13

Hagan, R. C. 1992. Letter to USFWS regarding 1992 fish and wildlife sampling activities and renewal of WCNOC's Neosho madtom sub-permit 91-27. R.C. Hagan, WCNOC, Burlington, Kansas. December 22.

Aquatic

WOLF CREEK
NUCLEAR OPERATING CORPORATION

Robert C. Hagan
Vice President Nuclear Assurance

December 22, 1992

NA 92-0137

United States Fish and Wildlife Service
Post Office Box 25486
Denver Federal Center
Denver, Colorado 8025

Attention: Mr. Max Schroeder

Subject: 1992 Activities and Renewal Request of Threatened Neosho Madtom Subpermit

Dear Mr. Schroeder:

The purpose of this letter is to report 1992 activities and request renewal of Wolf Creek Nuclear Operating Corporation's threatened Neosho Madtom subpermit 91-27 under authority of PRT-704930. Due to flooding conditions in the Neosho River during November and December, we were unable to complete seining activities to the extent originally intended. We were only able to seine in one gravel riffle area on December 15, 1992 at the Burlington city dam in the SE 1/4 of 23-21-15 in Coffey County, Kansas. We did not capture any madtoms during three kick-seine hauls with a 6' x 15' straight seine with 1/4 inch mesh. *

Renewal of this permit is requested for 1993. We intend to continue environmental monitoring of the Neosho River as in the past and expect to incidentally catch Neosho madtoms. There will be no changes to the schedule, methods, or justifications presented in our application for subpermit 91-27.

If you need more information or have questions, please feel free to contact Brad Loveless or Dan Haines at (316) 364-4168.

Very truly yours,

Robert C. Hagan
Vice President Nuclear Assurance

RCH/tlr

cc: William H. Gill (State Supervisor, Fish and Wildlife Service)

P.O. Box 411 / Burlington, KS 66839 / Phone: (316) 364-8831

14

Maynard, O.L. 1990a. Letter to Kansas Dept. of Wildlife and Parks with 1989 Conditional Wildlife Permit Activities Report. O.L. Maynard, WCNOC, Burlington, Kansas. January 19.

Bio – Aquatic

WOLF CREEK
NUCLEAR OPERATING CORPORATION

Maynard 1990a
WCNOC 195

Otto L. Maynard
Manager-Regulatory Services

January 19, 1990

LI 90-0036

Mr. Bill Hlavachick
Kansas Dept. of Wildlife and Parks
Partt Headquarters
PO Box 54A
Pratt, KS 67214

Subject: 1989 Conditional Wildlife Permit Activities Report

Dear Mr. Hlavachick:

The purpose of this letter is to report 1989 Conditional Wildlife Permit #SC-036-89 activities by Wolf Creek Nuclear Operating Corporation's Environmental Management Section. Most fish used for radioisotopic analyses were sent to a private laboratory for testing. The remainder were given to the Kansas Department of Health and Environment under the Power Plant Monitoring Act.

In addition, a copy of our current Federal Fish and Wildlife Special Purpose Permit is enclosed for your records. As this permit is renewed in the future, WCNOC will provide a current copy for KDWP files.

If you have any questions, please contact Brad Loveless or Dan Haines at (316) 364-4168 or (316) 364-8831, Ext. 5140, respectively.

Sincerely,

Otto L Maynard

Otto L. Maynard
Manager-Regulatory Services

OLM/rrw

Attachments (2)

bcc: D. E. Haines (WC-TR), w/a
B. S. Loveless (WC-TR), w/a
TE: 42084-W (WC-TR), w/a
Rec. Mgt. (WC-MS), w/a

SC-036-89 — Permit Number

19 89

WCNOC Environmental Mgt. — Permit Holder Name

Date of Each Collection Month/Day/Year	Number & Species Handled at Each Location No.	Species (Common Name)	Give each collection location, including legal description (Quarter Section, Section Number, Township Number, Range Number, and County)	Disposition of Specimens - (Include Museum Voucher Numbers if Applicable)
1989	355	White bass	Wolf Creek Cooling Lake	
	1	Striped bass		Used for radioisotopic analyses
	184	Wiper hybrid		2 used for radioisotopic analyses
	48	Morone sp		
	98	Green sunfish		
	6	Orange-spotted sunfish		
	1883	Bluegill		
	2	Longear sunfish		
	12	Hybrid sunfish		
	287	Smallmouth bass		2 used for radioisot c analyses
	851	Largemouth bass		4 used for radioisotopic analyses
	200	White crappie		3 used for radioisotopic analyses
	189	Black crappie		5 used for radioisotopic analyses
	127	Logperch		
	133	Walleye		3 used for radioisotopic analyses
	134	Freshwater drum		

SC-036-89 — Permit Number

19 89

WCNOC Environmental Mgt. — Permit Holder Name

Date of Each Collection Month/Day/Year	Number & Species Handled at Each Location No.	Species (Common Name)	Give each collection location, including legal description (Quarter Section, Section Number, Township Number, Range Number, and County)	Disposition of Specimens - (Include Museum Voucher Numbers if Applicable)
1989	1740	Gizzard shad	Wolf Creek Cooling Lake	Returned to WCCL unless otherwise noted
	161	Common carp	↓	2 used for radioisotopic analyses
	1	Ghost shiner		
	66	Golden shiner		
	361	Red shiner		
	1	Suckermouth minnow		
	1	River carpsucker		
	27	Smallmouth buffalo		1 used for radioisotopic analyses
	13	Bigmouth buffalo		
	35	Yellow bullhead		
	158	Channel catfish		3 used for radioisotopic analyses
	1	Blue catfish		
	14	Flathead catfish		
	8	Blackstripetopminnow		
	2	Mosquitofish		
	185	Brook silverside		

CS-036-89 — Permit Number

19 89

WCNOC Environmental Mgt. — Permit Holder Name

Date of Each Collection Month/Day/Year	Number & Species Handled at Each Location		Give each collection location, including legal description (Quarter Section, Section Number, Township Number, Range Number, and County)		Disposition of Specimens - (Include Museum Voucher Numbers if Applicable)
	No.	Species (Common Name)			
		The following are migratory birds handled under U.S. Fish and Wildlife Service Special Wildlife Permit number PRT-715225			
8/8/89	33	Purple martin	NE 1/4	7-21-16	Buried
9/5/89	21	Purple martin	NE 1/4	7-21-16	Buried
9/25/89	1	Great horned owl	NE 1/4	8-21-16	Buried
10/19/89	3	Brown-headed bowbird	NE 1/4	7-21-16	Buried
10/31/89	1	American coot	NE 1/4	7-21-16	Buried
12/8/89	1	Lesser scaup	NE 1/4	7-21-16	Returned live to WCCL

SCIENTIFIC COLLECTING, T&E, ...AGE PERMIT REPORT FORM

SC-036-89
Permit Number

19 89

WCNOC Environmental Mgt.
Permit Holder Name

Date of Each Collection Month/Day/Year	Number & Species Handled at Each Location No.	Species (Common Name)	Give each collection location, including legal description (Quarter Section, Section Number, Township Number, Range Number, and County)	Disposition of Specimens - (Include Museum Voucher Numbers if Applicable)
4/28/89	3	Smallmouth buffalo	John Redmond Spillway NW 1/4 10-21-15, Coffey Co.	Used for radioisotopic analyses
	5	Common carp	↓	↓
	2	White bass	↓	↓
	2	Largemouth bass	↓	↓
	3	Freshwater drum	↓	↓
10/17/89	5	Neosho madtom	Neosho River NW 1/4 12-22-15, Coffey Co.	Returned Live
10/31/89	1	Bigmouth buffalo	John Redmond Spillway NW 1/4 10-21-15, Coffey Co.	Used for radioisotopic analyses
	2	Largemouth bass	↓	↓
	1	White crappie	↓	↓

Special Agent in Ch[...]
U. S. Fish & Wildli[...]ice
P. O. Box 25486, DFC
Denver, Colorado 80225

69400 42093-W

[...]NT OF THE INTERIOR
U.S. FI[...] AND WILDLIFE SERVICE

3-201 (10 86)

FEDERAL FISH AND WILDLIFE PERMIT

1. PERMITTEE

WOLF CREEK NUCLEAR OPERATING CORP.
P.O. BOX 411
BURLINGTON KS 66839

2. AUTHORITY-STATUTES

16 USC 703-712

REGULATIONS *(Attached)*

50 CFR Part 13
50 CFR 21.27

3. NUMBER

PRT-715225

4. RENEWABLE	5. MAY COPY
XX YES	XX YES
☐ NO	☐ NO

6. EFFECTIVE	7. EXPIRES
1/ 1/89	12/31/90

8. NAME AND TITLE OF PRINCIPAL OFFICER *(If #1 is a business)*

PRES. & CHIEF EX.OF.
BART D WITHERS

9. TYPE OF PERMIT

SPECIAL PURPOSE

10. LOCATION WHERE AUTHORIZED ACTIVITY MAY BE CONDUCTED

WOLF CREEK GENERATING STATION
(COOLING LAKE AND VICINITY) LOCATED IN
CENTRAL COFFEY COUNTY, NEAR BURLINGTON, KANSAS.

11. CONDITIONS AND AUTHORIZATIONS:

A. GENERAL CONDITIONS SET OUT IN SUBPART D OF 50 CFR 13, AND SPECIFIC CONDITIONS CONTAINED IN FEDERAL REGULATIONS CITED IN BLOCK #2 ABOVE, ARE HEREBY MADE A PART OF THIS PERMIT. ALL ACTIVITIES AUTHORIZED HEREIN MUST BE CARRIED OUT IN ACCORD WITH AND FOR THE PURPOSES DESCRIBED IN THE APPLICATION SUBMITTED. CONTINUED VALIDITY, OR RENEWAL, OF THIS PERMIT IS SUBJECT TO COMPLETE AND TIMELY COMPLIANCE WITH ALL APPLICABLE CONDITIONS, INCLUDING THE FILING OF ALL REQUIRED INFORMATION AND REPORTS.

B. THE VALIDITY OF THIS PERMIT IS ALSO CONDITIONED UPON STRICT OBSERVANCE OF ALL APPLICABLE FOREIGN, STATE, LOCAL OR OTHER FEDERAL LAW.

C. VALID FOR USE BY PERMITTEE NAMED ABOVE.

and any other person(s) under the direct control of or employed by the Environmental Assessment Group only to the extent necessary in accomplishing the purpose authorized below.

D. Permittee is authorized to salvage, transport, and temporarily possess live and dead nonendangered migratory birds which consist of various waterfowl, raptors, and species of Charadriiformes found in and around cooling lake for analysis and disposition.

E. Permittee, and any other person(s), shall carry a copy of this permit whenever exercising its authority.

F. All birds found live shall be turned over to the Kansas Fish and Game Department for disposition to Federally licensed migratory bird rehabilitators. All birds found dead shall be analyzed to determine cause of death.

☐ ADDITIONAL CONDITIONS AND AUTHORIZATIONS ON REVERSE ALSO APPLY X

12. REPORTING REQUIREMENTS

FIRST ANNUAL REPORT DUE 1/10/90
ANNUALLY BY JANUARY 10 FOR PRECEDING CALENDAR YEAR ENDING DEC. 31
AS OUTLINED IN 50 CFR 21.27(C)(1) AS PER CONDITION 11.H.

ISSUED BY	TITLE	DATE
Bernadette A. Hilbourn	CHIEF, PERMIT SECTION REG 6	8/ 1/89

ORIGINAL

Carcasses shall be donated to public scientific or educational institutions or be destroyed by burning or burying.
G. Permittee shall maintain records as required in 50 CFR 13.46. All records relating to permitted activities shall be kept at the facility where activities are conducted.
H. Permittee shall submit a report to the Assistant Regional Director of Law Enforcement, (69400), P.O. Box 25486, DFC, Denver, Colorado, 80225, (303) 236-7540 with the following information: a) species and date of acquisition, b) cause of death, and c) disposition of each.

15

Maynard, O.L. 1990b. Letter to Kansas Dept. of Wildlife and Parks with information on 1988 and 1989 Neosho madtom sampling. O.L. Maynard, WCNOC, Burlington, Kansas. January 23.

Aquatic

Maynard 1990b
WC NOC 196

WOLF CREEK
NUCLEAR OPERATING CORPORATION

Otto L. Maynard
Manager-Regulatory Services

January 23, 1990

LI 90-0051

Robert D. Wood
Environmental Services Section
Kansas Department of Wildlife and Parks
Box 54A
Pratt, Kansas 67124

Subject: Neosho Madtom Data Request

Dear Mr. Wood:

Attached are the Neosho madtom data you requested of Greg Wedd. Greg has made a career move to our Training Department and is no longer a member of the Environmental Management staff. Brad Loveless has assumed the duties of supervisor of this group. Our monitoring activities of the Neosho River have been reduced since 1987, however, we continue to monitor long term sampling locations for Neosho madtoms. Also, since collection methods are similar, we record any madtoms that are collected during our Asiatic clam (Corbicula) surveys of the river.

If you have any questions, please call Brad Loveless or Dan Haines at (316) 364-4168.

Sincerely,

Otto L. Maynard

Otto L. Maynard
Manager-Regulatory Services

OLM/rrw

Attachment

bcc: D. E. Haines (WC-TR), w/a
B. S. Loveless (WC-TR), w/a
TE: 42084-W (WC-TR), w/a
Rec. Mgt. (WC-MS), w/a

Attachment to LI 90-0051

1988 and 1989 Neosho Madtom Sampling

Date	Location	# Seine Hauls	# Neosho Madtoms
10/4/88	Loc 10, NW 1/4 12-22-15 Above Wolf Creek/Neosho confluence	2	5
10/4/88	Loc 11, SW 1/4 7-22-16 Below Wolf Creek/Neosho confluence	2	21
10/4/88	Burlington City Dam, SW 1/4 23-21-15	2	0
10/4/88	Hartford Rapids, S 1/4 10-20-13, NE 1/4 15-20-13	2	0
10/17/89	Loc 10	3	5
10/17/89	Loc 11	3	0
10/17/89	Burlington City Dam	2	0
10/17/89	Hartford Rapids	2	0
11/24/89	Hartford Rapids	3	0

16

Obermeyer, Brian K. 2000. Recovery Plan for Four Freshwater Mussels in Southeast Kansas: Neosho Mucket, Ouachita Kidneyshell, Rabbitsfoot, Western Fanshell. Kansas Department of Wildlife & Parks, Pratt, Kansas. November.

Aquatic

Recovery Plan
for
Four Freshwater Mussels in Southeast Kansas:

NEOSHO MUCKET—*Lampsilis rafinesqueana*
OUACHITA KIDNEYSHELL—*Ptychobranchus occidentalis*
RABBITSFOOT—*Quadrula cylindrica cylindrica*
WESTERN FANSHELL—*Cyprogenia aberti*

Upper left to right: Neosho mucket, Ouachita kidneyshell, and western fanshell mussels collected from the Verdigris River, KS.

© B. K. Obermeyer

Prepared by

Brian K. Obermeyer
Stream & Prairie Research

for

Kansas Department of Wildlife & Parks

Recovery Plan
for
Four Freshwater Mussels in Southeast Kansas:

NEOSHO MUCKET—*Lampsilis rafinesqueana*
OUACHITA KIDNEYSHELL—*Ptychobranchus occidentalis*
RABBITSFOOT—*Quadrula cylindrica cylindrica*
WESTERN FANSHELL—*Cyprogenia aberti*

Prepared by

Brian K. Obermeyer
Stream & Prairie Research
Rt. 2 Box 141
Eureka, KS 67045

for

Kansas Department of Wildlife & Parks
512 SE 25th Ave.
Pratt, KS 67124-8174

November, 2000

Approved: Steve Williams **Date: 11/6/2000**

Steve Williams,
Secretary of the Kansas Department of Wildlife & Parks

PREFACE

The Kansas Department of Wildlife and Parks (KDWP) is required to develop recovery plans for all state-listed threatened and endangered species under the authority of K.S.A. 32-960(a). The concept of developing state recovery plans for Kansas' endangered, threatened, and SINC species (species in need of conservation) was conceived by the Kansas Nongame and Endangered Species Task Force, which was created by passage of substitute Senate bill No. 473 during the 1996 Legislative Session. The Task Force, which consisted of 17 members[1], met six times during the summer and fall of 1996. Issues and concerns addressed by the Task Force included listing procedures for endangered, threatened, and SINC species, incentives for affected property owners, recovery and conservation plans, and funding. After receiving the Task Force's report, the 1997 legislature enacted into law the Task Force's recommendations by amending existing state laws and by enacting new laws (H.B. No. 2361). As part of that legislation, KDWP was required to implement several of the measures through regulation. Regulatory language addressing these measures was drafted by Department staff and presented to the KDWP Commission and the public. These recommendations were approved by the Commission in the fall of 1997. A new regulation, K.A.R. 115-15-4, outlined procedures to establish recovery plans[2]. These procedures included the appointment of an advisory group to evaluate recovery plan development priority. The advisory group determined that the highest priority was the immediate development of a joint recovery plan for four threatened and endangered mussel species that occur in southeast Kansas.

