis), Broad-winged Hawk (Buteo platypterus), Rough-legged Hawk (Buteo lagopus), and Marsh Hawk (Circus cyaneus). Birds observed during June were primarily summer and permanent resident species that probably bred in the area; the Eastern Meadowlark, Dickcissel, House Sparrow (Passer domesticus), Mourning Dove, and blackbirds were the most common species. Species observed during January were primarily Fringillids (sparrows); a Bald Eagle (Haliaeetus leucocephalus) was also observed during this season.

b. Comparison with Previous Studies

Eighty-three species were recorded along the 20-mile wildlife survey route in 1976, compared to 81 species in 1975 and 64 species each in 1974 and 1973. Compared to previous years, the number of species noted in 1976 was higher in each month except January (Table 9.10). The total number of observations in 1976 was generally intermediate in magnitude compared to previous years except for November and January when the numbers of observations were lower; these lower numbers may be attributed to the severe winter weather and the partial census in January.

3. Game Species

a. Bobwhite

Bobwhite were commonly observed along the abandoned railroad right-of-way and 20-mile wildlife survey route; many of these areas were representative of the mixture of wooded, edge, and open field habitats favored by Bobwhite (Edminster 1954).

Bobwhite call counts conducted in June 1976 along the 20-mile survey route resulted in an average of 28/20 mi (Table 9.11). The 1976 Bobwhite population index (28/20 mi) near WCGS was lower than similar indices from the 1973 baseline and 1974 monitoring studies (57 and 39/20 mi, respectively) but higher than the 18/20 mi recorded during the 1975 study.

Bobwhite population trends derived from rural mail carrier counts and call count studies conducted by the Kansas Forestry, Fish, and Game Commission for the years 1966-71 in southeast Kansas correlated very well

(J. Norman, Kansas Forestry, Fish, and Game Commission, Pratt, Kansas, personal communication). The 1966-71 call count study was discontinued in 1972, thus call count data collected near the WCGS cannot be compared with that study, but yearly trends in the call count data near the WCGS and rural mail carrier count data for Coffey County for the years 1973-76 can be compared.

Bobwhite call counts (78-136 cocks/20 mi; Kansas Forestry, Fish, and Game Commission 1974) and rural mail carrier counts for the years 1966-71 were among the highest indices ever recorded for southeast Kansas and Coffey County (J. Norman, Kansas Forestry, Fish, and Game Commission, Pratt, Kansas, personal communication). Results of the July 1972-76 rural mail carrier counts for Coffey County indicated a slow-gradual decline in the Bobwhite population between 1972 and 1975 and an increase in 1976. The 1973-76 Bobwhite population trend derived from call counts near WCGS was nearly identical to that noted in the rural mail carrier counts for Coffey County.

The call count and rural mail carrier count surveys were not designed to determine causes for increases or decreases in game populations and to apply a cause and effect relationship would be subjective at best. J. Norman (Kansas Forestry, Fish, and Game Commission, Pratt, Kansas, personal communication) indicated that Bobwhite populations will fluctuate between years but they generally fluctuate in an increasing or decreasing trend as opposed to erratic increases and decreases. These changes generally are in response to a matrix of unpredictable factors; e.g. rainfall, cover, carrying capacity, severe weather, and are considered natural variations. No marked changes in habitat have occurred near the WCGS between 1972 and 1976, therefore, the trend noted in the Bobwhite call counts can be attributed to natural variation.

b. Mourning Dove

The mean number of Mourning Doves observed in June along the 20-mile wildlife survey route was 80.0/20 mile in 1976, compared with 37.5 during 1975 and 29.5 during 1974. The abundance of Mourning Doves has increased each year in the study area.

4. Rare and Endangered Species

One Bald Eagle was observed along the 20-mile wildlife survey route in January, and 30 were estimated to be wintering near John Redmond Reservoir in 1976 (J. Plummer, Flint Hills National Wildlife Refuge, personal communication). Johnston (1965) believed that the northern subspecies (*Haliaeetus leucocephalus alascanus*) winters in Kansas; only the southern subspecies (*H.l. leucocephalus*) is currently endangered (U.S. Dep. Interior 1976). However, proposed rule changes by the Fish and Wildlife Service would classify all subspecies of the Bald Eagle in the lower 48 states as endangered.

Construction and filling of the WCGS cooling lake will create additional habitat for wintering eagles and eagle use of the site should increase. Care should be taken to insure that wintering eagles in the area are not jeopardized by plant construction and operation. No other endangered avian species were observed.

C. Reptiles and Amphibians

Increased emphasis was placed on locating and identifying reptiles and amphibians during the 1976 monitoring study. Fourteen species were identified including 3 turtle, 1 lizard, 3 snake, 2 toad, and 5 frog species (Table 9.12). Other herptile species probably inhabit the site but were not observed due to their secretive nature and the variable conditions encountered during survey periods.

1. Species Accounts

Ornate box turtle (*Terrapene ornata*): The ornate box turtle was commonly observed near the site and appeared to be fairly abundant. Collins (1974) reports this species to be common throughout Kansas. Preferred habitat includes grassy vegetation, pastures, fields, and open woodland. This diurnal, terrestrial species feeds primarily on insects; breeding may take place throughout the summer.

Map turtle (*Graptemys geographica*): This species was observed on one occasion near John Redmond Reservoir and its distribution in Kansas is limited to the southeast portion of the state (Collins 1974). The map turtle is semi-aquatic, preferring large, slow-moving rivers and quiet lakes. Aquatic crustaceans, clams, and snails are important components of its diet.

Western painted turtle (*Chrysemys picta belli*): The semi-aquatic painted turtle occurs abundantly throughout Kansas (Collins 1974) and was noted twice near the Wolf Creek Generating Station. This species resides in slow-moving, shallow streams and rivers and is frequently encountered crossing dry land; both plant and animal matter are consumed.

Eastern glass lizard (*Ophisaurus ventralis*): The glass lizard occurs in the eastern two-thirds of the state but is most abundant in the Osage Cuestas region of southeastern Kansas (Collins 1974). Although probably common near the site, only one individual was noted in 1976. Clarke (1958) also recorded only one specimen during his study of the herpetofauna of Osage County. The species prefers open grassland, prairie, and wooded edge habitats; insects compose the majority of the diet and breeding usually takes place in May (Collins 1974).

Yellow-bellied racer (*Coluber constrictor*): This diurnal predator is common throughout Kansas and was only observed once in 1976 at John Redmond Reservoir. Preferred habitats include open grasslands, prairies, and pastures (Collins 1974). Mammals are the main food source. Clarke (1958) frequently observed this species in Osage County.

Black rat snake (*Elaphe obsoleta*): The black rat snake is common throughout the eastern third of Kansas but has not been recorded west of the lowplains of the Great Bend Prairie (Collins 1974); the species was observed several times during 1976 near the Wolf Creek Generating Station. The black rat snake prefers forested habitats and feeds on a variety of vertebrates.

Western massasauga (Sistrurus catenatus): This small rattlesnake is limited to the eastern two-thirds of Kansas and inhabits a variety of habitats; one individual was noted in the abandoned railroad right-of-way during the 1976 monitoring study. Clarke (1958) did not record this species during his study in Osage County but did list the timber rattlesnake (Crotalus horridus) as fairly common. Food items include frogs, lizards, and small mammals (Collins 1974).

American toad (Bufo americanus): This species is restricted to the eastern third of Kansas and has not been recorded west of the Flint Hills. The American toad was recorded in wooded habitat near the site. The optimal habitat for this species is rocky, open forests with some standing water nearby. Food consists primarily of insects and the species migrates to ponds and streams to breed in early spring.

Woodhouse's toad (Bufo woodhousei): This species occurs throughout Kansas but is least common in the Osage Cuestas region in the southeast section of the state (Collins 1974). Observations of this species near the site were limited to John Redmond Reservoir and to a pond along the 20-mile wildlife survey route. Woodhouse's toad prefers sandy lowlands near larger bodies of water and generally is the only toad on floodplains of larger lakes and rivers. Insects are the main food source; breeding takes place in the spring.

Western chorus frog (Pseudacris triseriata): The western chorus frog is found in the eastern third of Kansas and inhabits damp meadows, pastures, and areas along streams and ditches. This species was fairly abundant in June 1976 and was frequently heard throughout the area. Insects are the primary food items.

Gray tree frog (Hyla chrysoscelis): This species is restricted to the eastern third of Kansas, primarily the Osage Cuestas region, and does not occur west of the Flint Hills. One specimen was noted near the Wolf Creek Generating Station in June 1976. The tree frog inhabits forested areas where it forages for insects in trees and shrubs. The species migrates to woodland pools to breed during April and May.

Leopard frog (Rana pipiens): This species occurs throughout Kansas and was commonly observed during the 1976 monitoring study. Leopard frogs inhabit a wide variety of aquatic situations ranging from temporary ponds to large lakes and streams (Collins 1974). Individuals may sometimes be observed far from water. They are insectivores.

Crawfish frog (Rana areolata): The crawfish frog is restricted to the Osage Cuestas region and plains of southeast Kansas where it inhabits moist lowland meadows, pastures, and floodplains. One individual was noted at John Redmond Reservoir in September 1976. This secretive frog feeds on insects and possibly crustaceans.

The crawfish frog is considered threatened in Kansas (Platt et al. 1973). The species is disappearing rapidly in Kansas and is particularly susceptible to fluctuations of the water table caused by construction of dams, dikes, and levees (Collins 1974). Platt et al. (1973) suggested that areas supporting breeding colonies be designated as sanctuaries.

Bullfrog (Rana catesbeiana): The bullfrog is found throughout Kansas where it inhabits permanent lakes, rivers, streams, and swamps (Collins 1974). Numerous individuals were observed near the Wolf Creek site during 1976. This species is an opportunistic feeder consuming insects, crustaceans, and small vertebrates; breeding usually occurs in late April or May.

2. Community Distribution

Community searches for herptiles were conducted at the north floodplain woods, abandoned railroad right-of-way, and along John Redmond Reservoir during 1976. A total of 13 species was observed with the greatest number recorded at John Redmond Reservoir and the smallest at the north floodplain woods (Table 9.13).

a. North Floodplain Woods

Only two species, the leopard frog and American toad, were recorded in this community (Table 9.13). Although extensive searches were conducted, no salamanders or lizards were recorded. Clarke (1958) studied an oak-walnut forest in Osage County and considered the five-lined skink (Eumeces fasciatus), prairie ringneck snake (Diadophis punctatus), western worm snake (Carphophis amoenus), and black rat snake characteristic of that community. Although not observed during this study, it is likely that several of these species inhabit woodlands near Wolf Creek.

b. Abandoned Railroad Right-of-Way

Three species of herptiles were observed in this community: the ornate box turtle, eastern glass lizard, and western massasauga (Table 9.13). The box turtle was the most frequently observed species and appeared to be abundant in this community; the remaining species were observed on only one occasion. Clarke (1958) noted that several species of lizards and snakes were characteristic of prairie communities in Osage County, including the six-lined racerunner (Cnemidophorus sexlineatus), northern prairie skink (Eumeces septentrionalis), bullsnake (Pituophis melanoleucus sayi), and prairie kingsnake (Lampropeltis c. calligaster). Weather conditions during census periods were not conducive to lizard activity, which may explain why these species were not observed even though the abandoned railroad right-of-way appeared to be good habitat for these species.

c. John Redmond Reservoir

The majority of species observed during 1976 were recorded near John Redmond Reservoir (Table 9.13); the large amount of aquatic habitat accounted for the large number of species. Eight species were observed, including 2 turtle, 1 snake, 1 toad, and 4 frog species. Additional species probably occur near the reservoir; Clarke (1958) listed the mudpuppy (Necturus maculosus), snapping turtle (Chelydra serpentina), map turtle, western painted turtle, red-eared turtle (Chrysemys scripta), and western spiny softshell (Trionyx spiniferus) as characteristic of aquatic habitats. Construction of the cooling lake will provide additional habitat for these aquatic species.

The gray tree frog was the only species observed that was not recorded during community studies; one individual was noted along the 20-mile wildlife survey route (Table 9.13). Herpetofauna observed were generally recorded in their preferred habitats. The ornate box turtle, leopard frog, and western chorus frog were widely distributed and appeared to be the more abundant species in the area.

3. Rare and Endangered Species

No herptile species listed as rare or endangered by the U.S. Department of Interior were observed near the WCGS site; however, the crawfish frog, considered rare in Kansas, was recorded near John Redmond Reservoir. The species has declined greatly in Kansas (Collins 1974; Platt et al. 1973) and appears susceptible to flooding and alterations in the water table. Breeding occurs in March and April and is correlated with heavy spring rains; breeding congregations normally occur in temporary pools of water. Should this species occupy seasonally flooded areas along Wolf Creek as well as John Redmond Reservoir, construction of the cooling lake could have a negative effect on this species.

D. Relationships Between Wildlife and the Environment

1. Mammals

a. Wolf Creek

Mammalian distribution near the WCGS was governed by vegetative cover and food availability, which in turn were governed by precipitation and land-use practices. Species that are generalists, such as the coyote and eastern cottontail, have widespread distribution, whereas others, such as the white-tailed deer, gray squirrel, and hispid cotton rat, are more restricted in their distribution in Kansas.

Small mammal captures in grassland habitats declined between 1974 and 1975 but increased in 1976. This fluctuation was probably in response to land use changes, the drought conditions in the summer of 1974, and the return of more favorable conditions in 1976. Small mammal captures in woodland habitats increased in 1975 from 1974 but decreased from June to September 1976. This was probably a natural variation in the population.