The Legislature also amended K.S.A. 32-962 to create conservation and recovery plan agreements with landowners. This amendment was based on recommendations made by the Task Force to create incentives for public participation, encourage sound management practices, and encourage communication between state agencies and affected landowners. A recovery plan agreement must meet the following criteria: i.) participant must carry out

[1] Members of the Taskforce included the Chairperson of the Kansas Nongame Wildlife Advisory Council, Kansas Farm Bureau, Kansas Association for Conservation and Environmental Education, Kansas Chapter of the American Fisheries Society, Kansas Herpetological Society, Kansas Chapter of the Wildlife Society, Kansas Ornithological Society, Kansas Livestock Association, Kansas Audubon Council, Kansas Association of Conservation Districts, Kansas Natural Resource Council, Secretary of the Kansas Department of Wildlife and Parks, President of the Kansas Building Industry Association, Inc., State Association of Kansas Watersheds, one private landowner appointed by the State Executive Director of the USDA Farm Service Agency, one member of the Kansas Department of Wildlife and Parks Commission, and one landowner appointed by the other members of the task force.

[2] "a designated strategy or methodology that, if fully funded and implemented, is reasonably expected to lead to the eventual restoration, maintenance, or delisting of listed species", K.A.R. 115-15-4.

management activities specified in a recovery plan; ii.) property must pass critical habitat designation guidelines for the targeted T&E species; iii.) duration of agreement shall be five years; and iv.) KDWP and other essential personnel will have access privileges to the property for the duration of the agreement for monitoring purposes.

A landowner who meets the recovery criteria will be eligible for state income tax credit equal to the amount of property taxes paid on enrolled property during each year of the agreement. A landowner may also be eligible for state income tax credit equal to the cost incurred for compliance of the recovery plan. This cost may include expenses from maintaining easement roads, planting riparian habitat, building fences for excluding livestock from accessing streams, and constructing alternative watering sources for livestock. KDWP will outline the procedure for applying for state income tax credit before an agreement is signed. However, it is the responsibility of the landowner to acquire the proper tax form (Schedule K-63) created for this purpose from the Kansas Department of Revenue (KDR). The landowner will also be responsible for supplying a copy of the signed recovery plan agreement with KDWP, a completed Real Estate Tax Computation Worksheet, and an itemized list of costs specified in the agreement, with copies of invoices to KDR. If for any reason an agreement is terminated before its end date, KDWP will notify the KDR.

DISCLAIMER

This recovery plan outlines actions believed reasonable to maintain and/or restore self-sustaining populations of state-listed freshwater mussels that occur in southeast Kansas. However, budgetary restraints and social obstacles may hamper or postpone recovery objectives. Moreover, it may take years to reverse a trend of species decline and habitat degradation that has occurred during the past 100 years or so. The full recovery of all of these species is an ambitious goal. The rich historic diversity of freshwater mussels in Kansas was the product of a pristine landscape dominated by prairie, not agriculture and industry. Therefore, some of these species may continue to experience range reductions, and perhaps even extirpation or extinction, despite aggressive conservation efforts. Nonetheless, these possibilities should not be an excuse to abandon efforts to recover these species. Instead, the full recovery of these species should be viewed as a worthwhile challenge.

Suggested citation:

Obermeyer, B.K. 1999. Recovery plan for four freshwater mussels in southeast Kansas: Neosho mucket (*Lampsilis rafinesqueana*), Ouachita kidneyshell (*Ptychobranchus occidentalis*), rabbitsfoot (*Quadrula cylindrica cylindrica*), and western fanshell (*Cyprogenia aberti*). Kansas Department of Wildlife and Parks, Pratt, Kansas. 83 pp.

ACKNOWLEDGMENTS

I wish to thank the following persons who have provided much valued assistance and advice throughout the development of this recovery plan:

> Steven Ahlstedt, Dr. Bob Angelo, Phil Balch, Dr. Chris Barnhart, Ken Brunson, Robert Butler, Dr. Bill Busby, Melissa Carr, Karen Couch, Bob Culbertson, Rich Davis, Linda Drees, Dr. David Edds, Dr. Craig Freeman, Paul Hartfield, Jerry Horak, Jeff Keating, Greg Kramos, Dr. Hsiu-Ping Liu, Chris Mammoliti, Edwin Miller, Jim Minnerath, Kristen Mitchell, Tom Mosher, Dan Mulhern, Richard Neves, Bernadine Obermeyer, Frank Riusech, Clint Riley, Andy Roberts, Susan Rogers, Keith Sexon, Kenneth Sherraden, Stephanie Sherraden, Dr. David Strayer, Rick Tush, Dr. Caryn Vaughn, and Kenny Whitehead.

I apologize to anyone I may have inadvertently omitted from this list.

EXECUTIVE SUMMARY

This recovery plan outlines strategies and methods to recover and eventually delist four freshwater mussel species native to the Neosho, Spring, and Verdigris river basins (Arkansas River system) in southeast Kansas. These mussels are the Neosho mucket (*Lampsilis rafinesqueana*), Ouachita kidneyshell (*Ptychobranchus occidentalis*), rabbitsfoot (*Quadrula cylindrica cylindrica*), and western fanshell (*Cyprogenia aberti*). The recovery plan also provides a process of conserving—through proposed watershed enhancements—14 additional state-listed mussels that occur in these three basins: the bleedingtooth mussel[1] and elktoe (state-endangered); butterfly and flutedshell (state-threatened); and creeper (= squawfoot), deertoe, fat mucket, fawnsfoot, round pigtoe, spike, Wabash pigtoe, washboard, wartyback, and yellow sandshell (SINC).

The four targeted mussel species historically occurred in the Neosho, Spring, and Verdigris river basins; none is believed to have occurred elsewhere in the state. The rabbitsfoot mussel is considered extirpated from the Verdigris River basin, and is dangerously close to extirpation in the Neosho River basin. It has recently been collected alive in only the Spring and Neosho rivers. The Ouachita kidneyshell remains in only three Kansas streams—at scattered locales in the Fall, Verdigris, and Spring rivers—from a "historic" total of ten streams. The western fanshell remains at sporadic locations in the Fall, Verdigris, and Spring rivers; it is believed to be extirpated from the Neosho River basin. Although the Neosho mucket still occurs in all three river basins, it is extirpated from seven southeastern Kansas streams. It is presently found in the Neosho, Verdigris, Fall, and Spring rivers.

The recovery plan integrates two approaches for the recovery of these species: species-level and ecosystem. The ecosystem approach examines watersheds pertinent to all state-listed mussel species that occur in the three stream basins, and proposes practices that could help reverse a trend of watershed degradation that has occurred since Euro-American settlement. The ecosystem approach will also benefit non-target species associated with riverine habitats. The species-level approach includes projects such as life history, genetic, and demographic studies, as well as propagation of mussels into stream reaches where they are extirpated.

The estimated five-year cost of implementing proposed recovery tasks is $324,500. Additional costs, such as landowner participation in the state income tax incentive program and government conservation programs, are not included because these costs will be dependent upon landowner acceptance of such programs. Downlisting dates cannot be estimated because it may require up to ten years to fully assess population trends, and because funding is presently not available for many of the recovery tasks outlined in this plan.

[1] Genetic research at Southwest Missouri State University indicates that the bleedingtooth mussel (*Venustaconcha pleasii*) in the Spring River basin is more similar, both morphologically and genetically, to *V. ellipsiformis* (ellipse) than to the bleedingtooth mussel (Frank A. Riusech and Dr. Hsiu-Ping Liu, SMSU, pers. comm.). Consequently, ellipse will be used in place of bleedingtooth mussel hereafter in the recovery plan.

CONTENTS

LIST OF FIGURES AND TABLES

FIGURES

TABLES

I. INTRODUCTION

This recovery plan addresses the recovery needs of four freshwater mussel species native to the Neosho, Spring, and Verdigris river basins (Arkansas River system) in southeast Kansas. These mussels are the Neosho mucket (*Lampsilis rafinesqueana*), Ouachita kidneyshell (*Ptychobranchus occidentalis*), rabbitsfoot (*Quadrula cylindrica cylindrica*), and western fanshell (*Cyprogenia aberti*). Beginning in 1986, these species received legal protection by KDWP under the authority of the state's Nongame and Endangered Species Conservation Act of 1975. In 1992 their listing status was upgraded from SINC (species in need of conservation) to Threatened (Ouachita kidneyshell) and Endangered (Neosho mucket, rabbitsfoot, and western fanshell) (K.A.R. 115-15-1 and 115-15-2).

This plan, as governed by K.A.R. 115-15-4, outlines specific strategies and methods to recover and eventually delist these four mussel species. The plan also provides a process of conserving 14 additional state-listed mussel species (Table 1) that occur in southeast Kansas.

A. OVERVIEW OF FRESHWATER MUSSELS

The world's greatest diversity of freshwater mussels (Unionoida) is concentrated in North America, with approximately 300 species and subspecies (Turgeon *et al.* 1998). Freshwater bivalves have been around for a long time, dating back to the late Devonian Period (Gray 1988). Unfortunately, the rich historical mussel fauna of North America has recently become seriously jeopardized. In fact, freshwater mussels are now considered the most imperiled group of animals in North America (Allan and Flecker 1993). Sixty-one species are federally listed as endangered and eight as threatened (USFWS Box Score, 30 April 1999). Thirty-six species are believed extinct in North America (Neves *et al.* 1997), and that number is expected to increase (Shannon *et al.* 1993).

Unionids in Kansas have undergone a similar decline. Of the 46 species known to have occurred in Kansas, five are now state-listed as endangered, four as threatened, and 12 as SINC. Additionally, at least four species are thought to be extirpated from the state: the black sandshell (*Ligumia recta*), hickorynut (*Obovaria olivaria*), snuffbox (*Epioblasma triquetra*), and winged mapleleaf (*Quadrula fragosa*) (Couch 1997, Obermeyer *et al.* 1997a, Bleam *et al.* 1998).

TABLE 1. ***Status, distribution, and potential hosts of state-listed mussel species that presently occur in southeast Kansas.***

Species	Status	Basin[a]	Potential hosts found in SE KS
butterfly (*Ellipsaria lineolata*)	Threatened	N, V	freshwater drum and green sunfish
deertoe (*Truncilla truncata*)	SINC	N, V	freshwater drum
elktoe (*Alasmidonta marginata*)	Endangered	S	white sucker, northern hogsucker, shorthead redhorse, rock bass, and warmouth
ellipse (bleedingtooth mussel) (*Venustaconcha ellipsiformis*)	Endangered	S	banded sculpin, bluntnose minnow, fantail darter, greenside darter, Johnny darter, logperch, orangethroat darter[c], and redfin darter[c]
fat mucket (*Lampsilis siliquoidea*)	SINC	N, S, V	black crappie, bluegill, bluntnose minnow, largemouth bass, longear sunfish, orangespotted sunfish, rock bass, smallmouth bass, striped shiner, walleye, warmouth, white bass, white crappie, and white sucker
fawnsfoot (*Truncilla donaciformis*)	SINC	N, V	freshwater drum
flutedshell (*Lasmigona costata*)	Threatened	N, V	banded darter, common carp, and northern hogsucker
Neosho mucket[b] (*Lampsilis rafinesqueana*)	Endangered	N, S, V	largemouth bass, smallmouth bass, and spotted bass[c]
Ouachita kidneyshell[b] (*Ptychobranchus occidentalis*)	Threatened	N, S, V	orangethroat darter and greenside darter
rabbitsfoot[b] (*Quadrula cylindrica*)	Endangered	N, S	bigeye chub* and spotfin shiner
round pigtoe (*Pleurobema sintoxia*)	SINC	N, S, V	bluegill, bluntnose minnow, northern redbelly dace, smallmouth bass, and spotfin shiner
spike (*Elliptio dilatata*)	SINC	N, V	black crappie, flathead catfish, gizzard shad, and white crappie
creeper (= squawfoot) (*Strophitus undulatus*)	SINC	N, S, V	banded darter, black bullhead, bluegill, bluntnose minnow, creek chub, fantail darter, fathead minnow, golden shiner, green sunfish, largemouth bass, sand shiner, spotfin shiner, walleye, yellow bullhead, and white crappie
Wabash pigtoe (*Fusconaia flava*)	SINC	N, S, V	black crappie, bluegill, creek chub, and white crappie
washboard (*Megalonaias nervosa*)	SINC	N, V	American eel*, black bullhead, black crappie, bluegill, central stoneroller, channel catfish, flathead catfish, freshwater drum, gizzard shad, green sunfish, highfin carpsucker, largemouth bass, logperch, longear sunfish, longnose gar, slenderhead darter, white bass, and white crappie
wartyback (*Quadrula nodulata*)	SINC	N, V	black crappie, bluegill, channel catfish, flathead catfish, largemouth bass, and white crappie
western fanshell[b] (*Cyprogenia aberti*)	Endangered	S, V	banded sculpin, fantail darter, and logperch
yellow sandshell (*Lampsilis teres*)	SINC	N, S, V	black crappie, green sunfish, largemouth bass, longnose gar, orangespotted sunfish, shortnose gar, warmouth, and white crappie

[a] N = Neosho River basin, S = Spring River basin, V = Verdigris River basin; [b] Species targeted in the recovery plan; [c] Inferred host; * = presumed extirpated.

Reasons for protecting the state's rich diversity of freshwater mussels are numerous. Because mussels are filter feeders, they contribute to water quality by removing suspended particles of sediment and detritus. According to Allen (1914), an average-sized mussel can filter over eight gallons of water during a 24 h period. In high-density mussel beds, the filtering effect of thousands of mussels is ecologically significant. Let's consider a high density mussel bed in the Verdigris River near Syracuse, Montgomery County, which has been estimated to harbor from 128,000 to 313,000 individuals in a 300 m stretch of riffle habitat (Miller 1999a). Between 500,000 to 1,000,000 gallons of water may be siphoned[1] each day by mussels at this site, assuming optimal water temperatures. During a typical summer-time flow of 50 cubic feet/sec, roughly 1.6 to 3.9% of the stream flow may be siphoned by mussels at this site at any given moment.

Mussels are an important food source for aquatic and terrestrial animals. Furbearers such as the raccoon, muskrat, and otter feed extensively on mussels. Many fish species benefit because filter-feeding mussels discard undigested food in strands of mucus. This material is fed upon by other stream invertebrates that are, in turn, fed upon by fishes.

The shells of mussels are an economic resource. Currently, the monkeyface (*Quadrula metanevra*), threeridge (*Amblema plicata*), mapleleaf (*Q. quadrula*), and bleufer (*Potamilus purpuratus)* are commercially harvested in Kansas for the cultured pearl industry. During the early part of the century, most species in southeastern Kansas, especially in the Neosho River, were harvested for use in the manufacture of buttons and other pearly products. According to a musseler active during the late 1920s (A.A. Frischenmeyer, Chanute resident, pers. comm.), the mucket [Neosho mucket] was one of the most sought after species by the Iola shell-blank factory (also, see Coker 1919). Over 17,000 tons of shells were collected from the Neosho River during 1912, representing approximately 17% of the nation's total pearly products (Coker 1919, Murray and Leonard 1962). Coker (1919) estimated that a ton of shells taken from virgin beds equaled 5,000 to 10,000 live mussels. Based on this estimate, over 85 million mussels may have been harvested from the Neosho River in this one year. During 1918, a shell blank factory in Iola processed up to 30 tons of shells a week; most of these shells were collected from the Neosho River near Leroy (Iola Register, 6 April 1918). By 1920, annual harvest

[1] Filtering estimate is based on a summer filtering rate estimate of four gallons of water per mussel during a 24 h period.

yields had declined, with only 500 tons of shells processed at the Iola factory (Iola Register, 2 September 1920).

Mussel shells are collected by amateur and professional biologists, who find them aesthetically pleasing and educational. The shells provide a durable record of a species' historical presence. They also provide a record of the history of each individual in the annual rings of growth, showing that some species live over a century. This record also documents changes in stream health through time because of the mussels' sensitivity to pollution. Therefore, freshwater mussels, as important indicators of aquatic health, serve much the same purpose as canaries in a coal mine.

Perhaps the most fundamental reason for protecting any endangered species is the concept of stewardship. Mussels are an integral part of nature, yet can be destroyed all too easily by the acts of man. The concept of stewardship holds that, apart from any perceived utility or profit in a species, man has the moral obligation to protect and preserve nature. Each species is an irreplaceable part of our heritage and that of our children.

"To keep every cog and wheel is the first precaution of intelligent tinkering."

—Aldo Leopold, *Sand County Almanac*

1. Life History

The life history of freshwater mussels consists of four basic life stages: reproductive, larval or parasitic, juvenile, and adult (Figure 1). Most mussels are dioecious (having separate sexes). Males release sperm into the water, and the sperm are filtered from the water by the female. Fertilized eggs are brooded within the female's gills or marsupium, which contain hollow spaces for this purpose. Fecundity varies among species, ranging from 75,000 to 3,000,000 larvae (Surber 1912, Coker *et al.* 1921). Mussel larvae, called glochidia, may be released soon after they are mature, or may be retained in the gills for several months or until the next season (Ortmann 1911). Species that release glochidia soon after they are mature are called short-term breeders (tachytictic), whereas species that retain their glochidia for extended periods of time are called long-term breeders (bradytictic). Tachytictic species generally spawn in the spring, whereas bradytictic species usually spawn during summer months.