Mammal populations near WCGS have therefore been influenced by land use changes, drought, and natural variation; construction activities may become an additional factor influencing local populations.

b. John Redmond Reservoir

As mentioned above, mammal distribution is generally governed by an interaction of available water, vegetative cover, food availability, and land-use practices. The irregular flooding of John Redmond Reservoir is the most prominent factor governing the distribution and abundance of small mammals on the reservoir's mudflats. Floodwaters are retained and drawn down gradually to a conservation pool level (311 m) to protect the farmland and towns downstream. During floodwater retainment, exposed mudflats may be inundated in a

matter of hours and remain flooded for a few days to a month or more before being exposed again.

Yeager (1949) and Anderson and Shapiro (1957) have studied the effects of permanent flooding on small mammals and concluded that a large percentage of small mammals perish as a result of permanent flooding. Stickel (1948) found that temporary flooding of the Patuxent River did not adversely affect the small mammal population. Fisler (1961) and Shure (1971) addressed the effects of tidal flooding on small mammals and noted that species associated with tidal areas are adapted to periodic short-term flooding and there is no marked increase in small mammal mortality with tidal flooding. These types of flooding are not representative of that which occurs on flood control reservoirs, and to date few people have studied the effects of floodwater retainment and subsequent drawdown on small mammals.

When a new habitat (mudflat) becomes available, the invading species disperse rapidly to occupy all available areas. This rapid expansion occurs because there is an abundance of food, space, and cover, and an absence of competition. As the community develops, the vegetation stabalizes and additional small mammal species will invade as their habitat requirements are met. Thus the flora and fauna of a frequently inundated mudflat will be composed of invading species, whereas an infrequently inundated mudflat will consist of perennials, a well developed ground layer, and cover-dependent mammals. These relationships were noted in the data from the wet and dry mudflats. The number and species of small mammals captured on the dry mudflat were representative of a more successionally-advanced community than those captured on the wet mudflat. The number of small mammals decreased on the dry mudflat from June to September by nearly half, whereas a 22-fold increase occurred during the same time period on the wet mudflat. The population increase noted on the wet mudflat was typical of a faunal group exploiting a new habitat. The dry mudflat was exposed longer and, thus, was more vegetationally advanced. The decrease noted on the dry mudflat from June to September probably occurred because the population was changing from an invading-expanding population to a more permanent-stablized population where intra-and interspecific competition for food and cover was population limiting. Pioneer species such as the deer mouse and house mouse were present on both mudflats, but the cover-dependent hispid cotton rat, typical of more successionally advanced habitats, was captured only on the dry mudflat.

Floral and faunal succession on mudflats are often interrupted by flood conditions lasting for several days. Anderson and Shapiro (1957) noted that only 2 of the 147 white-footed mice marked before flooding on a Connecticut marsh were recaptured on islands after flooding. He concluded that a large percentage of the mice perished as a result of flooding. Deer mice have been observed in shrubs on the reservoirs's mudflats after flooding but their survival was doubtful because of increased exposure to predators and lack of food. Blair 1939) cited exposure and the inability of small mammals to swim long distances for their low survival during flooding. The closest dry land to the wet mudflat during flooding was the dam, approximately 600 m away. As a result, nearly 100% mortality of the wet mudflat's small mammal population is expected when inundated by flood waters. After the flood waters recede, our data indicate that the process of repopulating the mudflat should begin with two weeks.

2. Avifauna

Avifauna relationships with the environment were similar to those described for mammals; cover, food, and vegetation structure usually determine avian distribution and abundance. Some avian species are generalists and occur in a wide variety of habitats, whereas others have narrow habitat requirements and only occur in specific areas. Appropriate habitat for breeding species is perhaps most critical to local avian populations.

Data on avian abundance collected in the spring and summer of 1976 near the WCGS showed increases over 1975, demonstrating a partial recovery from drought conditions of previous years. However, fall and winter data were generally lower than previous years and reflected population reductions caused by the unusually cold weather during those time-periods.

3. Herpetofauna

Herpetofauna, especially amphibians, have more specific habitat requirements than mammals and birds. Being poikilotherms (cold blooded), they are also more sensitive to weather variables, and severe conditions may drastically affect populations and breeding times. Except for wide-ranging snake species, reptiles and amphibians observed in the study area were generally restricted in distribution to specific habitats similar to those reported in the literature.

E. Anticipated Construction Impacts

1. Sampling Communities

The sampling communities are not located within anticipated construction areas; therefore, little or no impact is expected on small short-ranging faunal species existing within the two sampling areas. Larger, more mobile species are expected to alter their home ranges to avoid construction areas.

2. Site

Small faunal species residing within construction areas will probably be destroyed or displaced. Larger species will move out of the construction areas to avoid noise and vehicular traffic. Sensitive species will decline in numbers, and the more adaptable species will continue to use nearby areas. In areas where habitat quality is improved, carrying capacity will be increased and total populations will increase. Species that require a permanent water source will increase; these will include aquatic and semi-aquatic species. Amphibians and aquatic reptiles will increase, as will shorebirds, waterfowl, and marsh birds. The small mammal distribution and population fluctuations noted on anually and irregularly inundated mudflats at John Redmond Reservoir are probably typical of midwestern flood control reservoirs. Although not a flood control reservoir, water levels of the WCGS cooling lake will undoubtedly fluctuate, creating exposed and inundated mudflats. Small mammal populations on annually or irregularly inundated areas around the cooling lake will fluctuate from high populations when mudflats are exposed to extirpation under flooded conditions. This fluctuation will also have positive and negative impacts on predators. If areas

adjacent to the lake have an elevated water table, better vegetational growth will occur where the roots can reach the water table; this increased vegetational growth will provide better habitat for wildlife populations, particularly small mammals. In areas removed from the lake, land use will be the most significant factor influencing wildlife.

IV. Summary and Conclusions

1. Small mammals were trapped in two communities near Wolf Creek Generating Station and on two mudflats at John Redmond Reservoir.

2. The white-footed mouse and hispid cotton rat were the predominant species in the north floodplain woods and abandoned railroad right-of-way, respectively; species richness was highest in the abandoned railroad right-of-way.

3. Density estimates for the white-footed mouse in the north floodplain woods were 34/ha in June and 26/ha in September 1976. Densities of hispid cotton rats in the abandoned railroad right-of-way for 1976 were 16/ha in June and 23/ha in September.

4. A summer-fall decline in the white-footed mouse population was noted during 1975 and 1976, but it was less pronounced in 1976. The cause of this decline was undetermined. Seasonal density figures were higher for 1976 than comparable figures for 1975.

5. A definite cyclic pattern was noted in the hispid cotton rat population between 1974 and 1976. Cotton rat populations were moderate in June 1974, declined in September 1974, were extirpated in June 1975, extremely low in September 1975, and increased markedly in 1976. A combination of mowing and drought conditions was the apparent cause of the decline in 1974-75. The cessation of mowing and greater precipitation in late 1975 and 1976 was probably responsible for the resurgence of the hispid cotton rat population.

6. Seven small mammal species were collected from two mudflats at John Redmond Reservoir in 1976. The deer mouse and house mouse were the prominent species captured. Six species were captured on the two mudflats; five species were common to both mudflats.

7. Flooding was the most important factor regulating the abundance and distribution of small mammals on the mudflats. Small mammal mortality is probably 100% during flooded conditions and repopulation would probably begin within two continuous weeks after exposure.

8. Small mammal populations on annually and irregularly inundated mudflats at the WCGS cooling lake will fluctuate greatly, from high populations when mudflats are exposed to extripation under flooded conditions. This fluctuation will have positive as well as negative impacts on predators in the area.

9. The number of eastern cottontails recorded along the 20-mile wildlife survey route in 1976 was the highest since 1973. The eastern cottontail data

from the 20-mile wildlife route between 1973 and 1975 showed a decreasing trend, whereas a stable population was documented by the rural mail carrier counts for Coffey County over the same period.

10. Ninety-nine avian species were recorded in the 1976-77 monitoring study compared to 90 in 1975 and 83 in 1974; 70 avian species were observed at John Redmond Reservoir.

11. The greatest number of avian species was recorded in the north floodplain woods. Seasonal density estimates were generally higher in the north floodplain woods compared to the abandoned railroad right-of-way; data from both communities showed a lower number of species and individuals in the fall and winter seasons compared to previous years. Lower species richness and density were probably related to weather conditions and not construction activity.

12. Eighty-three avian species were observed along the 20-mile wildlife survey route; normal seasonal patterns of species abundance were noted.

13. An average of 28 Bobwhite per census was recorded from surveys in June 1976. This was higher than the 1975 figure but lower than in 1974 or 1973. Results of the July 1972-76 rural mail carrier counts for Coffey County indicated a slow-gradual decline in the Bobwhite population between 1972 and 1975 and an increase in 1976. The 1973-76 Bobwhite population trend derived from call counts near WCGS was nearly identical to that noted in the rural mail carrier counts for Coffey County. No marked changes in habitat have occurred near the WCGS between 1972 and 1976, therefore, the trend noted in the Bobwhite call counts can be attributed to natural variation.

14. Mourning Dove population data collected along the 20-mile wildlife survey route showed a large increase during 1976 compared to data from previous years.

15. Fourteen species of reptiles and amphibians were recorded; herpetofauna were widely distributed but were concentrated near aquatic habitats.

16. Reptile and amphibian species were generally observed in their preferred habitat. Local weather conditions in May and June sampling periods were not favorable for reptile activity.

17. Two rare or endangered species were observed. The Bald Eagle was noted along the 20-mile survey route in January. This species winters in the area and will soon be classified as endangered by the U.S. Department of Interior. Use of the study area by this species is expected to increase after the cooling lake is filled. The crawfish frog, a species considered rare in Kansas, was observed at John Redmond Reservoir. Local populations may be affected by cooling lake construction.

18. The sampling communities are not located within anticipated construction areas; therefore, little or no impact on the fauna is expected. Small, less mobile faunal species will be extirpated and large species will move from the construction areas to avoid noise and vehicular traffic and seek new cover. In

areas where habitat quality is improved, such as idle land, the carrying capacity will increase.

19. Filling of the cooling lake will increase the amount of habitat for aquatic and semi-aquatic fauna, but will remove important floodplain habitat and associated riparian fauna.

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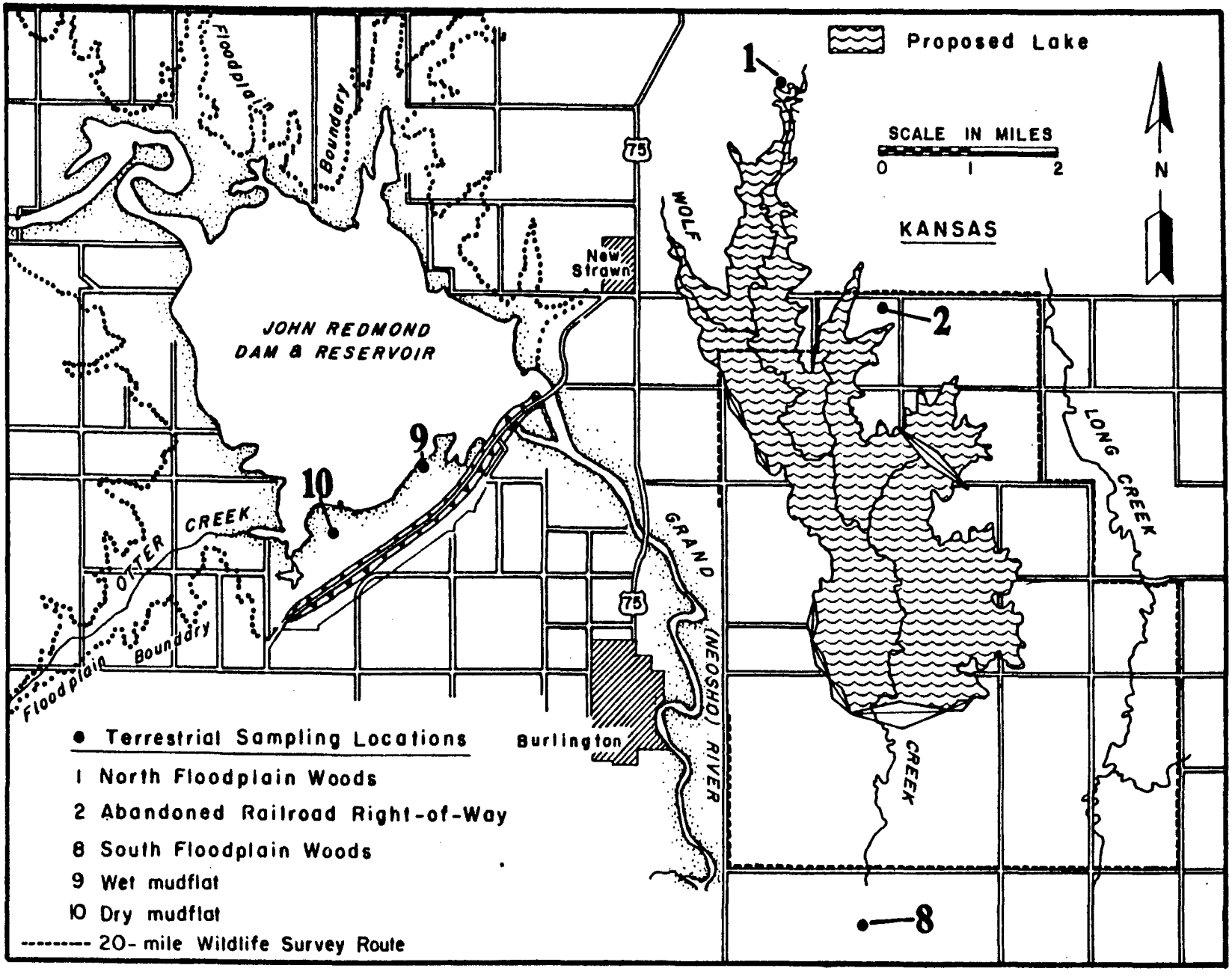

Figure 9.1. Wildlife sampling locations in the vicinity of the Wolf Creek Generating Station, Burlington, Kan[illegible] 1977.