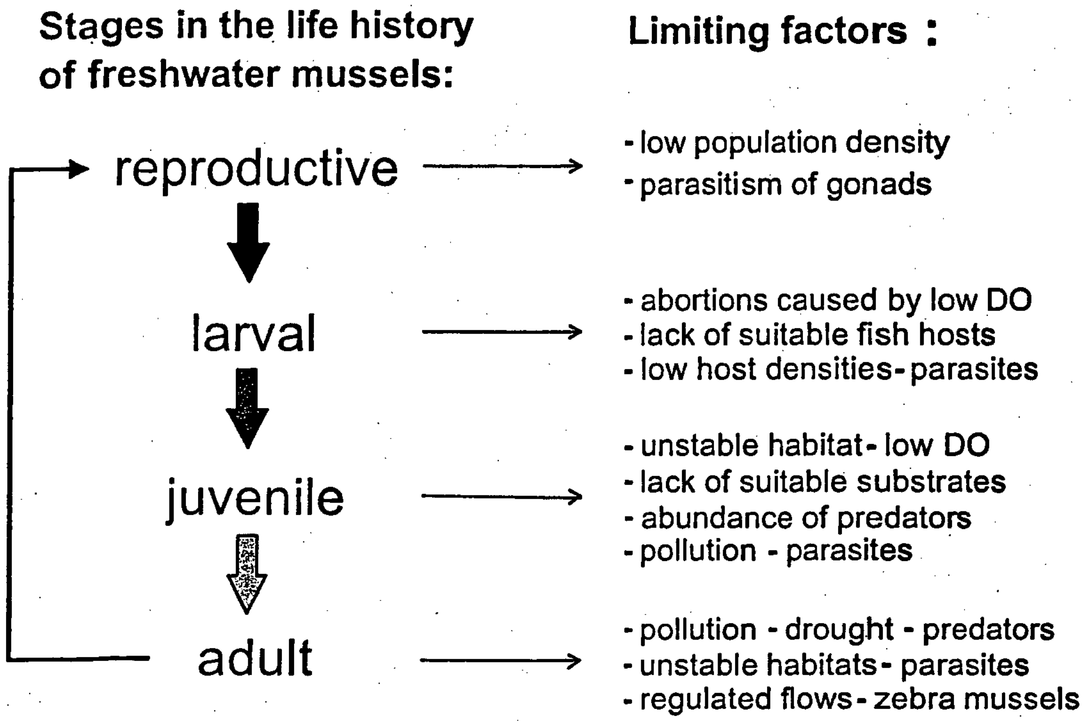

Figure 1. *Four basic life stages of freshwater mussels and possible limiting factors.*

Glochidia must briefly parasitize a vertebrate host (usually a fish) to complete its development[1] (see Table 1). The primary function of larval parasitism on fish appears to be transport to upstream habitats (Surber 1913). Larvae attached to fish may be carried upstream, whereas adult mussels are not very mobile, and unattached larvae can only drift downstream. Glochidia must come in contact with a vertebrate host soon after leaving the female mussel. Only a small percentage of glochidia actually make contact with a suitable host. Upon contact with a gill filament, a fin, or the epithelium of a fish, a glochidium clamps on to host tissue. Glochidia, however, cannot discriminate between suitable and non-suitable tissue, and may snap shut in response to just about any stimulus. If the glochidium attaches to an unsuitable host, it will be rejected and sloughed off. On a suitable host, the tissue encapsulates the glochidium by proliferation of epithelial cells. In most species the encapsulation period lasts

[1] Only one North American species, the green floater (*Lasmigona subviridis*), is positively known to bypass the parasitic life phase (Barfield and Watters 1998, Lellis and King 1998).

from 2 to 3 weeks, although it can range from 6 days to 7 months (Howard 1915). Following metamorphosis, the juvenile mussel will excyst, drop from the fish, and take up life as a sedentary filter feeder. The percentage of glochidia that reach this stage is extremely small. Young and Williams (1984) estimated that only about 0.001% of the glochidia of *Margaritifera margaritifera* develop into juveniles.

The juvenile or post-parasitic stage represents the period from metamorphosis to when a young mussel produces gametes, which usually occurs from two to six years of age for most species in Kansas. This stage, especially during the first few months, is thought to be a vulnerable link in the life cycle of freshwater mussels (Dimock and Wright 1993, O'Beirn *et al.* 1998, Sparks and Strayer 1998), and may be affected by Kansas' eutrophic waters (Obermeyer *et al.* 1997a). Specific ecological requirements of juvenile mussels remain unknown for most species, and attempts to raise juveniles have only recently yielded acceptable results (Gatenby *et al.* 1996, 1997, O'Beirn *et al.* 1998).

The adult life stage is typically what most people envision when they think about freshwater mussels. Consequently, past mussel research has largely focused on this life stage. Fortunately, researchers have recently begun to address the entire life cycle of freshwater mussels. Nonetheless, emphasis on the adult life stage is appropriate for certain aspects of mussel research, such as distributional assessments.

2. Habitat Requirements

Characterization of specific habitat requirements for freshwater mussels is difficult because of their broad microhabitat tolerances and site-specific preferences (Strayer 1981, Kat 1982, Gordon and Layzer 1989, Strayer and Ralley 1993, Obermeyer *et al.* 1997a). Habitat use on a broader scale, however, is more predictable. Many of the state-listed mussels that occur in southeast Kansas are generally found in medium to large streams at depths less than one meter in predominantly stable and well compacted gravel substrate (Obermeyer 1996, Obermeyer *et al.* 1997b). Although some species are more abundant in deeper habitats, such as the washboard (*Megalonaias nervosa*) (Obermeyer 1997a), this abundance may be the result of deepwater habitat serving as refugia from drought and mussel harvesting rather than being a preferred habitat of a species (see Cochran and Layzer 1993). Another characteristic common to riverine mussels in Kansas is their association with stable instream habitats, which is especially noticeable in streams with a high rate of channel migration. In meandering streams like the Neosho River (Dort 1998), mussels are mostly restricted to stable reaches, such as where the river meets limestone outcrops (Obermeyer 1996, Obermeyer *et al.* 1997a).

3. Causes for the Decline

There are many potential causes for the decline of mussels in southeast Kansas. Factors such as habitat degradation and fragmentation and point and nonpoint source pollution are implicated in mussel declines throughout North America (*e.g.* Ortmann 1909, Baker 1928, van der Schalie 1938, 1958, Fuller 1974, Stansbery 1973, Bogan 1993, Neves 1993, Neves *et al.* 1997), including southeast Kansas (Obermeyer *et al.* 1997a). These factors may affect all four life stages of a species or may be especially detrimental to a particular life phase. More recently, the nonindigenous zebra mussel (*Dreissena polymorpha*), because of its reproductive prolificacy and competitive interaction with native mussels, has begun to wreak havoc on mussels in states as close as Oklahoma.

The deterioration of Kansas' water resources is a widespread problem for the state's freshwater mussel assemblage. The persistent influx of organic nutrients from point (*e.g.* municipal effluents) and nonpoint source pollution, particularly agricultural sources, is a major problem for mussels in Kansas. Eutrophication and resulting deficits in dissolved oxygen, especially in interstitial habitats, may be detrimental to juvenile mussels, resulting in poor recruitment in sensitive species. Sparks and Strayer (1998) observed stress responses (gaped valves, extended siphons, and surfacing) in juveniles of *Elliptio complanata* when subjected to dissolved oxygen (DO) levels less than 2 mg l^{-1}, and found a significant increase in mortality when they were held at this concentration of DO for one week. They speculated that behavioral responses to low DO may make juvenile mussels more vulnerable to predation and displacement. The reproductive stage of gravid females may also be adversely affected by an increased risk of bacterial and protozoan attacks to fertilized ova and glochidia (van der Schalie 1938, Fuller 1974).

Another cause of stream deterioration in Kansas is high sediment loads from chiefly agricultural runoff, which is considered the most serious pollutant of North American streams (Waters 1995). Anthropogenic sediment degrades mussel habitats by covering the substrate and by decreasing substrate permeability. Sparks and Strayer (1998) suggested that substrate permeability was an important factor in determining DO availability to juvenile mussels. Because juvenile mussels are restricted to primarily interstitial habitats (Isely 1911, Clarke 1986, Neves and Widlak 1987, Yeager *et al.* 1994), the smothering effect of silt is probably a major factor in preventing successful recruitment for sensitive species. The smothering effect of silt is also linked to mortality in adult mussels (Ellis 1936, Imlay 1972). Moreover, elevated levels of suspended solids can interfere with visually-oriented reproductive adaptations, gas exchange (Ellis 1936, Aldridge *et al.* 1987), and the brooding of glochidia (Ellis 1931). Suspended solids can also interfere with filter feeding, causing both a decrease in the productivity of the organisms consumed by mussels (Fuller 1974) and in the filtering efficiency of food particles (Ellis 1936, Stansbery 1970, Kat 1982).

The decrease in mussel abundance and diversity in Kansas' streams and rivers can be attributed to a combination of factors and the persistence of these factors rather than any single cause or event. However, abrupt mussel declines from events like exposure to toxic spills are documented in Kansas. Examples include oil and saltwater spills into the Cottonwood River (Doze 1926), feedlot runoff into the Cottonwood River during the 1960s (Cross and Braasch 1968, Prophet 1969, Prophet and Edwards 1973), and contamination by heavy metals from mine tailings into the Spring River (KDHE 1980, Davis and Schumacher 1992). These effluents can have devastating results to mussels, especially less tolerant species that are unable to close their valves and cease siphoning during intermittent pulses of toxins.

Anthropogenic habitat modifications can also lead to declines in mussel diversity and abundance (Stansbery 1970, 1973, Fuller 1974, Williams *et al.* 1993, Bogan 1993, Layzer and Madison 1995). Instream gravel mining affects mussels by increasing sediment loads downstream, accelerating bank erosion and channel migration, and upstream headcutting (Hartfield 1993). When a stream is dammed, the impounded stream channel is transformed from a free-flowing, well-oxygenated environment to one that is more stagnant and prone to silt deposition, an intolerable condition for many riverine mussel species. The suitability of downstream habitats for mussels is also influenced by the operation of dams. The discharge of accumulated flood waters from reservoirs may be maintained at half- to full-channel capacity for extended periods, confining the energy of a flood to the downstream channel rather than allowing it to be distributed over the flood plain. The result can be a degradation of the stream channel by bed downcutting and/or lateral migration (Williams and Wolman 1984, Obermeyer *et al.* 1997a, Poff *et al.* 1997, Hadley and Emmett 1998). Dams are also barriers to host fish, preventing upstream and downstream recolonization.

B. OVERVIEW OF RIVER BASINS

The Neosho, Spring, and Verdigris river basins are located in the Flinthills and Central Irregular Plains ecoregions (Omernik 1987), formerly an extensive area of grasslands dominated by warm season grasses, with riparian forests bordering most perennial streams. Although degraded from over a century of intensive cattle grazing, native grasslands remain in some of the uplands of the Neosho and Verdigris river basins where upland soils are too shallow to permit cultivation. Because of rich alluvial soils in the flood plains, bottomland prairie communities have been replaced by intensive agriculture, with the exception of a few relict patches. Many of the riparian forests along major streams have been reduced to thin ribbons of trees.

Principal streams and drainage areas (km^2) in the Neosho River basin include the Neosho (15,000) and Cottonwood (4,940) rivers. Major streams in the Verdigris River basin include the Verdigris (8,690), Fall (2,290), and Elk (1,820) rivers. Water flow in these streams are subject to flow interruptions during severe droughts (Deacon 1961, Miller and Obermeyer 1997) and by operation of flood-control impoundments. The flow regime of the Neosho River is regulated by Council Grove Lake and John Redmond Reservoir, and the flow of the Cottonwood River is affected by Marion Lake. Flows of the Verdigris, Fall, and Elk rivers are influenced by Toronto, Fall River, and Elk City dams.

The Spring River basin drains approximately 5,414 km^2 of southwest Missouri, and 1373 km^2 in southeast Kansas (Davis and Schumacher 1992). Principal streams of the basin in Kansas are the Spring River and Shoal Creek, both of which originate from the Ozark Plateau. Unlike streams in the Neosho and Verdigris basins, the hydrology of the Spring River basin has not been altered by flood-control impoundments. Moreover, the Spring River and Shoal Creek are more tolerant of drought because of spring-fed flows. Differences in geology and land use (*e.g.* 45% of the Shoal Creek watershed is forested, Davis and Schumacher 1992) result in lower turbidities than most other Kansas streams, and may help explain why the Spring River and Shoal Creek have richer aquatic faunas than other Kansas streams (Cross and Collins 1995). However, mussel species richness is not significantly different in the Spring River basin from the Neosho and Verdigris river basins (Obermeyer *et al.* 1997b). Despite the rich diversity of mussels and other aquatic organisms in the Spring River basin, past mining has resulted in the contamination of several streams with heavy metals, such as zinc, lead, copper, and cadmium (KDHE 1980, Davis and Schumacher 1992). This contamination has apparently eliminated much of the mussel fauna in the lower Spring River (Obermeyer *et al.* 1997a).

C. RECOVERY STRATEGY

An ecosystem approach is the most appropriate way to recover these four mussel species. The goal of ecosystem management of rivers is to restore the biological integrity of the river ecosystem (Poff *et al.* 1997). Accomplishment of this goal may require changing dam operations to mimic natural flow regimes. Adopting land management practices that reduce the delivery of nutrients and sediments into streams will also be required.

The recovery of these species will also require species-level management (Noss *et al.* 1995), especially for fragmented populations. Even in pristine environments, natural recolonization may be insufficient to balance extinction in sparse and fragmented populations (Vaughn 1993). The rabbitsfoot in the Neosho River is a good example. Because it is dangerously close to becoming extirpated in the Neosho River basin, watershed improvements alone are probably too little, too late. Instead, a species-level approach will be required, which might include, for example, reestablishing the species into stream reaches where it has become extirpated.

II. Species Accounts

A. NEOSHO MUCKET *LAMPSILIS RAFINESQUEANA* FRIERSON 1927

1. Taxonomy and Description

Original Description.—*Lampsilis rafinesqueana* Frierson 1927, a classified and annotated check list of the North America naiades, Baylor University Press, 111 p. Type locality: Moodys, Oklahoma [Illinois River: 10 mi. N Tahlequah, Cherokee County]. Holotype (MZUM 87576) was figured in Frierson, L.S., 1928, Nautilus 41:138, pl. 1, figs. 1,2; paratypes are MZUM 90665 and ANSP 145238; allotype (MZUM) is presumed lost (Johnson 1980).

Taxonomic Discussion.—Prior to Frierson's (1927) description of the Neosho mucket, the species was identified in Kansas as *Actinonaias carinata, A. ligamentina, A. ligamentina carinata, Lampsilis ligamentina, L. ligamentina gibba, L. powellii, Unio ligamentina, and U. powellii* (Eberle 1994). Even after Frierson's published description of the Neosho mucket, it was often mistakenly identified as the mucket; that is, *A. ligamentina* or *A. carinata* (*e.g.* Murray and Leonard 1962) (Cope 1979, Mather 1990, D.H. Stansbery, Ohio State University Museum of Biodiversity, pers. comm.). The Neosho mucket was not referred to in Kansas prior to Cope (1979).

Shell characteristics of the Neosho mucket and mucket are remarkably similar, making them difficult to distinguish. The shell of the Neosho mucket can also be confused with the fat mucket (*Lampsilis siliquoidea*), plain pocketbook (*L. cardium*), and aged butterfly (*Ellipsaria lineolata*) females. However, the two species can be separated by locality information, because their ranges do not overlap; *A. ligamentina* does not occur in the Arkansas River system upstream from the Fourche le Fave River in Arkansas (D.H. Stansbery *in* Mather 1990). The two species can also be separated anatomically. The mantle edge of the Neosho mucket is orange with dark markings (Oesch 1984), whereas the mantle edge of the mucket is light to dark brown (Ortmann 1912, Oesch 1984). Neosho mucket females can also be positively identified by a pair of mantle flaps, which are characteristic of the genus *Lampsilis*.

Shell Description (Figure 2).—The shell is smooth, oblong, and relatively thick, especially specimens from the Neosho and Verdigris river basins. Maximum length for the species is 163 mm (6.4 inches) (Obermeyer 1996). The anterior and ventral margins of shell are gently rounded. The posterior end of the female shell is more inflated laterally and more

extended from dorsal to ventral margin than the shell of the male, which is more elliptical and compressed. Beaks extend only slightly beyond the hinge line. The periostracum is olive-yellow to dark brown, with rays consisting of chevrons across the disc of shell in younger specimens. The left valve has two pseudocardinal teeth, whereas the right valve has one erect tooth. The interdentum is broad and sometimes extends about the same distance in length as the lateral tooth, which curves slightly downward. The nacre is creamy white.

2. Historical and Current Distribution

Historical Distribution.—The Neosho mucket is endemic to the Arkansas River system in southeast Kansas, southwest Missouri, northeast Oklahoma, and extreme northwest Arkansas (Obermeyer *et al.* 1997b). Streams where the species occurred in Kansas include the Neosho, Cottonwood†, South Fork of the Cottonwood†, Spring, Verdigris, Elk†, Fall, and Caney† rivers, and Middle†, Otter†, and Shoal† creeks (Obermeyer *et al.* 1997a, 1997b).

Current Kansas Distribution (Figure 3).—In the Spring River, the Neosho mucket is presently found from where the river first enters the state to just downstream from the confluence of Center Creek (Obermeyer *et al.* 1997a, 1997b). Relatively high densities of the Neosho mucket occur throughout this reach of stream. The highest density ever recorded for the species was in this reach, approximately 1.25 km downstream from K-96 highway bridge (site BKO-94-48, Obermeyer *et al.* 1995). Here, the maximum density of Neosho muckets was 67 in a single m^2 quadrat and the average density was 12.9 per m^2 (SD = 20.27) (n = 20 m^2). Although the Neosho mucket was apparently extirpated in the remaining downstream portion of the Spring River (*i.e.* below the confluence of Turkey Creek, near Hwy US-66), two recently dead valves were collected in the Oklahoma portion of this stream in 1996 (Vaughn 1998). In Shoal Creek, the species is likely extirpated downstream from the Joplin wastewater treatment plant (WWTP) near the state line (Clarke and Obermeyer 1996). It remains, however, in the Missouri portion of Shoal Creek (Clarke and Obermeyer 1996).

Obermeyer *et al.* (1997a, 1997b) collected 32 live Neosho muckets at seven of 23 sites in the Neosho River. These were found from near Burlington downstream to a site located in the old Neosho River cutoff channel near St. Paul (BKO-94-23, see Obermeyer *et al.* 1995).

† = Presumed extirpated.

The majority of live Neosho muckets were collected from three sites, located between Iola and Humboldt. These were the only sites in the Neosho River that revealed any evidence of recent recruitment (Obermeyer *et al.* 1995).

In the Verdigris River, Obermeyer *et al.* (1997a, 1997b) found the Neosho mucket restricted to an area from just downstream of the Altoona city dam to near Independence, collecting just five individuals at four of 14 Verdigris River sites. Miller (1992, 1993) found five live Neosho muckets at eight sites (from 320 m^2 quadrat samples) in a ten-mile reach near Sycamore. A follow-up survey at these eight sites in 1997 yielded only two Neosho muckets (Miller 1999b). Additional sampling (120 m^2 quadrats) in 1998 at a new site in this stream reach (EJM-98-01), which is located approximately one mile downstream from site BKO-94-15 (see Obermeyer *et al.* 1995), failed to yield any live or recently dead Neosho muckets (E.J. Miller, KDWP, pers. comm.).

In the Fall River, 34 Neosho muckets were collected at five of 12 sites in 1994 (Obermeyer *et al.* 1997a, 1997b). Live specimens were found downstream from the town of Fall River to near the river's confluence with the Verdigris River. Most of the live Neosho muckets collected were aged adults, although one individual was estimated to be six or seven years of age (Obermeyer *et al.* 1995).

3. Reproduction and Habitat

Reproduction.—Mussels have evolved some fascinating reproductive adaptations to increase the chances that glochidia will make contact with a suitable host. The female Neosho mucket extends a pair of mantle flaps (actually an extension of the inner lobe of the mantle edge, Kraemer 1970) that, from a side angle, remarkably resembles a small fish. Each mantle flap, in addition to its fish-like shape, has pigmentation that resembles an eyespot as well as a fish's lateral line. Muscular contractions of the mantle flaps create an undulating or "swimming" motion that apparently acts as a lure to attract potential fish hosts (Gordon and Layzer 1989, Barnhart and Roberts 1997). If a fish comes close or strikes at the lure, the female Neosho mucket may spray a cloud of glochidia at the fish through ostia or pores of the swollen marsupial gills, which extend between the two mantle flaps.

The Neosho mucket is a bradytictic breeder. Thirteen fish species have been tested under laboratory conditions to determine host suitability for the Neosho mucket. Of these, glochidia transformed on only two species, largemouth bass (*Micropterus salmoides*) and smallmouth bass (*M. dolomieu*) (Barnhart and Roberts 1997). The spotted bass (*M. punctulatus*) is another a likely host (M.C. Barnhart, SMSU, pers. comm.).

Habitat.—The Neosho mucket is most often found in shallow riffle and runs in moderately clean and compacted gravel substrate (Table 2, Figure 5) (Oesch 1984, Obermeyer 1996, Obermeyer *et al.* 1997b). More specific characterizations of habitat use for the species is difficult because of high variability of habitat use among streams, especially between prairie streams (Neosho, Fall, and Verdigris rivers) and Ozarkian streams (Obermeyer *et al.* 1997b, Figure 5). For example, mean current speed (60% depth) at specific locales where the species was collected was 51.8 cm/s higher in the Spring River than in other Kansas streams (Table 2) (Obermeyer 1996, Obermeyer *et al.* 1997b). Also, silt deposition at specific locales where the species was collected was substantially lower in the Spring River compared to the Neosho, Verdigris, and Fall rivers.

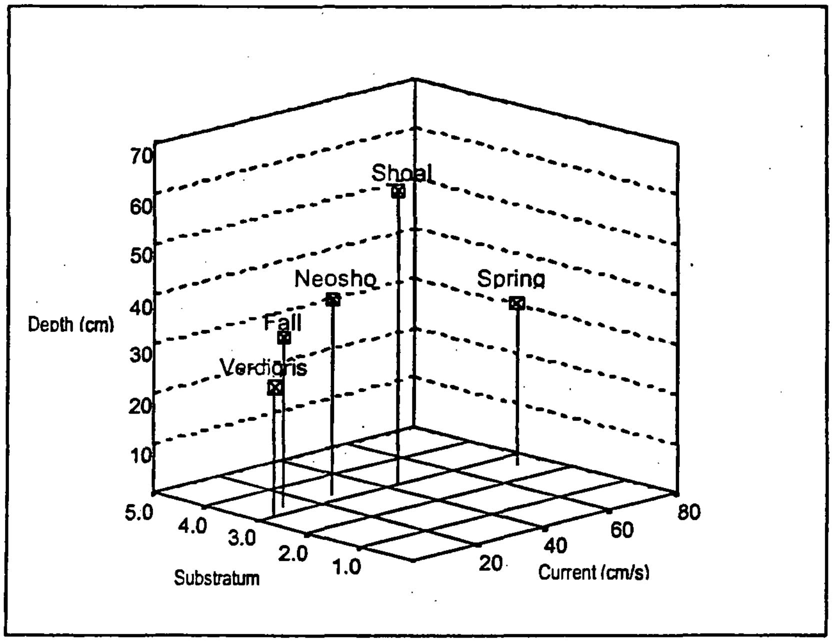

Figure 4. ***Three-dimensional ordination plot of habitat measurements taken for the Neosho mucket in southeast Kansas and southwest Missouri.*** *The substratum value is the proportion of mud (1), sand (2), gravel (3), cobble (4), and boulder (5). Current velocities were taken at depths of 60%. (From Obermeyer 1996)*

TABLE 2. *Habitat use (mean values) for the four mussel species targeted in the Recovery Plan. (From Obermeyer et al. 1997b) Data represents individual habitat use for each mussel collected, with the exception of the Neosho mucket in the Illinois River, Oklahoma*[3].

Species	Stream	n	Depth (cm)	Current speed (cm/s):		Substrate character (%)						
				100% depth	60% depth	Mud	Sand	Gravel	Cobble	Boulder	Compaction[1]	Silt[2]
Neosho mucket												
	Fall	34	34.1	12.4	13.2	0.7	11.7	48.4	37.6	1.5	1.2	1.3
	Verdigris	5	26.2	3.2	5.2	11.0	11.0	52.0	27.0	0.0	1.0	1.6
	Neosho	32	39.6	16.0	27.0	3.3	14.9	41.3	35.9	4.4	1.1	1.4
	Spring	258	33.0	43.5	72.4	1.0	16.4	74.3	0.0	0.0	1.0	0.2
	Shoal Cr.	20	59.4	20.4	42.2	0.3	17.1	74.5	8.3	0.0	0.9	0.1
	Illinois[3]	8	75.9	-	111.3	-	-	82.0	-	-	-	-
Ouachita kidneyshell												
	Fall	17	17.5	12.2	14.1	1.8	13.3	62.0	13.9	6.9	0.9	1.2
	Verdigris	9	19.0	13.2	18.6	2.6	15.3	73.2	8.9	0.0	1.0	1.3
	Spring	12	41.0	26.8	44.4	1.0	24.6	69.0	5.4	0.0	0.9	0.3
	Shoal Cr.	4	73.5	34.9	97.1	0.0	11.8	82.0	7.5	0.0	1.3	0.0
rabbitsfoot												
	Neosho	2	12.5	27.5	38.0	0.5	7.0	60.0	32.5	0.0	1.0	1.0
	Spring	5	44.2	23.8	56.2	0.0	20.0	80.0	0.0	0.0	0.9	0.2
western fanshell												
	Fall	5	29.6	8.4	16.8	0.2	14.2	18.4	45.2	22.0	1.0	1.2
	Verdigris	9	26.5	17.1	20.9	4.1	12.6	7.3	75.1	0.0	0.8	1.5
	Spring	3	37.3	27.2	65.0	0.0	30.0	1.7	68.3	0.0	0.7	0.3

1. Substrate compaction was based on a qualitative assessment, which was coded 0 through 2: loose = 0; moderately compacted = 1; very compacted = 2.
2. Silt deposition: 0 = no detectable silt, 1 = fine layer of silt; 2 = moderately covered with silt; 3 = heavy covering of silt.
3. Data represents average depth, flow, and percent gravel at eight sites in the Illinois River, OK. (Data taken from Vaughn 1998)

4. Designated Critical Habitat (Figure 5)

Critical habitat currently occupied:

- *Neosho River*: from John Redmond dam (Coffey Co.) to Parsons city dam (Labette Co.).
- *Spring River*: from where the Spring River first enters Kansas to the confluence of Turkey Creek, near Hwy US-66 (Cherokee Co.).
- *Fall River*: from Fall River dam (Greenwood Co.) to its confluence with the Verdigris River (Wilson Co.).
- *Verdigris River*: from K-47 (Wilson Co.) to the city of Coffeyville (Montgomery Co.).

Critical habitat, but lacking recent documentation of the species:

- *Neosho River*: from the Morris-Lyon county line to John Redmond Lake; from Parsons city dam (Labette Co.) to the Kansas-Oklahoma border.
- *Cottonwood River*: from Elmdale (Chase Co.) to the river's confluence with the Neosho River (Lyon Co.).
- *South Fork of the Cottonwood River*: from Bazaar to the river's confluence with the Cottonwood River (Chase Co.).
- *Spring River*: from Empire Lake dam (Cherokee Co.) to the Kansas-Oklahoma border.
- *Shoal Creek*: from the Kansas-Missouri border to Empire Lake (Cherokee Co.).
- *Big Caney River*: from US-166 (Chautauqua Co.) to the Kansas-Oklahoma border.
- *Elk River*: from Elk Falls (Elk Co.) to Elk City Lake (Montgomery Co.).
- *Fall River*: from K-99 to Fall River Lake (Greenwood Co.).
- *Otter Creek*: from K-99 to Fall River Lake (Greenwood Co.).
- *Verdigris River*: from Toronto Lake dam to K-47 (Wilson Co.), and from the city of Coffeyville (Montgomery Co.) to the Kansas-Oklahoma border.

B. OUACHITA KIDNEYSHELL *PTYCHOBRANCHUS OCCIDENTALIS* (Conrad 1836)

1. Description

Original Description.—Unio occidentalis Conrad 1836, monography of the Family Unionidae, or naiades of Lamarck, (fresh water bivalve shells) of North America, figures drawn on stone from nature, privately published in Philadelphia, Pennsylvania. 7:57-64, plates 32-36; type locality: Currant River [= Current River, Randolph County], Arkansas; figured holotype not found (Johnson and Baker 1973).

Shell Description (Figure 6).—The shell is compressed to slightly inflated and oblong; younger specimens are more oval in shape. Maximum length of shell in Kansas is 143 cm (5.5 inches) (BKO, unpub. data). The anterior end is gently and uniformly rounded, whereas the posterior end is pointed in a downward direction; ventral margin is straight to concave. The shell is sturdy and relatively thick, and the surface is smooth, other than concentric growth-rest lines. The posterior ridge is rounded to absent, and the posterior field is steeply sloped in males, more gradual in females. Beaks are slightly elevated and sculpturing is absent. The periostracum is straw-colored to greenish-yellow, with fine green rays that extend from the umbonal region to the shell margin. The left valve has two pseudocardinal teeth and two lateral teeth. The groove between the two lateral teeth in the left valve points to the middle of the posterior adductor muscle scar. The right valve has one pseudocardinal tooth and one lateral tooth. The lateral teeth curve downward about one-fourth the length of valve. A distinct shelf runs along the ventral edge of the lateral tooth in the right valve. The interdentum is broad and extends approximately three-fourths to an equal distance in length as the lateral teeth. A sulcus or groove, which accommodates the marsupial gill, originates in the umbonal region and extends in a posterior-ventral angle to near the pallial line. The sulcus is less pronounced in the shell of males. Nacre is creamy white, with iridescence posteriorly.

2. Historical and Current Distribution

Historical Distribution.—The Ouachita kidneyshell historically occurred in the Arkansas, Meramec, Ouachita, Red, St. Francis, and White river systems in Arkansas, Kansas, Missouri, and Oklahoma (Johnson 1980). Although earlier published accounts of the species in the Meramec River basin (Buchanan 1980, Oesch 1984) have been questioned because of possible specimen mislabeling (Obermeyer *et al.* 1997a), the species was apparently collected

from Meramec State Park in 1956 by Morris Jacobson (K.S. Cummings, Illinois Natural History Survey, pers. comm.). The species may have also occurred in the upper Osage River system, based on UMMZ specimens (K.S. Cummings, pers. comm.). Call (1885b) lists the species in the Wakarusa River (Call 1885b); however, Scammon (1906) failed to find the species there. The Wakarusa specimen may have been confused with the spike (*Elliptio dilatata*). The Ouachita kidneyshell is thought to be extirpated from the Neosho, Cottonwood, South Fork of the Cottonwood, Caney, and Elk rivers, and Shoal and Otter creeks (Obermeyer *et al.* 1997a). Its occurrence elsewhere in the state is questionable.

Current Kansas Distribution (Figure 7).—Miller (1992) collected seven live specimens at four of eight Verdigris River sites. Resampling of these sites in 1997 yielded 21 individuals from five sites (Miller 1999b). Twenty-one individuals were collected in 1998 from another site, EJM-98-01, in the same stretch of river (E.J. Miller, pers. comm.; Miller 1999a). Obermeyer *et al.* (1997a, 1997b) collected 11 live Ouachita kidneyshells at four Verdigris River sites between Altoona and Independence. The species is apparently extirpated above and below this reach. In the Fall River, 19 specimens were collected from near the city of Fall River to the river's confluence with the Verdigris River. In the Spring River, 34 live specimens were collected (Obermeyer *et al.* 1997a, 1997b). Although the species is apparently extirpated in the Kansas portion of Shoal Creek, Clarke and Obermeyer (1996) collected six individuals at Shoal Creek sites in Missouri.

3. Reproduction and Habitat

Reproduction.—The Ouachita kidneyshell is a bradytictic breeder (Johnson 1980, Barnhart and Roberts 1997), which releases glochidia packets from pleated marsupial gills in early spring (Barnhart and Roberts 1997). Each packet, which strikingly resembles a larval fish, contains 200-plus glochidia housed inside a membranous sheath measuring 1 to 1.5 cm in length (Barnhart and Roberts 1997). Glochidia packets are readily taken as food by darters, which, during the process of consumption, infect themselves with glochidia (Barnhart and Roberts 1997). The orangethroat (*Etheostoma spectabile*), greenside (*E. blennioides*), yoke (*E. juliae*), and rainbow (*E. caeruleum*) darters have been identified as potential hosts (Barnhart and Roberts 1997). Of these four species, only the greenside darter and orangethroat darter are found in southeast Kansas. The greenside darter is found in the Spring River basin, whereas

the orangethroat darter is widely distributed in all three stream basins (Pflieger 1975, Cross and Collins 1995).

Habitat.—According to Buchanan (1980) and Oesch (1984), the preferred habitat of the Ouachita kidneyshell is riffle habitat with a gravel-sand substrate having a moderate current at depths between 2.5 and 75 cm. In southeast Kansas and southwest Missouri, Obermeyer *et al.* (1997b) found the Ouachita kidneyshell in well compacted and relatively clean riffle habitats, usually in or near the swiftest flows, with stable sand and gravel substrate (Figure 8, Table 2). However, depth and current speed where the species was collected varied greatly between different streams (Figure 8, Table 2).