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Table 9.1. Seasonal capture data from two communities in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

Location/Species	Sampling Period	Total Captured	Total Marked	Total Recaptured	Number of Individuals	Percent Composition	Density Estimate (No./ha)[a]
North Floodplain Woods							
Blarina brevicauda	Jun	6	1	0	6	16.7	1.5
	Sep	13	11	1	12	30.8	14.6
Peromyscus leucopus	Jun	55	30	25	30	83.3	34.0
	Sep	59	27	32	27	69.2	26.0
Abandoned Railroad Right-of Way							
Blarina brevicauda	Jun	2	1	0	2	9.1	0.5
	Sep	3	2	0	3	9.4	1.3
Peromyscus maniculatus	Jun	2	2	0	2	9.1	0.7
	Sep	7	5	2	5	15.6	2.9
Peromyscus leucopus	Jun	0	0	0	0	0.0	0.0
	Sep	2	1	1	1	3.1	0.9
Sigmodon hispidus	Jun	16	13	3	13	59.1	16.0
	Sep	36	22	14	22	68.8	23.0
Microtus ochrogaster	Jun	5	5	0	5	22.7	7.5
	Sep	1	1	0	1	3.1	0.4

[a]Home range of *Blarina brevicauda*, *Peromyscus maniculatus*, and *P. leucopus* after Fitch (1958), *Sigmodon hispidus* after Goertz (1964), and *Microtus ochrogaster* after Martin (1956).

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Table 9.2. Summary of small mammal densities (No./ha) in two communities in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1974 - 76.

Location/Species	1974		1975		1976	
	Jun	Sep	Jun	Sep	Jun	Sep
North Floodplain Woods						
Peromyscus leucopus	-[a]	-	23.0	7.0	34.0	26.0
Abandoned Railroad Right-of-Way						
Sigmodon hispidus	13.0	2.0	NC[b]	0.5	16.0	23.0

[a]Not sampled
[b]None captured

Table 9.3. The number captured, number per 100 trapnights (TN), and percent composition of small mammal species captured on two mudflats at John Redmond Reservoir, New Strawn, Kansas, 1976.

Species	Wet Mudflat (Community 9) June No.	Wet Mudflat (Community 9) June No. Per 100 TN	Wet Mudflat (Community 9) September No.	Wet Mudflat (Community 9) September No. Per 100 TN	Dry Mudflat (Community 10) June No.	Dry Mudflat (Community 10) June No. Per 100 TN	Dry Mudflat (Community 10) September No.	Dry Mudflat (Community 10) September No. Per 100 TN	Total No.	Total No. Per 100 TN	Percent Composition of Each Species
Reithrodontomys megalotis			1	0.3					1	0.1	1.0
Peromyscus maniculatus	2	0.7	25	8.3	44	14.7	13	4.3	84	7.0	70.7
Peromyscus leucopus			5	1.7	1	0.3			6	0.5	5.1
Sigmodon hispidus							3	1.0	3	0.3	3.0
Microtus ochrogaster			1	0.3			1	0.3	2	0.2	2.0
Mus musculus			13	4.3	2	0.7	5	1.7	20	1.7	17.2
Total	2	0.7	45	15.0	47	15.7	22	7.3	116	9.9	

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Table 9.4. Incidental mammal observations in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976 - 77.

Location/Species	Date	Observation	Number
1/2 Mile S. of Location 2			
White-tailed deer (*Odocoileus virginianus*)	17 May	Sight	1
North Floodplain Woods			
Least shrew (*Cryptotis parva*)	20 Sep	Sight	1
Eastern mole (*Scalopus aquaticus*)	12 May	Tunnel	Several
Fox squirrel (*Sciurus niger*)	13 May	Sight	2
	14 May	Sight	2
	21 Sep	Sight	1
	22 Sep	Sight	1
	23 Sep	Sight	1
	10 Nov	Sight	2
	17 Jan	Sight	2
Coyote (*Canis latrans*)	12 May	Track	1
Raccoon (*Procyon lotor*)	21 Sep	Sight	1
White-tailed deer (*Odocoileus virginianus*)	14 May	Sight	1
Abandoned Railroad Right-of-Way			
Eastern cottontail (*Sylvilagus floridanus*)	12 May	Sight	1
	25 Jun	Sight	2
	22 Sep	Sight	1
	23 Sep	Sight	2
	10 Nov	Sight	1
Coyote (*Canis latrans*)	12 May	Scat	1
	17 Jan	Sight	1
20-Mile Route			
Eastern cottontail (*Sylvilagus floridanus*)	13 May	Sight	1
	24 Jun	Sight	8
	22 Sep	Sight	1
	19 Jan	Sight	1
Fox squirrel (Sciurus niger)	13 May	Sight	1
	14 May	Sight	1
	24 Jun	Sight	1
	9 Nov	Sight	3
	10 Nov	Sight	5
	19 Jan	Sight	2
Coyote (*Canis latrans*)	14 May	Sight	1

Table 9.5. Bird species observed near John Redmond Reservoir, New Strawn, Kansas, 1976.

Scientific Name	Common Name
Podilymbus podiceps	Pied-billed Grebe
Pelecanus erythrorhynchos	White Pelican
Phalacrocorax auritus	Double-crested Cormorant
Ardea herodias	Great Blue Heron
Butorides virescens	Green Heron
Branta canadensis	Canada Goose
Chen caerulescens	Snow Goose
Anas platyrhynchos	Mallard
Anas strepera	Gadwall
Anas acuta	Pintail
Anas discors	Blue-winged Teal
Anas crecca	Green-winged Teal
Anas americana	American Wigeon
Anas clypeata	Northern Shoveler
Aythya americana	Redhead
Aythya valisineria	Canvasback
Bucephala clangula	Common Goldeneye
Bucephala albeola	Bufflehead
Carthartes aura	Turkey Vulture
Buteo jamaicensis	Red-tailed Hawk
Buteo swainsoni	Swainson's Hawk
Buteo lagopus	Rough-legged Hawk
Haliaeetus leucocephalus	Bald Eagle
Circus cyaneus	Marsh Hawk
Pandion haliaetus	Osprey
Falco sparverius	American Kestrel
Charadrius semipalmatus	Semipalmated Plover
Charadrius vociferus	Killdeer
Pluvialis squatarola	Black-bellied Plover
Capella gallinago	Common Snipe
Bartramia longicauda	Upland Sandpiper
Tringa melanoleucus	Greater Yellowlegs
Tringa flavipes	Lesser Yellowlegs
Calidris melanotos	Pectoral Sandpiper
Calidris alpina	Dunlin
Tryngites subruficollis	Buff-breasted Sandpiper
Calidris alba	Sanderling
Steganopus tricolor	Wilson's Phalarope
Larus delawarensis	Ring-billed Gull
Larus pipixcan	Franklin's Gull
Sterna forsteri	Forster's Tern
Sterna albifrons	Least Tern