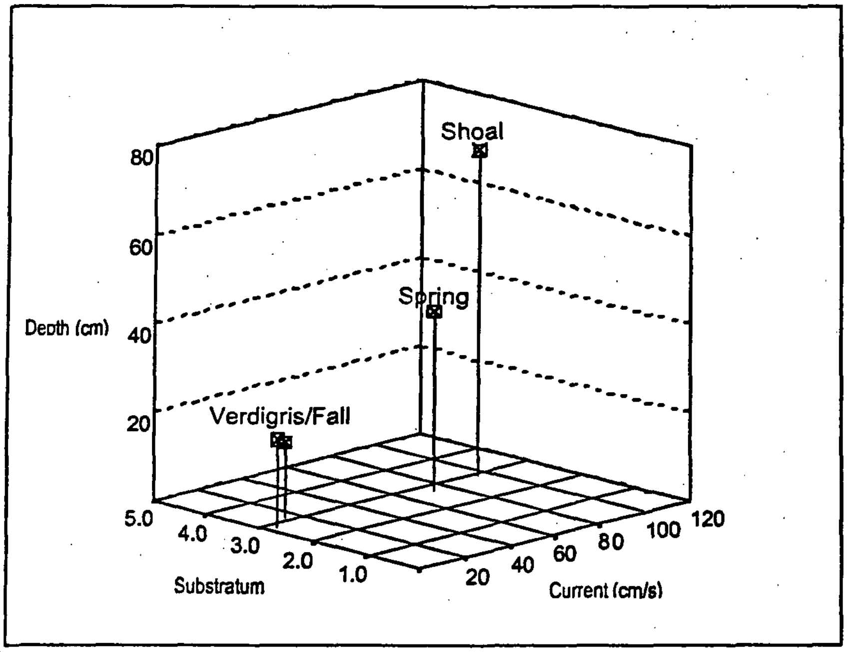

Figure 8. ***Three-dimensional ordination plot of habitat measurements taken for the Ouachita kidneyshell in southeast Kansas and southwest Missouri.*** *The substratum value is the proportion of mud (1), sand (2), gravel (3), cobble (4), and boulder (5). Current velocities were taken at depths of 60%. (From Obermeyer 1996)*

4. Designated Critical Habitat (Figure 9)

Critical habitat currently occupied:

- *Spring River*: from where the Spring River first enters Kansas to US-66 (Cherokee Co.).
- *Fall River*: from Fall River dam (Greenwood Co.) to its confluence with the Verdigris River (Wilson Co.).
- *Verdigris River*: from K-47 (Wilson Co.) to the city of Independence (Montgomery Co.).

Critical habitat, but lacking recent documentation of the species:

- *Neosho River*: from the Morris-Lyon county line to the Kansas-Oklahoma border.
- *Cottonwood River*: from Florence (Chase Co.) to its confluence with the Neosho River (Lyon Co.).
- *South Fork of the Cottonwood River*: from Bazaar to the river's confluence with the Cottonwood River (Chase Co.).
- *Spring River*: from Empire Lake dam (Cherokee Co.) to the Kansas-Oklahoma border.
- *Shoal Creek*: from the Kansas-Missouri border to Empire Lake (Cherokee Co.).
- *Big Caney River*: from US-166 (Chautauqua Co.) to the Kansas-Oklahoma border.
- *Elk River*: from Elk Falls (Elk Co.) to Elk City Lake (Montgomery Co.).
- *Fall River*: from K-99 to Fall River Lake (Greenwood Co.).
- *Verdigris River*: from Toronto Lake dam to K-47 (Wilson Co.), and from the city of Independence (Montgomery Co.) to the Kansas-Oklahoma border.

C. RABBITSFOOT *QUADRULA CYLINDRICA CYLINDRICA* (SAY 1817)

1. Description

Original Description.—*Unio cylindricus* (Say 1817), article "Conchology," *In*: Am. Ed. of Nicholson's Encyclopedia of Arts and Sci., 1st ed.; type locality: Wabash River.

Shell Description (Figure 10).—The shell is elongate and rectangular, and inflated to the point that shells are nearly cylindrical in cross section. Valves are sturdy and relatively thick, although much thinner posteriorly. Maximum shell length in Kansas is 127 mm (5 inches) (Obermeyer 1996). The posterior ridge, which extends from the umbonal region to the posterior ventral margin, is rounded and sculptured with a row of knobs. The posterior slope is covered with fluting that angle posteriorly to the dorsal margin. The remaining surface of shell is smooth, with the exception of low concentric ridges formed by growth-rest lines. The umbonal region is moderately elevated above the hinge line, and is covered with irregular ridges and small pustules; lunule present. The periostracum is straw-colored to yellowish-brown, and is usually overlaid with dark green streaks, chevrons, and/or triangular markings. The left valve has two triangular pseudocardinal teeth and two straight lateral teeth. The right valve has a single serrated pseudocardinal tooth and a single straight lateral tooth. The anterior mussel scar is deeply incised in both valves. Interdentum is narrow to absent. The umbonal cavity is relatively deep. The nacre is white, iridescent posteriorly.

2. Historical and Current Distribution

Historical and Current Distribution (Figure 11).—The rabbitsfoot is native to the Ozarkian, Ohioan, and Cumberlandian faunal regions of 13 states (Williams *et al.* 1993). In Kansas, the species historically occurred in the Neosho, Cottonwood, Spring, Verdigris, and Fall rivers, and Shoal Creek (Obermeyer *et al.* 1997a). Extant representatives of the rabbitsfoot have recently been found in only two Kansas streams: the Neosho and Spring rivers. Two specimens were collected in the Neosho River in 1994, which was the first live collection of the species in the Neosho River since 1912 (Isely 1924, Obermeyer *et al.* 1997a, 1997b). Sampling at 21 additional Neosho River sites failed to recover evidence of extant populations, but relic valves of the species were found at nine of these sites. In the Spring River, five specimens were collected from one Kansas and two Missouri sites (Obermeyer *et al.* 1997b); five additional individuals were collected at the Kansas Spring River site in 1996 (BKO, unpub. data).

3. Reproduction and Habitat

Reproduction.—Except for breeding records by Utterback (1915) and Ortmann (1919), knowledge of the life history of the rabbitsfoot is based mostly on an eastern subspecies, the rough rabbitsfoot (*Q. cylindrica strigillata*). Yeager and Neves (1986) found the rough rabbitsfoot to be tachytictic, with the bigeye chub (*Notropis amblops*), spotfin shiner (*Cyprinella spiloptera*), and whitetail shiner (*C. galactura*) potential hosts. Obermeyer *et al.* (1997a) suspected that host specificity may be different between these two subspecies because suitable hosts identified by Yeager and Neves (1986) are believed to be absent in the Neosho River (Cross 1967, F.B. Cross, University of Kansas, pers. comm.).

Habitat.—The rabbitsfoot inhabits sand-gravel substrates at depths up to 10 feet of water (Parmalee 1967, Cummings and Mayer 1992) with a detectable current (Parmalee 1967), to shallow near-shore habitats in cobble substratum with a slack current (Stansbery 1974), or in close proximity to the swiftest flows (Gordon and Layzer 1989). In southeast Kansas and southwest Missouri, Obermeyer *et al.* (1997a) found the species in predominantly gravel substrates at depths up to a half meter (Table 2).

5. Designated Critical Habitat (Figure 12)

Critical habitat currently occupied:

- *Spring River*: from where the Spring River first enters Kansas to US-66 (Cherokee Co.).
- *Neosho River*: from Iola to Humboldt (Allen Co.).

Critical habitat, but lacking recent documentation of the species:

- *Neosho River*: from John Redmond dam (Coffey Co.) to the Kansas-Oklahoma border.
- *Cottonwood River*: from its confluence with the South Fork of the Cottonwood River (Chase Co.) to its confluence with the Neosho River (Lyon Co.).
- *Spring River*: from Empire Lake dam (Cherokee Co.) to the Kansas-Oklahoma border.
- *Shoal Creek*: from the Kansas-Oklahoma border to Empire Lake (Cherokee Co.).
- *Fall River*: from the Fredonia city dam to the river's confluence with the Verdigris River (Wilson Co.).
- *Verdigris River*: from K-47 (Wilson Co.) to the Kansas-Oklahoma border.

D. WESTERN FANSHELL *CYPROGENIA ABERTI* (CONRAD 1850)

1. Taxonomy and Description

Original Description.—*Unio aberti* (Conrad 1850), descriptions of a new species of *Unio*, Proc. Acad. Nat. Sci. Phila. Vol. 5, p. 10. Holotype [presumed lost] was figured by Conrad in Proc. Acad. Nat. Sci. Phila., 2nd series, Vol. II, Plate XXIV, Figure 1 (1851); type locality: Verdigris River, Arkansas [Oklahoma].

Taxonomic discussion.—The western fanshell was first collected by Samuel Woodhouse in 1849 at Chamber's Ford in the Verdigris River, Oklahoma. Conrad (1850) described Woodhouse's specimen and named it *Unio aberti.* Two year's later, Isaac Lea described and figured a similar mussel from Arkansas, which he named *Unio lamarckianus* (Lea 1852) (Holotype USNM 84306; type locality: White River, Arkansas). Lea (1870) later surrendered *lamarckianus* to *aberti.* Despite Lea's dropping of *lamarckianus*, Simpson (1914) stated: "...apparently well worthy of a varietal name". Call (1885a) described and named specimens from the Verdigris River, Kansas, as *Unio popenoi* (Figure 13; Holotype MCZ 4943). He later acknowledged that *aberti* should take precedence over *popenoi* (Call 1887a). Simpson (1900) listed *Cyprogenia* from the St. Francis and Saline rivers as *irrorata* (= *stegaria*) var. *pusilla*, but mentioned that they may be *aberti.* Call (1895) regarded specimens taken from both the Saline River and St. Francis River as *irroratus* (= *stegaria*), although he mentioned that young specimens from the St. Francis River were similar to *aberti.* Scammon (1906) stated: "As compared with specimens before me from the White River, Arkansas, the Kansas form [Arkansas River system] is a much larger, more inflated, and massive shell, with smaller muscle cicatrices." Frierson (1927) noted that *stegaria, stegaria-pusilla*, and *aberti* nearly merge into one unbroken chain across Arkansas. Johnson (1980) stated that *aberti* and *stegaria* closely resemble one another, but that *aberti* has a narrower, more compressed posterior slope.

Shell Description (Figure 13).—The shell is thick, round to triangular, and moderately compressed. The maximum size of shell is 89 mm (3.5 inches) (Couch 1997). Beaks are low, extending only slightly beyond the hinge line, compressed, and turned forward over the lunule; beak sculpturing is absent. The outside surface of shell has a wrinkled appearance, especially in the dorsal region of a shallow sulcus, which is situated anteriorly to the posterior ridge. The shell is marked by raised growth-rest lines that form concentric ridges that can be pronounced,

particularly those produced by second- and third-year rest periods. The periostracum is olive-tan overlaid with dark green specks and dots that are arranged in rays, extending from the umbonal region to the shell margin. Two lateral teeth and two pseudocardinal teeth are found in the left valve, with the posterior pseudocardinal tooth being the largest. One triangular pseudocardinal tooth and one lateral tooth are found in the right valve. The interdentum is broad, the beak cavity is shallow, and the nacre is creamy white, often iridescent posteriorly.

2. Historical and Current Distribution

Historical Distribution.—The western fanshell is endemic to the Arkansas, Ouachita, White, and St. Francis river systems of Arkansas, Kansas, Missouri, and Oklahoma. Its previously reported presence in the Meramec River basin of Missouri (Buchanan 1980, Oesch 1984) is questionable because of suspected mislabeling of specimens (Obermeyer *et al.* 1997b). The species is locally common at a number of sites in the Ouachita and White river systems in Arkansas (J.L. Harris, Arkansas Transportation Department, pers. comm.; BKO, pers. observ.), but is restricted to a small reach of the St Francis River in Missouri (Clarke 1985, Ahlstedt and Jenkinson 1991). In the Arkansas River system, the western fanshell is rare in Kansas and Missouri (Obermeyer *et al.* 1997b), and is considered extirpated in Oklahoma (Mather 1990). In Kansas, the species was historically found in the Neosho, Spring, Elk, Fall, and Verdigris rivers (Obermeyer *et al.* 1997a, 1997b). Although the species has not been reported from Shoal Creek, it is possible it has been overlooked.

Current Kansas Distribution (Figure 14).—In the Spring River, the western fanshell is apparently restricted from Carthage, Missouri, to near the confluence of Center Creek in Kansas (Obermeyer *et al.* 1996); it is unlikely that the species occurs downstream (Obermeyer *et al.* 1997b). The maximum number of individuals recently collected at any one site in the Spring River was seven (Obermeyer *et al.* 1995). The species was apparently more common in the Spring River in the early 1980s than at present (Charles Cope, KDWP, pers. comm.).

Miller (1992) collected four western fanshells in the Verdigris River near Syracuse. Obermeyer *et al.* (1995, 1997a, 1997b) collected 11 individuals at four Verdigris River sites. Resampling of refuge study sites by Miller (1999b) in 1997 yielded 16 specimens. Additional sampling during summer 1998 recovered three specimens (E.J. Miller,

pers. comm., Miller 1999a). The highest concentration of the western fanshell in this stream appears to be in southern Wilson and northern Montgomery counties. It is likely extirpated downstream from Independence and upstream from Altoona. In the Fall River, five specimens were collected from four sites, all of which were found downstream of Fall River Lake to near the river's confluence with the Verdigris River (Obermeyer *et al.* 1997a, 1997b).

3. Reproduction and Habitat

Reproduction.—The marsupial demibranchs of the female western fanshell are coiled (Call 1885a, 1887a, 1887b, Chamberlain 1934). These function to accommodate worm-like conglutinates (Ortmann 1912, Chamberlain 1934, Barnhart 1997a), which may be as much as 8 cm in length. Barnhart (1997a, 1997b) estimated that each conglutinate consists of approximately 30,000 eggs. Only the eggs along the periphery of the conglutinate are fertilized (~15-20% of the total). The unfertilized eggs may serve as bait for potential hosts by giving the conglutinate color (white; mature glochidia are transparent), as well as, perhaps, taste and odor.

Chamberlain (1934) observed the release of western fanshell conglutinates in late winter, whereas M.C. Barnhart (pers. comm.) noted the periodic release of conglutinates during winter and spring months. Barnhart (1997a) identified the banded sculpin (*Cottus carolinae*), fantail darter (*Etheostoma flabellare*), and logperch (*Percina caprodes*) as suitable hosts.

Habitat.—Generalized habitat descriptions for the western fanshell is shallow water (7-45 cm) with sand and gravel substrates (Buchanan 1980, Oesch 1984). In Kansas, average depth is approximately 25 to 40 cm (Table 2), although the species is often found at much greater depths in the White and Black rivers in Arkansas (J.L. Harris, unpub. data). Obermeyer *et al.* (1997b) found the species in a higher percentage of cobble substrate than the other target species (Table 2). The species is sometimes buried in coarser substrates (Oesch 1984, BKO, pers. observ.).

4. Designated Critical Habitat (Figure 15)

Critical habitat currently occupied:

- *Spring River*: from where the Spring River first enters Kansas to US-66 (Cherokee Co.).
- *Fall River*: from Fall River dam (Greenwood Co.) to the river's confluence with the Verdigris River (Wilson Co.).
- *Verdigris River*: from K-47 (Wilson Co.) to the city of Independence (Montgomery Co.).

Critical habitat, but lacking recent documentation of the species:

- *Neosho River*: from John Redmond dam (Coffey Co.) to the Kansas-Oklahoma border.
- *Spring River*: from Empire Lake dam (Cherokee Co.) to the Kansas-Oklahoma border.
- *Shoal Creek*: from the Kansas-Oklahoma border to Empire Lake (Cherokee Co.).
- *Fall River*: from K-99 to Fall River Lake (Greenwood Co.).
- *Verdigris River*: from Toronto Lake dam to K-47 (Wilson Co.), and from the city of Independence (Montgomery Co.) to the Kansas-Oklahoma border.

III. RECOVERY

A. OBJECTIVES

The ultimate objective of this recovery plan is to prevent the extirpation of the four target mussel species from Kansas, and to restore populations so they can be removed from the Kansas list of endangered, threatened, and SINC species. Reestablishment of viable populations[1] of these four species throughout their former range will not be an easy task given the current condition of watersheds and streams in southeastern Kansas. However, recovering these species to a point where delisting criteria can be met should be an obtainable goal, although, admittedly, not an easy one. Recovery and subsequent delisting of these mussels will require aggressive watershed conservation efforts as well as a propagation program. A better understanding of each species' ecological requirements is essential to successfully achieve this goal. Another important objective of this recovery plan is the recovery—through watershed enhancements—of other state-listed mussel species that occur in southeast Kansas (Table 1).

B. RECOVERY CRITERIA

The four target species should be considered for listing reclassification when: i.) recovery tasks outlined in *Section III—C* have been initiated or completed and ii.) populations are protected from current and foreseeable threats that might jeopardize their continued existence. Under such circumstances, KDWP's formal petition listing process will be followed. Recovery criteria specific to each species are summarized in Table 3.

[1] A viable population is defined as a group of reproducing individuals separated by barriers or unsuitable habitat (*e.g.* a riffle site isolated by unsuitable habitat by distances greater than 10 km).

TABLE 3. ***Downlisting criteria for the Neosho mucket, Ouachita kidneyshell, rabbitsfoot, and western fanshell in southeast Kansas.*** *In addition to the following criteria, downlisting will require completion or initiation of recovery tasks outlined in Section III—C and that populations are protected from any current and foreseeable threats that might jeopardize their continued existence.*

Species	Downlisting steps	Downlisting criteria
Neosho mucket	*Downlist to threatened*	A minimum of four populations present in each of the Neosho, Verdigris, Fall, and Spring rivers. A minimum of three age classes must be found in these populations, one of which has naturally produced within five years of the downlisting date. Gravid females and suitable host fishes must be present.
	Downlist to SINC	Same as above except six populations must be present in each of the above mentioned streams. In addition, four populations shall be reestablished in both the Cottonwood and Neosho rivers (two upstream from John Redmond Reservoir and two downstream from the Parsons city dam to the KS-OK border). Two populations shall also be reestablished in each the upper Fall and Verdigris rivers (above Federal impoundments), in the lower Spring River (downstream from Empire Lake), and in Shoal Creek. Reestablished populations must be self-perpetuating, with gravid females and suitable host fishes present.
	Delist	Self-perpetuating populations present throughout 75% of the species' historical range in Kansas.
Ouachita kidneyshell	*Downlist to SINC*	A minimum of six populations present in each of the Verdigris, Fall, and Spring rivers, with a minimum of three age classes, one of which has naturally produced within five years of the downlisting date. Gravid females and suitable host fishes must also be present. In addition, two reestablished populations shall be present in each the Elk River, lower Spring River (downstream from Empire Lake), Shoal Creek, and in each of the upper Neosho, Fall, and Verdigris rivers (above Federal impoundments). Four reestablished populations shall be present in both the Cottonwood River and in the Neosho River downstream from John Redmond dam. Reestablished populations must be self-perpetuating, with gravid females and suitable host fishes present.
	Delist	Self-perpetuating populations present throughout 75% of the species' historical range in Kansas.

TABLE 3 *(continued).*

Species	Downlisting steps	Downlisting criteria
rabbitsfoot	*Downlist to threatened*	Four distinct populations present in each of the Neosho and Spring rivers, with a minimum of three age classes, one of which has naturally produced within five years of the downlisting date. Gravid females and suitable host fishes must be present.
	Downlist to SINC	Same as above except that six distinct populations must be present in each of the above mentioned rivers, as well as three reestablished populations in each the lower Verdigris and Fall rivers, and two reestablished populations n the lower Spring River downstream from Empire Lake. Reestablished populations must be self-perpetuating, with gravid females and suitable host fishes present.
	Delist	Self-perpetuating populations present throughout 75% of the species' historical range in Kansas.
western fanshell	*Downlist to threatened*	Four distinct populations present in each of the Verdigris, Fall, and Spring rivers. A minimum of three age classes must be found in these populations, one of which has naturally produced within five years of the downlisting date. Gravid females and suitable host fishes must be present.
	Downlist to SINC	Same as above except: six distinct populations must be present in each of the Verdigris and Fall rivers; two reestablished populations shall be present in the lower Spring River (downstream from Empire Lake) and in both the upper Verdigris and Fall rivers; and four reestablished populations shall be present in the lower Neosho River (downstream from John Redmond dam to the KS-OK border). Reestablished populations must be self-perpetuating, with gravid females and suitable host fishes present.
	Delist	Self-perpetuating populations present throughout 75% of the species' historical range in Kansas.

IV. NARRATIVE OUTLINE

1. Protect existing populations and occupied habitats of state-listed mussels in the Neosho, Spring, and Verdigris river basins. Preservation of existing populations and critical habitats is essential in order to restore these species.

1.1. Promote stewardship to protect and/or restore essential habitats for the recovery of state-listed mussels and to reduce nonpoint source pollution. Because most Kansas streams and watersheds are privately owned, the willingness of landowners to participate in recovery activities is essential for the recovery of these mussels and critical habitats.

1.1.1. Provide state income tax credits to landowners who voluntarily enter into recovery plan agreements to protect and/or restore instream and riparian habitats. A recovery plan agreement must meet the following criteria: i.) participant shall carry out management activities specified in a recovery plan; ii.) property meets habitat designation criteria for the targeted T&E species; iii.) agreement shall be no less than five years; and iv.) KDWP and other essential personnel will have access to the property for the duration of the agreement for monitoring purposes. In exchange, landowners would receive state income tax credits equal to the amount of property taxes paid on acreages deemed by KDWP as necessary for the recovery of state-listed mussels and for costs incurred while complying with recovery plan agreements. Project eligibility will be dependent upon location (Appendix A). Tax credits would be granted for each year's enrollment in a recovery plan agreement. Before an agreement is signed, KDWP will outline the procedure for applying for state income tax credit.

1.1.1.1. Offer state income tax credits to landowners who agree to protect and restore riparian habitats. Eligible practices include maintaining and/or enhancing riparian habitats (see Appendix B for riparian buffer criteria), planting native vegetation along streams to serve as riparian buffers (Appendix B), preserving or restoring wetlands that are in the 100-year flood zone, and excluding livestock from riparian habitats and streams by building fences and developing alternative watering sources for livestock. The implementation of grazing strategies that minimize riparian damage will be considered along smaller streams, but these practices must first be approved by KDWP.

1.1.1.2. Provide tax credit incentives to farmers and ranchers who implement practices that reduce nonpoint source pollution. For example, planting buffer strips along riparian corridors can reduce nitrate and phosphorus concentrations from surface runoff (Osbourne and Kovacic 1993). Sites must be in a watershed with a HUC-11 (eleven-digit hydrologic unit code) point score of eight or more (see Appendix A). Eligible practices include the entrapment and proper disposal of animal wastes from confined livestock and the planting of field buffers and grassed waterways to retard soil erosion. Refer to the following Natural Resource Conservation Service (NRCS) Conservation Practice Standard Codes for technical specifications, located at http://www.ncg.nrcs.usda.gov/nhcp_2.html: 350 (sediment basins); 638 (water and sediment control basins); 393A (filter strips); 412 (grassed waterways); 570 (runoff management systems).

1.1.1.3. Provide tax credit incentives to landowners who participate in instream and channel rehabilitation projects, such as stream bank stabilization. Proposed instream and streambank stabilization projects must be approved by KDWP before being accepted into a recovery plan agreement.

1.1.1.3.1. Determine priority stream reaches and sites for instream and stream bank restoration projects. Streambank stabilization and instream projects may adversely affect channel morphology and instream habitats (both upstream and downstream). Because of possible risks to mussel habitats from such projects, only restoration sites with a high potential for benefiting mussels should be considered for inclusion into recovery plan agreements.

1.1.1.3.2. Review instream and stream bank restoration projects. Individual projects should be reviewed by experts (Task 10) to ensure that proposed projects would benefit mussels.

1.1.1.4. Provide tax credit incentives to landowners who grant stream access for research purposes. Because stream access is limited in Kansas, it is important to have a mechanism to acquire stream access for research purposes. A landowner of a desired research site would receive a state income tax credit equal to the amount of property tax for acreage on and near the research site, as well as acreage used for accessing the site. A landowner would also receive state income tax credit equal to costs incurred for the maintenance of access roads and other pertinent expenses related to the compliance of the recovery plan agreement. Research activities might include acquiring brood stock and suitable host fishes, seeding juvenile mussels for reintroduction/augmentation projects, and monitoring mussel populations and habitats.

1.1.1.5. Provide tax credit incentives to rural residents for non-mandated improvements to rural sewer systems in priority HUC-11 watersheds. Eligible sites must be within 100 m (~330 feet) of a perennial stream in a HUC-11 watershed with a point score of eight or more (Appendix A). All rural sewer system improvements must meet KDHE minimum standards (K.A.R. 28-5-6 to 9).

1.1.2. Encourage landowners to participate in State and Federal conservation programs to rehabilitate watersheds. Funding is currently available for a wide variety of watershed enhancement projects from state and federal conservation programs (Appendix C).

1.1.3. Provide safe harbor agreements for participants in recovery plan agreements. Landowners may be reluctant to enter into recovery plan agreements if they think they could be penalized if an endangered species is discovered or introduced on their property. A safe harbor agreement requires that the participant maintains or enhances suitable habitat currently unoccupied by state-listed species. In return, the participant is protected from land use restrictions that might result if a state-listed species becomes established into the habitat. However, state-listed species already inhabiting a property at the time the landowner signs into a recovery plan agreement would remain fully protected under the state's Nongame and Endangered Species Conservation Act.

1.2. Identify areas of concentrated land use, and investigate ways to mitigate water quality concerns. Large disturbances may negate other watershed enhancement projects.

1.3. Develop partnerships with state and federal agencies, local governments, private organizations, industries, and individuals to identify, assess, and mitigate projects that might impact state-listed mussels and mussel habitats.

1.4. Integrate mussel die-off emergency response strategies with the existing fish kill cooperative agreement between KDWP and KDHE, which outlines investigation procedures. It is important that appropriate agencies and individuals be promptly notified of mussel and fish kills, chemical spills, and other environmental emergencies in streams where state-listed mussels occur.

1.5. Solicit expertise and funding in protecting the four targeted species and essential mussel habitats.

1.6. Utilize existing state and federal legislation and regulations to protect species and habitats. Habitat and water quality degradation are largely to blame for the current fate of these mussel species. Therefore, it is essential to enforce existing laws and regulations designed to address these concerns.

1.7. Reevaluate commercial mussel harvesting in southeast Kansas. Disturbances from shell-fishing can dislodge juveniles and adults, leaving them vulnerable to predation and to floods. Handling protected mussels may also stress gravid females, causing them to abort glochidia prematurely (Lefevre and Curtis 1912, Coker 1919, Yokely 1972, Yeager and Neves 1986).

2. Improve the accessibility of historic and recent mussel distribution and demographic data.

2.1. Develop a centralized, georeferenced database of distribution data for state-listed mussels. Information regarding the distribution of Kansas' freshwater mussels (*e.g.* collections and databases maintained by KDWP, KDHE, Kansas Biological Survey, State universities, and individuals) is not readily accessible to any one individual or agency. Correcting nomenclature and identifications, and assembling this information into one georeferenced database are needed to identify distributional data gaps and to identify potential reintroduction sites. The database should include absence data and status information for presence data[1] of all mussels occurring in the state. The database would be linked to a GIS and made accessible to those involved in the conservation management of freshwater mussels.

2.2. Add species data as a resource element coverage to a GIS. Four categories of species data assembled by Task 2.1 would be tiled by HUC-11 boundaries, and added as resource element coverages to a GIS. These coverages would include the number of target species within each HUC-11 watershed (currently and historically), the number of extant state-listed species in each watershed, and the overall number of extant species in each watershed. This information would be used for making priority area designations (Appendix A).

2.3. Update distributional data with additional sampling in unsurveyed stream reaches. Fill distributional data gaps as identified in Task 2.1 and in the literature. This includes any reach of stream that is: 1.) within the historical range of one or more of the four target species, and 2.) lacking recent assessment of mussel populations in a stretch of stream exceeding 15 river km.

3. Conduct studies on genetics, life histories, population dynamics, and ecological requirements of target species. Knowledge of the biology and ecology of these species is inadequate to meet recovery objectives.

3.1. Conduct systematic studies to assess population genetic structure and to document hidden diversity. Taxonomic distinction of many mussel species in North America is based largely on shell morphology. However, recent advances in molecular genetic techniques have led to taxonomic revisions for several species, sometimes revealing a species complex within a single species. Although the taxonomy for the majority of Kansas species is not in question, clarification of possible species complexes is needed.

3.1.1. Conduct a systematic study of the western fanshell[2]. Populations of *Cyprogenia aberti* found west of the Mississippi River are considered one species. However,

[1] *i.e.* number of live specimens, recently dead valves, weathered valves, and relic or subfossil valves.

[2] This task is currently in progress (B.K. Obermeyer, C.L. Harris, C. Lydeard, and A.E. Bogan).

these populations may represent discrete taxa (either specific and/or infraspecific). A systematic study—using molecular genetic techniques (mtDNA sequence data) as well as anatomical and conchological (shell) characters—needs to be conducted throughout the current range of *Cyprogenia aberti* to assess the taxonomic distinction of populations among different river basins.

3.1.2. Conduct a systematic study of the Ouachita kidneyshell. A systematic study similar to that described in Task 3.1.1 needs to be conducted for the genus *Ptychobranchus* in the Ozarkian faunal province (van der Schalie and van der Schalie 1950) of Kansas, Arkansas, Missouri, and Oklahoma.

3.1.3. Assess population genetic structure and diversity for each of the four target species in southeast Kansas. Tissue samples (*e.g.* mantle clippings, see Berg *et al.* 1995) of each species would be collected from a minimum of three individuals per stream, and analyzed using molecular genetic techniques (mtDNA sequence data). Genetic diversity would be compared within a population, among populations within a drainage, and among populations between drainage basins. These data would help to establish management guidelines to protect the genetic integrity of each species. This information is critical when considering augmentation and reintroduction efforts.

3.2. Conduct research related to the life histories of the four target species. Knowledge of each species' life history is essential in determining management guidelines for recovery.

3.2.1. Determine fish hosts and the period of spawning and gravidity for the rabbitsfoot in Kansas.

3.2.2. Conduct ichthyofaunal surveys to determine the distribution and abundance of potential fish hosts for the four targeted mussel species. Knowledge of the distribution and relative abundance of potential fish hosts is critical for the restoration of freshwater mussels. A survey of the Verdigris River basin, especially in the Fall and Verdigris rivers, should be given priority because recent fish surveys in this basin are lacking. Additional sampling of stream fishes in the

Spring River basin is not critical at this time because of recent surveys (Edds and Dorlac 1995, Wilkinson and Edds 1996, Wilkinson *et al.* 1996, Wilkinson 1997).

3.2.2.1. Survey fishes in the Verdigris River basin. Priority streams and reaches include the Fall River from near Eureka to its confluence with the Verdigris River (excluding Fall River Lake), Verdigris River from Madison to the Kansas-Oklahoma border (excluding Toronto Lake), Elk River from near Longton to Elk City Wildlife Area, and Caney River from Cedar Vale to the Kansas-Oklahoma border.

3.2.2.2. Survey fishes in unstudied reaches in the Neosho River basin (Cottonwood and Neosho rivers). Priority reaches include the Cottonwood River from near Florence (Marion Co.) to the river's confluence with the Neosho River, and the Neosho River from near Dunlap (Morris Co.) to the Kansas-Oklahoma border (excluding John Redmond Reservoir).

3.2.3. Initiate fish surveys at proposed reintroduction sites (determined by Task 5.2). Potential fish hosts of target mussel species ***must*** be present to restore viable populations. Fish density and abundance data will be needed at proposed reintroduction sites, because species richness and abundance of mussels have been linked to diverse and abundant fish assemblages (Watters 1993, Vaughn 1997).

3.3. Determine population characteristics of each target species, including age and size at sexual maturity, growth rates, reproductive longevity, and mortality rates. This information is needed to determine the number of individuals and level of recruitment required to maintain long-term viable populations.

3.4. Determine ecological requirements of each species.

3.4.1. Determine habitat and nutritional needs, particularly during the juvenile stage, for each of the four target species. Knowledge of habitat and nutritional requirements would assist in the rearing of juvenile mussels for propagation purposes.

3.4.2. Evaluate physiochemical variables that potentially limit recruitment and/or survival of the four target species. Because juvenile mussels are more sensitive to environmental stresses than adults (Dimock and Wright 1993, Warren *et al.* 1995, Pohlhill and Dimock 1996), they should be emphasized for study. This task could establish minimum habitat and water quality standards at recovery sites.

3.4.2.1. Determine the sensitivity of juvenile mussels to physiochemical variables that may negatively affect them. Calculate LC50 endpoints for juveniles of the four targeted species for parameters identified by KDHE as being of primary and secondary concern in the three stream basins (Appendix D - E).

3.4.2.2. Conduct field bioassays of juvenile mussels. This task could be done in conjunction with juvenile reintroduction projects.

4. Conduct habitat and water quality studies of the four target mussel species.

4.1. Conduct surveys of stream habitats. Describe instream and riparian habitats within the historic and current distribution of target mussel species.

4.1.1. Quantify instream habitats by measuring habitat variables along priority stream reaches and relate to mussel populations.

4.1.2. Evaluate riparian and stream habitats using remote sensing. Use aerial and satellite imagery to fill data gaps in unsampled stream reaches. Remote imagery could also be used to classify riparian habitats (Clemmer 1994, Prichard *et al.* 1999).

4.2. Conduct a geomorphic study of stream stretches with a history of gravel mining.

4.2.1. Evaluate past and recent habitat changes from instream gravel mining, and assess the impact to mussels from instream gravel mining. Because most mussel species require relatively stable substrates, it is important to understand the potential threat to mussels from instream gravel mining. Such a study may be beneficial in locating suitable stream reaches for reintroduction efforts.

4.2.2. Work with appropriate agencies and Legislative Committees to develop guidelines for mining sand and gravel from alluvial channels and floodplains.