Table 9.5. (continued)

Scientific Name	Common Name
Chlidonias niger	Black Tern
Zenaida macroura	Mourning Dove
Megaceryle alcyon	Belted Kingfisher
Melanerpes erythrocephalus	Red-headed Woodpecker
Tyrannus tyrannus	Eastern Kingbird
Muscivora forficata	Scissor-tailed Flycatcher
Eremophila alpestris	Horned Lark
Iridoprocne bicolor	Tree Swallow
Hirundo rustica	Barn Swallow
Corvus brachyrhynchos	Common Crow
Mimus polyglottos	Mockingbird
Toxostoma rufum	Brown Thrasher
Turdus migratorius	American Robin
Regulus calendula	Ruby-crowned Kinglet
Anthus spinoletta	Water Pipit
Lanius ludovicianus	Loggerhead Shrike
Sturnus vulgaris	Starling
Sturnella spp.	Meadowlark
Agelaius phoeniceus	Red-winged Blackbird
Quiscalus quiscula	Common Grackle
Cardinalis cardinalis	Cardinal
Spiza americana	Dickcissel
Spinus tristis	American Goldfinch
Ammodramus savannarum	Grasshopper Sparrow
Pooecetes gramineus	Vesper Sparrow
Junco hyemalis	Dark-eyed Junco
Spizella arborea	Tree Sparrow
Zonotrichia querula	Harris' Sparrow
Melospiza melodia	Song Sparrow

Table 9.6. Species list, residency status, and community and monthly occurrence of avifauna in the vicinity of the Wolf Creek Generating Station, May 1976 - January 1977.

Scientific Name	Common Name	Residency[a] Status	Community 1	Community 2	20-Mile Survey	Month May	Month Jun	Month Sep	Month Nov	Month Jan
Phalacrocorax auritus	Double-crested Cormorant	M			X	X			X	
Ardea herodias	Great Blue Heron	S			X	X	X	X		
Butorides virescens	Green Heron	S			X		X			
Branta canadensis	Canada Goose	W			X				X	
Chen caerulescens	Snow Goose	M			X			X		
Anas platyrhynchos	Mallard	P			X				X	
Anas discors	Blue-winged Teal	M			X	X				
Aix sponsa	Wood Duck	M			X			X		
Carthartes aura	Turkey Vulture	S	X		X	X		X		
Buteo jamaicensis	Red-tailed Hawk	P	X	X	X	X	X	X	X	X
Buteo platypterus	Broad-winged Hawk	S			X			X		
Buteo swainsoni	Swainson's Hawk	S		X	X	X	X	X	X	
Buteo lagopus	Rough-legged Hawk	W			X				X	X
Haliaeetus leucocephalus	Bald Eagle	W			X					X
Circus cyaneus	Marsh Hawk	W			X				X	X
Falco sparverius	American Kestrel	P			X		X	X	X	X
Colinus virginianus	Bobwhite	P	X	X	X	X	X	X	X	X

NALCO ENVIRONMENTAL SCIENCES

Table 9.6. (continued)

Scientific Name	Common Name	Residency[a] Status	Community 1	Community 2	20-Mile Survey	Month May	Month Jun	Month Sep	Month Nov	Month Jan
Charadrius vociferus	Killdeer	S		X	X	X	X	X	X	
Larus delawarensis	Ring-billed Gull	M			X				X	
Columba livia	Rock Dove	P			X		X	X	X	X
Zenaida macroura	Mourning Dove	P	X	X	X	X	X	X	X	X
Coccyzus americanus	Yellow-billed Cuckoo	S	X				X	X		
Coccyzus erythropthalmus	Black-billed Cuckoo	P			X		X			
Strix varia	Barred Owl	P								X
Chordeiles minor	Common Nighthawk	S			X	X	X			
Chaetura pelagica	Chimney Swift	S			X	X				
Colaptes auratus	Common Flicker	P	X	X	X	X	X	X	X	X
Centurus carolinus	Red-bellied Woodpecker	P	X		X	X	X	X	X	X
Melanerpes erythrocephalus	Red-headed Woodpecker	P	X		X	X	X	X	X	X
Dendrocopos villosus	Hairy Woodpecker	P	X			X				X
Dendrocopos pubescens	Downy Woodpecker	P	X	X	X	X	X	X	X	X
Tyrannus tyrannus	Eastern Kingbird	S		X	X	X	X	X		
Muscivora forficata	Scissor-tailed Flycatcher	S			X	X	X	X		
Myiarchus crinitus	Great Crested Flycatcher	S	X		X	X	X			
Sayornis phoebe	Eastern Phoebe	S			X	X	X			

NALCO ENVIRONMENTAL SCIENCES

Table 9.6. (continued)

Scientific Name	Common Name	Residency[a] Status	Community 1	Community 2	20-Mile Survey	Month May	Month Jun	Month Sep	Month Nov	Month Jan
Contopus virens	Eastern Wood Pewee	S	X		X		X	X		
Eremophila alpestris	Horned Lark	P		X	X	X	X	X	X	X
Stelgidopteryx ruficollis	Rough-winged Swallow	S			X		X			
Hirundo rustica	Barn Swallow	S		X	X	X	X	X		
Petrochelidon pyrrhonota	Cliff Swallow	S			X	X				
Cyanocitta cristata	Blue Jay	P	X	X	X	X	X	X	X	X
Corvus brachyrhynchos	Common Crow	P	X		X	X	X	X	X	X
Parus atricapillus	Black-capped Chickadee	P	X		X	X	X	X	X	X
Parus carolinensis	Carolina Chickadee	P		X			X			
Parus bicolor	Tufted Titmouse	P	X		X	X	X	X	X	X
Sitta carolinensis	White-breasted Nuthatch	P	X		X		X		X	X
Certhia familiaris	Brown Creeper	W	X						X	X
Troglodytes aedon	House Wren	S	X	X	X	X	X	X		
Thryothorus ludovicianus	Carolina Wren	P	X		X		X	X	X	
Mimus polyglottos	Mockingbird	P		X	X	X	X	X	X	
Dumetella carolinensis	Gray Catbird	S	X		X	X				
Toxostoma rufum	Brown Thrasher	S	X	X	X	X	X	X		

NALCO ENVIRONMENTAL SCIENCES

Table 9.6. (continued)

Scientific Name	Common Name	Residency[a] Status	Community 1	Community 2	20-Mile Survey	Month May	Month Jun	Month Sep	Month Nov	Month Jan
Turdus migratorius	American Robin	S	X	X	X	X	X	X	X	X
Hylocichla mustelina	Wood Thrush	S	X				X			
Catharus fuscescens	Veery	M	X			X				
Sialia sialis	Eastern Bluebird	P			X	X	X	X	X	
Polioptila caerulea	Blue-gray Gnatcatcher	S	X			X	X			
Regulus satrapa	Golden-crowned Kinglet	M	X		X				X	
Regulus calendula	Ruby-crowned Kinglet	M	X		X			X		
Lanius ludovicianus	Loggerhead Shrike	P		X	X	X	X	X	X	
Sturnus vulgaris	Starling	P			X	X	X	X	X	X
Vireo flavifrons	Yellow-throated Vireo	S	X				X			
Vireo solitarius	Solitary Vireo	M			X			X		
Vireo olivaceus	Red-eyed Vireo	S	X				X			
Vireo gilvus	Warbling Vireo	S			X		X			
Mniotilta varia	Black-and-white Warbler	M	X			X				
Parula americana	Northern Parula	S	X			X	X			
Dendroica petechia	Yellow Warbler	S			X	X				
Dendroica coronata	Yellow-rumped Warbler	M	X			X				
Oporornis formosus	Kentucky Warbler	S	X				X			

Table 9.6. (continued)

Scientific Name	Common Name	Residency[a] Status	Community 1	Community 2	20-Mile Survey	Month May	Month Jun	Month Sep	Month Nov	Month Jan
Geothlypis trichas	Common Yellowthroat	S	X		X	X	X			
Wilsonia pusilla	Wilson's Warbler	M			X	X				
Passer domesticus	House Sparrow	P			X	X	X	X	X	X
Dolichonyx oryzivorus	Bobolink	S			X	X				
Sturnella magna	Eastern Meadowlark	P		X	X	X	X	X	X	X
Sturnella neglecta	Western Meadowlark	S			X		X			
Agelaius phoeniceus	Red-winged Blackbird	P		X	X	X	X	X	X	
Icterus spurius	Orchard Oriole	S			X	X	X			
Icterus galbula	Northern Oriole	S	X		X	X	X			
Quiscalus quiscula	Common Grackle	S	X	X	X	X	X	X	X	
Molothrus ater	Brown-headed Cowbird	P		X	X	X	X	X		X
Piranga rubra	Summer Tanager	S			X		X			
Cardinalis cardinalis	Cardinal	P	X	X	X	X	X	X	X	X
Pheucticus ludovicianus	Rose-breasted Grosbeak	S	X			X				
Passerina cyanea	Indigo Bunting	S	X		X	X	X	X		
Spiza americana	Dickcissel	S		X	X	X	X	X		
Spinus tristis	American Goldfinch	P	X	X	X	X	X	X	X	X
Passerculus sandwichensis	Savannah Sparrow	M		X	X	X		X		

Table 9.6. (continued)

Scientific Name	Common Name	Residency[a] Status	Community 1	Community 2	20-Mile Survey	Month May	Month Jun	Month Sep	Month Nov	Month Jan
Ammodramus savannarum	Grasshopper Sparrow	S			X	X	X	X		
Chondestes grammacus	Lark Sparrow	S		X	X	X	X	X		
Junco hyemalis	Dark-eyed Junco	M	X		X			X	X	X
Spizella arborea	Tree Sparrow	W		X	X	X		X	X	X
Spizella pusilla	Field Sparrow	P		X	X	X	X	X	X	
Zonotrichia querula	Harris' Sparrow	W			X	X			X	X
Zonotrichia leucophrys	White-crowned Sparrow	W		X	X	X		X	X	X
Zonotrichia albicollis	White-throated Sparrow	W			X				X	
Passerella iliaca	Fox Sparrow	M			X				X	
Melospiza lincolnii	Lincoln's Sparrow	M		X				X		
Melospiza melodia	Song Sparrow	W		X	X			X	X	X

[a]M = migrant, S = summer resident, P = permanent resident, W = winter resident, primarily from Johnston 1965.

NALCO ENVIRONMENTAL SCIENCES

Table 9.7. The number of birds observed per hour in the north floodplain woods community in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, May 1976 - January 1977.

Species	Number Per Hour				
	May	Jun	Sep	Nov	Jan
	Floodplain Woods (Community 1)				
Turkey Vulture	0.7	-	-	-	-
Red-tailed Hawk	-	-	-	0.8	3.4
Bobwhite	-	-	1.5	-	-
Mourning Dove	-	0.7	-	-	-
Yellow-billed Cuckoo	-	2.2	-	-	-
Common Flicker	2.0	1.5	3.7	3.2	6.9
Red-bellied Woodpecker	-	5.1	14.1	10.6	23.0
Red-headed Woodpecker	0.7	-	3.0	11.4	28.7
Downy Woodpecker	1.3	2.2	3.0	4.1	11.5
Hairy Woodpecker	-	-	-	-	1.1
Great-crested Flycatcher	1.3	5.8	-	-	-
Eastern Wood Pewee	-	10.9	2.2	-	-
Flycatcher spp.	4.7	-	-	-	-
Blue Jay	1.3	2.9	16.3	6.5	3.4
Common Crow	-	-	-	1.6	-
Black-capped Chickadee	2.0	8.0	6.7	6.5	26.4
Tufted Titmouse	3.3	8.8	0.7	0.8	5.7
White-breasted Nuthatch	-	4.4	7.4	4.1	3.4
Brown Creeper	-	-	-	2.4	1.1
House Wren	10.7	29.2	1.5	-	-
Carolina Wren	-	3.6	2.2	2.4	-
Mockingbird	0.7	-	-	-	-
Gray Catbird	1.3	-	-	-	-
Brown Thrasher	0.7	-	-	-	-
American Robin	1.3	-	2.2	352.0	16.1
Wood Thrush	-	0.7	-	-	-
Veery	0.7	-	-	-	-
Blue-gray Gnatcatcher	5.3	2.2	-	-	-
Golden-crowned Kinglet	-	-	-	1.6	-
Ruby-crowned Kinglet	-	-	0.7	-	-
Yellow-throated Vireo	-	2.9	-	-	-
Red-eyed Vireo	-	3.6	-	-	-
Black-and-white Warbler	2.0	-	-	-	-
Northern Parula	6.0	1.5	-	-	-
Yellow-rumped Warbler	2.7	-	-	-	-
Kentucky Warbler	-	2.9	-	-	-
Common Yellowthroat	2.0	-	-	-	-
Warbler spp.	2.0	-	-	-	-
Northern Oriole	1.3	-	-	-	-
Common Grackle	-	-	-	25.2	-
Cardinal	1.3	11.7	6.7	3.3	-
Rose-breasted Grosbeak	1.3	-	-	-	-
Indigo Bunting	0.7	-	-	-	-
American Goldfinch	-	-	-	-	10.3
Dark-eyed Junco	-	-	-	4.9	2.3
Sparrow spp.	0.7	-	-	-	-
Total	58.0	110.8	71.9	441.4	143.3

Table 9.8. The number of birds observed per hour in the abandoned railroad right-of-way community in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, May 1976 - January 1977.