4.3. Evaluate the fate of the old Neosho River cutoff channel in Neosho County (Appendix F). An approximate 28 km (17.4 mi) stretch of the old river channel is becoming isolated from the active channel, and may eventually become an oxbow lake. This reach holds at least 21 extant species, including the Neosho mucket and eight other state-listed mussel species (see Obermeyer *et al.* 1995, site BKO-94-23). The study would evaluate the future suitability of mussel habitat in this stream reach

4.4. Evaluate the effect of regulated lake releases and current minimum flow standards to mussels.

4.4.1. Study the effect of regulated releases on stream morphology (*e.g.* movement of the stream channel and substrate) in the Neosho, Verdigris, and Fall rivers. A better understanding of the fluvial geomorphic processes of these streams under regulated flow regimes may help efforts to restore unstable habitats (Task 1.1.1.3).

4.4.2. Evaluate the effect of stream flow on mussel populations, develop environmental instream flow requirements, and make recommendations to the U.S Army Corps of Engineers (USACE) and the Kansas Water Office (KWO). Assess the impact to mussels from abrupt reservoir gate changes[1], and make recommendations to the USACE to minimize potential threats. For instance, a recommendation might be made for more gradual gate changes following extended periods of high-volume lake releases, which would likely reduce mussel stranding. Gradual gate changes might also lessen instream habitat loss, because abrupt gate changes can contribute to stream bank sloughing, thus destabilizing instream habitats. This task would also reexamine current minimum stream flows agreements, and make recommendations to the KWO to ensure adequate minimum flows for mussels.

4.5. Study the impact to mussels from traditional wastewater disinfectants, and investigate the potential of converting municipal wastewater treatment plants (WWTPs) from chlorine to alternative disinfectant methods. Residual chlorine in wastewater reacts with effluent ammonia to form chloramines, which can be toxic to freshwater mussels (Goudreau *et al.* 1993). This effluent can cause the extirpation of mussels downstream from a WWTP (Stansbery and Stein 1976, Goudreau *et al.* 1993). Evidence of

[1] Obermeyer *et al.* (1995) found hundreds of mussels, including two freshly dead rabbitsfoots, stranded on a gravel bar in the Neosho River (site BKO-94-04) after the U.S. Army Corps of Engineers (USACE) abruptly reduced dam releases from John Redmond Reservoir in June of 1994. Stranding was attributed to the migration of mussels during an extended period of high lake discharge into areas that were exposed when normal flows resumed.

potentially toxic WWTP outfalls in Kansas includes a several mile reach of Shoal Creek, beginning at the outflow of Joplin's WWTP, near the Missouri-Kansas border, to the backwater of Empire Lake in Cherokee County.

5. Initiate a reintroduction/augmentation program using propagated juveniles and, to a lesser extent, translocated adults. Adherence to USFWS guidelines to protect the genetic integrity of aquatic mollusks (Appendix G) should be considered for all reintroduction/augmentation projects to prevent the introduction of unfavorable genetic traits to the recipient population (Berg and Guttman 1998, Butler 1998).

   5.1. Establish experimental population boundaries for future reintroduction projects. Reintroduced populations would be classified as experimental populations (EP). A species' critical habitat designation would be reclassified to EP habitat if: i.) the species has not been documented extant during the past 35 years, based on tasks 2.1 - 2.3, and ii.) there are active reintroduction projects for the species within the stream reach under consideration. Landowners within the habitat boundaries of an experimental population would not be imposed with additional land-use restrictions.

   5.2. Establish priority sites for reintroduction/augmentation projects. Specific sites would be selected based on habitat evaluations, water quality, and other ecological considerations, such as the presence of suitable hosts.

   5.3. Initiate reintroduction projects for the four target species.

      5.3.1. Initiate a pilot reintroduction project using juveniles. .

      5.3.2. Initiate a reintroduction project by releasing fish (suitable hosts) infected with glochidia. This method of reintroduction would be less expensive than Task 5.3.1, although it is less likely to succeed in establishing new populations. Suitable hosts of target species would be collected at or near the reintroduction site, exposed to glochidia, then immediately returned to the stream.

      5.3.3. Initiate a pilot reintroduction project using translocated adult mussels in the Spring River. A prospective pilot translocation project would be the relocation of non-listed adult mussels from one or more Spring River sites upstream from the confluence of Center Creek to the Spring River downstream from Empire Lake. A determination for relocating state-listed species to this stream reach would be made following a preliminary assessment of survival.

5.3.4. Consider relocating mussels from the old Neosho River cutoff channel (Appendix F). Mussels would be moved to other sites in the Neosho River that contain suitable mussel habitats as well as potential fish hosts. Initiation of this task would be dependent on the findings from tasks 3.2.3 and 4.3.

6. Develop a long-term monitoring program.

6.1. Establish long-term monitoring sites at locations where populations of target mussel species occur.

6.1.1. Continue to sample established quantitative sampling sites in the Neosho and Verdigris rivers at five-year intervals. Neosho River sites (*i.e.* eight sites) were sampled in 1994 (Obermeyer 1997b), whereas eight Verdigris River study sites were sampled in 1992 and 1997 (Miller 1993, 1999b).

6.1.2. Initiate quantitative sampling at eight sites in the lower Fall River and approximately four sites in the upper Kansas portion of the Spring River. Sample a minimum of 25, 1-m^2 quadrats at each site in a 100 m reach of habitat. Sites would be sampled at five-year intervals to assess population change. To correspond with long-term monitoring in the Neosho and Verdigris rivers, Fall River sites would be represented by sites within its mussel harvest refuge[1] and sites outside refuge boundaries (upstream and downstream).

6.1.3. Monitor mussel populations at reintroduction, augmentation, and translocation sites. Sites should be monitored annually for a minimum of five years following the release of propagated and/or translocated individuals. Thereafter, sites would be sampled at five-year intervals to evaluate long-term survival and reproductive success.

6.2. Reevaluate stream reaches within the historic range of the four target species using qualitative sampling methods to assess changes in species distribution, abundance, and

[1] The Fall River mussel refuge begins at a ford located 1.9 km (1.2 mi.) E of Hwy K-96 and 5.2 km (3.2 mi.) S of Fredonia, Wilson Co., and exends downstream to Dunn's Dam [4.0 km (2.5 mi.) W and 3.6 km (2.25 mi.) N of Neodesha, Wilson Co.] for a total of 15.9 stream km (9.9 mi.).

diversity of freshwater mussels. Streams should be re-surveyed at no less than ten-year intervals.

7. Prepare for the likely invasion of zebra mussels and other nonindigenous species. Although the zebra mussel is not presently found in Kansas, its likely invasion (see Strayer 1991) should be considered a threat to Kansas mussels. Such an invasion will likely compound efforts to restore the target mussel species in the near future.

    7.1. Implement a nonindigenous species management plan (NSMP) for Kansas.

        7.1.1. Provide input to the NSMP to educate the public about zebra mussels. The public needs to be aware of zebra mussels and how to prevent their spread into Kansas.

        7.1.2. Provide input to the NSMP to develop a risk assessment model (see Schneider *et al.* 1998) for the potential spread of zebra mussels in Kansas. This information would aid in the prioritization of sites for relocation efforts and habitat restoration.

        7.1.3. Provide input to the NSMP to develop guidelines and thresholds for mussel rescue efforts. Develop a protocol to determine when a population is at serious risk from zebra mussels. This task would develop procedures for the removal of native mussels from contaminated habitats to suitable relocation sites. The identification of potential quarantine habitats and facilities would be dictated by Task 7.1.2 and USFWS guidelines for protecting the genetic integrity of aquatic mollusks (Butler 1998).

        7.1.4. Provide input to the NSMP to develop a protocol for future monitoring of zebra mussels.

8. Develop and implement an educational program about Kansas' freshwater mussels and their recovery. The public's interest and support of freshwater mussels and watershed stewardship are essential for the recovery of these species and their habitat.

    8.1. Establish educational stream sites by acquiring access to streams through the use of state income tax incentives. A landowner of an educational stream site would receive state income tax credit equal to the amount of property tax for acreage on and near the learning site, land used for accessing the site, and maintenance of access roads.

8.2. Compile and distribute mussel-related educational materials. Specific learning materials might include a pictorial presentation of Kansas' mussels, educational mussel displays, and a Kansas mussel identification field guide with an illustrated, dichotomous key.

8.3. Develop a slide and/or video presentation that describes the mussel recovery plan and what it will mean to the public. The slide/video presentation would be targeted to landowners to inform them of the recovery plan. The presentation would provide information about threatened and endangered mussels in southeast Kansas, and would outline conservation programs pertinent to the recovery plan, especially the state income tax incentive program. It should prove to be a useful tool for District Biologists and other KDWP personnel when informing the public about the recovery plan at social gatherings, such as County Conservation District meetings and banquets.

8.4. Develop and publish an interactive Internet web site about the recovery plan and watershed stewardship. The web site would provide specific information about the recovery plan, including an online version in Portable Document Format (PDF), and would serve as a means to disseminate progress and success of recovery tasks. The web site would also provide in-depth information about state income tax incentives and conservation programs currently available to landowners, and would provide online inquiry forms, email and mailing addresses, phone numbers, links to other pertinent web sites (*e.g.* NRCS and USFWS web sites), and a list of frequently asked questions. In addition, the site would list case studies that identify and summarize successful habitat restoration and preservation projects related to this recovery plan, and provide a way to commend landowners that have participated in the recovery plan.

8.5. Create an automated toll-free phone hotline dedicated to provide information about the recovery plan and the state income tax incentive program.

8.6. Host meetings or workshops to educate and train aquatic resource managers and others about Kansas mussels and efforts to restore them. These workshops would include paper presentations, updates regarding recovery efforts, and training (*e.g.* mussel identification, habitat assessments, and mussel sampling). Workshops would be similar to previous mussel meetings hosted by KDWP.

8.7. Continue to publish a newsletter (semi-annually) about freshwater mussels, research, and progress of the recovery plan. A newsletter called the Pearly Mussel Newsline (Edwin J. Miller, editor), which is targeted towards persons interested in the conservation of freshwater mussels in Kansas, has been published by KDWP on an occasional basis since 1997.

8.8. Develop a video presentation about impacts to stream habitats from instream gravel dredging and other channel modifications.

9. Reevaluate recovery criteria and tasks once every five years, and recommend appropriate amendments. The recovery plan must be periodically reevaluated to determine if recovery objectives are being met.

10. Utilize experts to help implement the recovery plan. Persons with aquatic and other pertinent expertise from such affiliations as KDWP, other governmental resource agencies, and academia should be consulted to help review research proposals, evaluate recovery projects, and recommend amendments to the recovery plan as recovery tasks are completed and as new species information is gathered. KDWP may form technical committees to address such concerns as riparian stabilization projects.

IV. IMPLEMENTATION SCHEDULE

General Ranking Categories.—Actions necessary to recover the four targeted mussel species are ranked in three categories:

Priority 1 - an action that must be taken to prevent a species from irreversible decline or extirpation.

Priority 2 - an action that must be taken to prevent a further decline in species abundance/range, or other negative impacts to a species short of extirpation.

Priority 3 - all other actions necessary to meet recovery objectives.

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Appendix A. *Worksheet to determine priority HUC-11 (11-digit hydrologic unit code) watersheds and sites.*

HUC-11 Watershed Designation

1. **Number of target mussel species with a historic presence[1] in watershed:**
   Y none (0)[2] Y two (2) Y four (4)
   Y one (1) Y three (3)
2. **Number of extant target mussel species in watershed:**
   Y none (0) Y two (2) Y four (4)
   Y one (1) Y three (3)
3. **Number of extant state-listed mussels in watershed:**
   Y none (0) Y 4-6 (2) Y >9 (4)
   Y 1-3 (1) Y 7-9 (3)
4. **Overall species richness of extant mussels in watershed:**
   Y 0-3 (0) Y 8-12 (2) Y >17 (4)
   Y 4-7 (1) Y 13-17 (3)

Total Points ______

Site Designation

1. **Proximity to stream:**
   a. Y on property (4) - *go to 2*
   b. Y not on property but within 100 year flood zone (0) - *go to 2, items b or c*
   c. Y upland site (0) - *stop*
2. **Proximity to extant mussel populations:**
   a. Y on property (4)
   b. Y upstream (2)
   c. Y downstream (1)
3. **Historical presence of target species:**
   Y Yes (4) Y No (0)
4. **Presence of extant target species:**
   Y none (0) Y two (4) Y four (8)
   Y one (2) Y three (6)
5. **Presence of other state-listed mussels:**
   Y Yes (2) Y No (0)
6. **Overall species richness of extant mussels:**
   Y none (0) Y 6-10 (2) Y >15 (4)
   Y 1-5 (1) Y 11-15 (3)

Total Points ______

[1] Species records for each HUC-11 watershed are not necessary for this category, provided there is documentation of a species in both upstream and downstream reaches of a stream that borders or transects the watershed.

[2] Numbers in parentheses represent an arbitrary point score.

Appendix B. *Eligibility criteria for riparian buffers along perennial streams for the state income tax incentive program.*

Riparian buffers must be at least 75 feet in width. Buffers will be broken into three management zones: streamside (Zone 1), middle (Zone 2), and outer (Zone 3). All buffers entered into a recovery agreement must consist of zones 1 and 2 regardless of stream size; the outer zone is optional. Property tax credit will be based on the amount of land from the middle of stream to the outer limits of either Zone 2 or Zone 3.

Management Zone Criteria:

Streamside Zone (Zone 1): Begins at the normal full bank water line (or from the top of steep, cut banks) to a width of 15 feet measured perpendicular from the edge of stream. Logging will not be allowed within the Streamside Zone. Grazing will also be prohibited along streams with a Strahler stream order classification greater than 1. However, grazing strategies that minimize riparian damage along smaller perennial and intermittent streams may be allowed in special circumstances. Dominant vegetation should be composed of native trees and associated understory plants and/or native grasses and forbs. Establishment of native trees will be required for property that is presently farmed within this zone.

Middle Zone (Zone 2): Begins from the outer edge of Zone 1 and occupies a minimum width of 60 feet. Predominant vegetation should be native trees and/or native grasses and forbs. Although grazing restrictions will mirror Zone 1, management for wildlife, aesthetics, and timber will be allowed as long as buffer objectives are not compromised[1]. Native trees and/or native grasses and forbs will be allowed for buffer plantings on land presently cropped.

Outer Zone (Zone 3): Begins from the outer edge of Zone 2 and occupies an area encompassing up to 50 percent of the 100-year floodplain. Acceptable vegetation will include native trees and associated understory plants and/or native grasses and forbs. Management for wildlife, aesthetics, and timber, as well as limited haying and grazing will be allowed in this zone[1]. Inclusion of Zone 3 into a recovery plan agreement will be optional, except where natural riparian buffers presently extend beyond 75 feet. For newly created buffers, the shape of a buffer may be squared or straightened; however, the narrowest portion of a riparian buffer must not be less than the combined minimum widths of zones 1 and 2.

---

[1] Additional management restrictions may apply for lands signed into other conservation programs. In the case of CP22 buffers, the harvest of timber resources and grazing is prohibited within all three management zones for the duration of CRP-1 (refer to NRCS Conservation Practice Standard Code 391A for riparian forest buffer specifications).

Appendix G. *Guidelines for maintaining genetic integrity for propagated freshwater mussels.*

1) Seed source – in order of decreasing importance:
   a) Brood stock from the recipient stream metapopulation;
   b) Brood stock from another metapopulation in the same stream basin;
   c) Brood stock from another metapopulation in an adjacent stream basin in the same physiographic province;
   d) Brood stock from another metapopulation in an adjacent stream basin in an adjacent physiographic province;
   e) Brood stock from the only metapopulation with sufficient adults to provide progeny.

2) Reduce homozygosity by maximizing brood stock numbers.

Taken from USFWS draft guidelines for maintaining genetic integrity in translocation efforts for aquatic mollusks (Butler 1998).