Species	Number Per Hour				
	May	Jun	Sep	Nov	Jan
Red-tailed Hawk	-	-	1.5	1.0	-
Swainson's Hawk	-	-	-	1.0	-
Bobwhite	2.0	9.6	3.0	16.0	-
Killdeer	10.0	1.1	-	-	-
Mourning Dove	3.0	6.4	27.1	7.0	-
Common Flicker	-	1.1	1.5	2.0	1.2
Downy Woodpecker	-	-	0.8	1.0	-
Eastern Kingbird	-	1.1	-	-	-
Horned Lark	-	1.1	-	3.0	-
Barn Swallow	2.0	6.4	-	-	-
Blue Jay	-	-	6.0	-	-
House Jay	-	-	1.5	-	-
Mockingbird	1.0	5.3	2.2	-	-
Brown Thrasher	1.0	3.2	0.8	-	-
American Robin	8.0	2.1	2.2	-	-
Loggerhead Shrike	-	1.1	-	-	-
Eastern Meadowlark	6.0	23.5	21.0	74.0	6.3
Red-winged Blackbird	1.0	17.1	-	-	-
Common Grackle	21.0	19.3	-	16.0	-
Brown-headed Cowbird	10.0	4.3	-	-	-
Cardinal	-	1.1	-	-	-
Dickcissel	-	13.9	0.8	-	-
American Goldfinch	-	-	1.5	-	-
Savannah Sparrow	1.0	-	-	-	-
Lark Sparrow	7.0	3.2	-	-	-
Tree Sparrow	-	-	-	18.0	-
Field Sparrow	2.0	1.1	9.8	-	-
White-crowned Sparrow	-	-	2.2	-	-
Lincoln's Sparrow	-	-	1.5	-	-
Song Sparrow	-	-	5.3	-	-
Total	75.0	122.0	88.7	139.0	7.5

Table 9.9. Number of species, birds per hour, and species diversity of avifauna recorded in two communities in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, May 1974 - January 1977.

Variable	Month				
	May	Jun	Sep	Nov	Jan
North Floodplain Woods					
Number of Species					
1974	18	12	12	9	10
1975	23	9	11	11	20
1976	26	20	15	17	14
Birds Per Hour					
1974	37.3	22.7	26.0	18.7	17.3
1975	72.6	8.0	15.7	39.2	97.9
1976	58.0	110.8	71.9	441.3	143.3
Species Diversity					
1974	2.63	2.35	2.30	1.89	1.96
1975	2.74	2.11	2.09	2.21	2.67
1976	2.91	2.56	2.32	0.98	2.25
Abandoned Railroad Right-of-Way					
Number of Species					
1974	21	17	13	15	12
1975	14	11	3	5	15
1976	14	19	17	10	2
Birds Per Hour					
1974	69.6	63.3	239.0	176.0	274.0
1975	68.7	29.6	11.4	82.4	157.8
1976	75.0	122.0	88.7	139.0	7.5
Species Diversity					
1974	2.66	2.62	1.53	1.98	1.47
1975	2.13	2.14	1.01	0.85	1.81
1976	2.20	2.45	2.16	1.50	0.45

Table 9.10. Number of avian species and individuals observed along the 20-mile wildlife survey route in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, May 1973 - January 1977.

Variable	Month				
	May	Jun	Sep	Nov	Jan
Number of Species					
1973	37	a	27	37	a
1974	42	45	43	35	31
1975	45	41	42	34	33
1976	55	55	46	40	26[b]
Number of Individuals					
1973	471	a	530	1806	a
1974	837	955	1288	2104	5218
1975	1452	1065	678	2568	2242
1976	1146	1198	768	1618	530[b]

[a]Not censused.
[b]Partial census, several miles not included.

Table 9.11. Quail call counts and dove observations along a 20-mile census route in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, June 1976.

	Bobwhite		Mourning Dove	
	No. Bobwhite Call/2 Min		No. Observed	
Mile	22	24	22	24
1	2			
2				
3			1	
4	2	1		1
5	3	3	12	13
6	1	3	11	18
7	3	3	5	10
8	4	4	1	16
9	3	2	1	10
10	1	3		11
11		1	1	7
12			4	9
13		2	2	6
14				4
15	1	1	1	1
16	2	2		
17	1	2		1
18		1	3	
19		3	4	6
20	1	1		1
Total	24	32	46	114
Mean	1.20	1.60	2.30	5.70

Table 9.12. Composite species list of herpetofauna observed in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

Scientific Name	Common Name
Terrapene ornata	Ornate box turtle
Graptemys geographica	Map turtle
Chrysemys picta belli	Western painted turtle
Ophisaurus ventralis	Eastern glass lizard
Coluber constrictor	Yellow-bellied racer
Elaphe obsoleta	Black rat snake
Sistrurus catenatus	Western massasauga
Bufo americanus	American toad
Bufo woodhousei	Woodhouse's toad
Pseudacris triseriata	Western chorus frog
Hyla chrysoscelis	Gray tree frog
Rana pipiens	Leopard frog
Rana areolata	Crawfish frog
Rana catesbeiana	Bull frog

Table 9.13. Seasonal and community distribution of reptiles and amphibians recorded in the vicinity of the Wolf Creek Generating Station, Burlington, Kansas, 1976.

Location/Species	Month	Type of Observation	Number Observed
North Floodplain Woods			
Leopard frog	June	Sight	1
	September	Sight	1
American toad	June	Sight	1
Abandoned Railroad Right-of-Way			
Ornate box turtle	May	Sight	1
	June	Sight	6
	September	Sight	4
Eastern glass lizard	September	Sight	1
Western massasauga	September	Sight	1
John Redmond Reservoir			
Map turtle	September	Sight	1
Western painted turtle	June	Sight	1
Yellow-bellied racer	September	Sight	1
Woodhouse's toad	September	Sight	2
Western chorus frog	June	Audio	Several
Crawfish frog	September	Sight	1
Leopard frog	May	Sight	Several
	June	Sight	Several
	September	Sight	Several
Bullfrog	June	Sight	Many

NALCO ENVIRONMENTAL SCIENCES

Table 9.13. (continued)

Location/Species	Month	Type of Observation	Number Observed
20-mile Route			
Ornate box turtle	May	Sight	1
	June	Sight	1
	September	Sight	2
Western painted turtle	June	Sight	1
Black rat snake	June	Sight	1
	September	Sight	1
Woodhouse's toad	June	Audio	Many
Western chorus frog	June	Audio	Many
Gray treefrog	June	Sight	1

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