PERMISSION TO QUOTE

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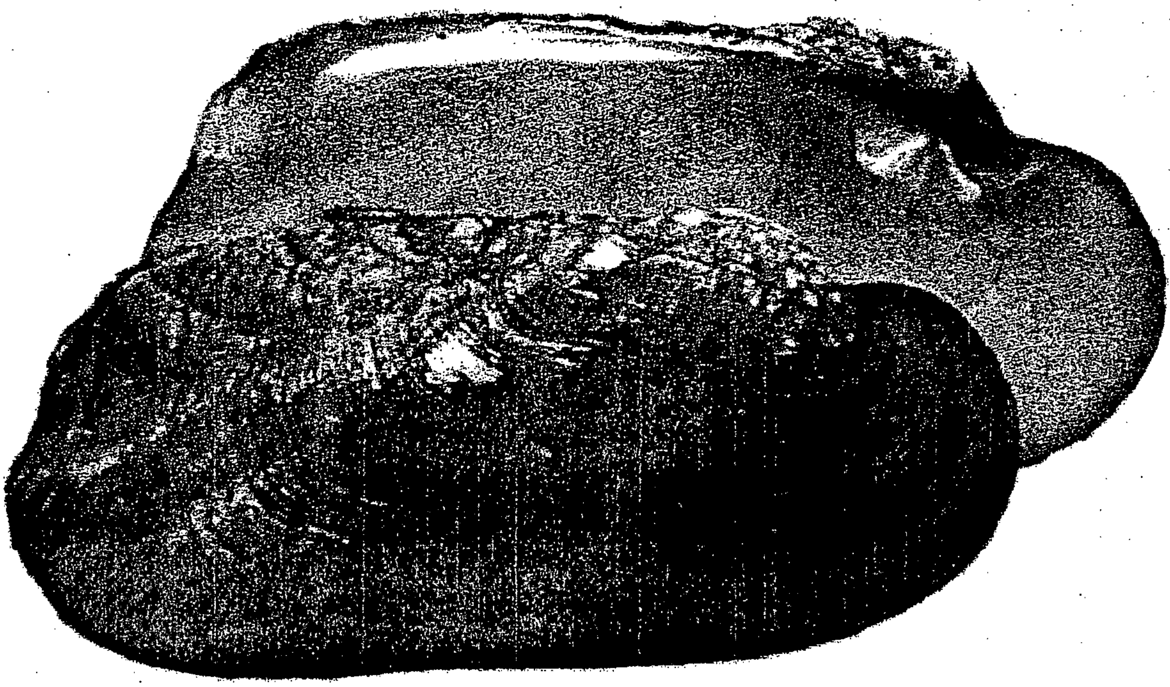

© B. K. Obermeyer

Recently dead rabbitsfoot collected from the Neosho River, KS.

Equal opportunity to participate in and benefit from programs described herein is available to all individuals without regard to race, color, national origin, sex, religion, age or handicap. Complaints of discrimination should be sent to the Office of the Secretary, Kansas Department of Wildlife and Parks, 900 Jackson St., Suite 502, Topeka, KS 66612.

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Rhodes, F. T. 1991. Letter to Kansas Dept. of Wildlife and Parks with 1990 Conditional Wildlife Permit Activities Report and 1991 Renewal Application. F. T. Rhodes, WCNOC, Burlington, Kansas. January 15.

Aquatic

WOLF CREEK
NUCLEAR OPERATING CORPORATION

Forrest T. Rhodes
Vice President
Engineering & Technical Services

January 15, 1991

ET 91-0004

Kansas Department of Wildlife and Parks
Fisheries and Wildlife Division
RR #2, Box 54A
Pratt, KS 67124

Attention: Mr. Bill Hlavachick

Subject: 1990 Conditional Wildlife Permit Report and 1991 Renewal Application

Dear Mr. Hlavachick:

The purpose of this letter is to report 1990 Conditional Wildlife Permit #SC-036-89 activities by Wolf Creek Nuclear Operating Corporation and to renew this permit for 1991. First, please find the report forms attached. Most fish used for radioisotopic monitoring were sent to a private laboratory for analysis. The remainder were given to the Kansas Department of Health and Environment under the Power Plant Monitoring Act.

Second, please find a renewal application for a 1991 permit. Environmental Management as well as selected Emergency and Radiological Services personnel are listed as subpermittees on the application. These individuals will carry a copy of the permit when conducting permitted activities. Please find a check for $5.50 for this renewal application.

If there are any questions, please contact Brad Loveless or Dan Haines at (316) 364-4168.

Very truly yours,

Forrest T. Rhodes
Vice President
Engineering & Technical Services

FTR/tlr

Attachments (2)

P.O. Box 411 / Burlington, KS 66839 / Phone: (316) 364-8831

ttachment to EI 91-0004

APPLICATION FOR SCIENTIFIC, EDUCATION, OR EXHIBITION PERMIT
(Collecting and Salvage)

Kansas Department of Wildlife and Parks
Fisheries and Wildlife Division
RR #2 Box 54A
Pratt KS 67124

FEE: $5.50

( ) NEW
(X) RENEWAL

PLEASE COMPLETE FULLY AND IN DETAIL.

Name of Applicant Brad S. Loveless for Wolf Creek Nuclear Operating Corporation

Address P.O. Box 411, Burlington, KS 66839

Date 12-24-90 Phone Number (316) 364-4168

Species to be collected, etc. (common names) See Attachment

Number of specimens involved See Attachment

Major area of activity See Attachment

Anticipated dates of activity See Attachment

State specific purpose of activity See Attachment

Methods of collecting See Attachment

Place where specimens are to be housed See Attachment

Federal Permit No. PRT-715225

J. D. Lickteig
(Conservation Officer Signature)

This permit, which expires December 31, must be in possession while conducting the above activity. A $5.00 fee plus a $.50 service charge ($5.50 total) must be submitted with this permit application. Any applicant desiring to conduct the above activities on any Department of Wildlife and Parks lands must first obtain written permission from the Department in addition to the special permit prior to the initiation of any activities.

FAILURE TO COMPLY WITH THE CONDITIONS SET FORTH IN THE PERMIT WILL RESULT IN THE IMMEDIATE REVOCATION OF THE PERMIT. Subpermittees: [illegible]

Don Eccles	Dan Haines	[illegible]
[illegible]	Lori Loney	[illegible]
Bruce Reischmann	Mark Schreiber	Ken Thrall
Bart Vince	Dan Williamson	Brian Winzenried

Brad Loveless
(Signature of Applicant)

Species to be Collected, etc.

It is expected that all fish common to Wolf Creek Cooling Lake (WCCL) and the Neosho River drainage in Coffey County, Kansas may be sampled. Only those species of commercial or recreational value will be kept for radiological analyses. These include but are not limited to such fish as largemouth bass, white crappie, white bass, channel catfish, buffalo, and carp.

Game bird and game mammal samples for radiological isotope analyses will be taken from readily obtainable species common to the Coffey County area. These include eastern cottontail, fox squirrel, white-tailed deer, greater prairie chicken, and northern bobwhite quail.

Salvage specimens will include wounded or dead nonendangered migratory birds which consist of, but are not limited to, various waterfowl, raptors, and other waterbirds subject to the conditions and requirements of WCNOC's Federal Fish and Wildlife Permit #PRT-715225.

Number of Specimens Involved

Only enough will be collected to complete biological and radiological environmental monitoring programs and facilitate the management of the WCCL fishery. The quantity of specimens to be handled is as follows:

Fisheries study:

Because of the quantitative nature of the gear types to be employed, the number of specimens involved will depend upon the concentration and species composition of fish present at the time of sampling. An adequate number of specimens will be sampled to accurately assess the fish populations in WCCL and if necessary, in the Neosho River in the vicinity of Wolf Creek Generating Station.

Radiological/Environmental:

Enough fish will be kept to satisfy Nuclear Regulatory Commission (NRC) radiological/environmental monitoring requirements. Each sample will consist of the minimum number of individual fish needed to yield 500-1000 grams of boneless flesh. The number and kind of samples needed will not exceed one sample of all commercially or recreationally important species monthly. These will be collected from WCCL and the Neosho River.

Game bird and game mammal samples will be collected annually. Each sample will consist of the minimum number of specimens needed to yield 500-1000 grams of boneless flesh. If available, road-killed birds and mammals will be used. Deer will not be collected unless a road kill is available from the appropriate areas or arrangements can be made with local legal hunters.

Major Area of Activities

Most of the sampling will occur in central Coffey County in the vicinity of WCCL and along the Neosho River. Major collecting locations on the Neosho River are immediately upstream (NW 1/4 of 12-22-15) and downstream (SE 1/4 of 12-22-15) of the Wolf Creek confluence. Work will also be completed at the Burlington City Dam (SW 1/4 of 23-21-15) and in the tailwater area of John Redmond Reservoir (W 1/2 of 9-21-15, and E 1/2 of 10-21-15). Monitoring will also be done on the Neosho River in southeastern Lyon County (S 1/2 10-20-13 and NE 1/4 15-20-13) near Hartford.

Game bird and mammal samples will be collected immediately north of the power plant in 6-21-16 and southeast in 16-21-16 and 17-21-16. Control samples will be collected in the vicinity of Hartford in east-central Lyon or west-central Coffey Counties on legal public hunting lands or on private property with consent from the landowner.

Purpose of Activity

The purpose of monitoring the cooling lake fishery is to provide data for making management decisions to reduce gizzard shad impingement problems and enhance station operability as a result. The WCCL monitoring programs will also provide adequate baseline data with which operational events can be compared in order to assess impacts. These involve both terrestrial and aquatic populations in the vicinity of WCCL.

A major purpose of the monitoring program on the Neosho River will be to determine the distribution and population density of the Asiatic clam (Corbicula fluminea). Because habitats are similar and collection gears will not discriminate, it is expected that various fishes including the Neosho madtom may be captured. Although this species will no longer be targeted, incidental catches will be recorded to document continued presence or absence above and below the Wolf Creek confluence. All will be immediately released alive to the river.

Collecting recreationally or commercially valuable fish species for the radiological/environmental studies will monitor operational radiological levels in the area of the power plant. Fish from the Neosho River, chiefly from the John Redmond tailwaters, will be used as control samples. Game bird and game mammal sampling will be used, as with the fish, to determine operational baseline data on potential pathways to humans of radiological isotopes.

Salvage investigation of wildlife mortality on the power plant grounds will be done to assess operational impacts to wildlife. This may include temporary possession of dead or wounded birds, chiefly migratory, that collide with station transmission lines or other facilities. These investigations will help determine proper mitigative strategies if excessive mortality develops.

Dates of Activity

The following table shows the time periods when the work is expected to be completed.

1991	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rad/Env. Fish Sample Collection	X	X	X	X	X	X	X	X	X	X	X	X
Rad/Env. Game Sample Collection	X											X
Wolf Creek Cooling Lake Monitoring	X	X	X	X	X	X	X	X	X	X	X	X
Asiatic Clam Monitoring									X	X	X	
Salvage/incidental mortality investigation	X	X	X	X	X	X	X	X	X	X	X	X

Methods of Collection

The following equipment will be used to collect samples:

Wolf Creek Cooling Lake:
- 6 x 50 foot bag seine with 1/4 inch mesh
- 6 x 15 foot straight seine with 1/8 inch mesh
- 8 x 100 foot monofilament gill nets w/1.0 inch mesh
- 8 x 100 foot monofilament gill nets w/1.5 inch mesh
- 8 x 100 foot monofilament gill nets w/2.5 inch mesh
- 8 x 100 foot monofilament gill nets w/4.0 inch mesh
- Large frame modified fyke nets
- Variable voltage AC/DC boat mounted shocker
- Otter trawl

Neosho River:
- 6 x 50 foot bag seine with 1/4 inch mesh
- 6 x 15-20 foot straight seine with 1/8 inch mesh
- Variable voltage AC/DC boat mounted shocker

Required game birds and game mammals will be collected using legal hunting methods.

Place Where Specimens are to be Housed

Fish collected during monitoring will be weighed and measured and returned to the water or disposed of properly. Voucher specimens may be preserved and stored in the Environmental Management laboratory in the Wolf Creek Education Center. No Neosho madtoms will be kept. All radiological/environmental samples will be kept in the same lab before being shipped to contracted analytical laboratories.

[illegible]

(Collecti[illegible]nd Salvage)

SC-005-90
Permit Number

WCNOC
Permit Holder Name

Date of Each Collection Month/Day	Number & Species Handled		Give each collection location including legal description (Quarter, section, township, and range numbers, and County)	Disposition of Specimens (Include Museum Voucher Numbers, if applicable)
	No.	Species (Common Name)		
1990	1	Morone Spp.	Wolf Creek Cooling Lake	All specimens returned to WCCL unless noted otherwise
1990	52	Green sunfish	" " " "	
1990	5	Orangespotted sunfish	" " " "	
1990	897	Bluegill	" " " "	
1990	3	Longear sunfish	" " " "	
1990	2	Hybrid sunfish	" " " "	
1990	185	Smallmouth bass	" " " "	4 used for radioisotopic analyses
1990	264	Largemouth bass	" " " "	6 used for radioisotopic analyses
1990	130	White crappie	" " " "	4 used for radioisotopic analyses
1990	61	Black crappie	" " " "	4 used for radioisotopic analyses
1990	14	Logperch	" " " "	
1990	231	Walleye	" " " "	5 used for radioisotopic analyses
1990	130	Freshwater drum	" " " "	

SCIENTIFIC, EDUCATION, OR EXHIBITION PERMIT REPORT FORM

(Collecting and Salvage)

SC-005-90
Permit Number

WCNOC
Permit Holder Name

Date of Each Collection Month/Day	Number & Species Handled		Give each collection location including legal description (Quarter, section, township, and range numbers, and County)	Disposition of Specimens (Include Museum Voucher Numbers, if applicable)
	No.	Species (Common Name)		
1990	1900	Gizzard shad	Wolf Creek Cooling Lake	All specimens returned to WCCL unless noted otherwise
1990	99	Common carp	" " " "	5 used for radioisotopic analyses
1990	27	Golden shiner	" " " "	
1990	331	Red shiner	" " " "	
1990	4	Bullhead minnow	" " " "	
1990	20	Smallmouth buffalo	" " " "	3 used for radioisotopic analyses
1990	7	Bigmouth buffalo	" " " "	1 used for radioisotopic analyses
1990	6	Yellow bullhead	" " " "	
1990	200	Channel catfish	" " " "	4 used for radioisotopic analyses
1990	3	Blue catfish	" " " "	
1990	20	Flathead catfish	" " " "	2 used for radioisotopic analyses
1990	8	Blackstripe topminnow	" " " "	
1990	7	Mosquito fish	" " " "	
1990	194	Brook silverside	" " " "	
1990	442	White bass	" " " "	
1990	2	Striped bass	" " " "	
1990	117	Wiper hybrid	" " " "	5 used for radioisotopic analyses

(Collecti[illegible]d Salvage)

SC-005-90
Permit Number

WCNOC
Permit Holder Name

Date of Each Collection Month/Day	Number & Species Handled		Give each collection location including legal description (Quarter, section, township, and range numbers, and County)	Disposition of Specimens (Include Museum Voucher Numbers, if applicable)
	No.	Species (Common Name)		
4-24-90	4	Common carp	John Redmond Spillway NW1/4 10-21-15, Coffey Co.	Used for radioisotopic analyses
"	3	Largemouth bass	" " " " " " "	" " " "
"	6	White crappie	" " " " " " "	" " " "
10-15-90	3	Common carp	" " " " " " "	" " " "
"	1	Blue sucker	" " " " " " "	" " " "
"	2	Channel catfish	" " " " " " "	" " " "
"	2	Largemouth bass	" " " " " " "	" " " "
"	2	White crappie	" " " " " " "	" " " "
10-18-90	1	Neosho madtom	Neosho River NW1/4 12-22-15, Coffey County	Incidental capture, returned al
10-18-90	19	Neosho madtom	Neosho River SE1/4 12-22-15, Coffey County	Incidental capture, returned ali

SCIENTIFIC, EDUCATION, OR [illegible]IBITION PERMIT REPORT FORM
(Collectin[illegible]nd Salvage)

SC-005-90
Permit Number

WCNOC
Permit Holder Name

Date of Each Collection Month/Day	Number & Species Handled		Give each collection location including legal description (Quarter, section, township, and range numbers, and County)	Disposition of Specimens (Include Museum Voucher Numbers, if applicable)
	No.	Species (Common Name)		
			The migratory birds among the list below were	
			handled under U.S. Fish and Wildlife Service	
			Special Wildlife Permit number PRT-715225.	
1-25-90	6	Northern bobwhite	NE 1/4 6-21-16 Coffey County	Used for radioisotopic analyses
"	2	Eastern cottontail	" " " " "	" " " "
"	6	Northern bobwhite	NW 1/4 16-21-16 Coffey County	" " " "
"	1	Eastern cottontail	" " " " "	" " " "
9-23-90	1	American coot	NE 1/4 7-21-16 Coffey County	Buried
12-16-90	2	Snow goose	NE 1/4 7-21-16 Coffey County	Buried

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Rhodes, F. T. 1992. Letter to Kansas Dept. of Wildlife and Parks with 1991 Conditional Wildlife Permit Activities.

Aquatic

WOLF CREEK
NUCLEAR OPERATING CORPORATION

Forrest T. Rhodes
Vice President
Engineering & Technical Services

January 30, 1992

ET 92-0022

Kansas Department of Wildlife and Parks
Fisheries and Wildlife Division
RR #2, Box 54A
Pratt, KS 67124

Attention: Mr. Bill Hlavachick

Subject: 1991 Conditional Wildlife Permit Report and 1992 Renewal Application

Dear Mr. Hlavachick:

The purpose of this letter is to report 1991 Conditional Wildlife Permit #SC-067-91 activities by Wolf Creek Nuclear Operating Corporation and to renew this permit for 1992. First, please find the report forms attached. Most fish used for radioisotopic monitoring were sent to a private laboratory for analysis. The remainder were given to the Kansas Department of Health and Environment under the Power Plant Monitoring Act.

Second, please find a renewal application and a check for $5.50 for a 1992 permit. Subpermittees are listed on the application and will carry a copy of the permit when conducting permitted activities.

The renewal application requests that activities as they relate to the incidental capture of the threatened Neosho madtom be permitted. As you are aware these activities during 1991 were completed as allowed by the U.S. Fish and Wildlife Service permit PRT-704930, subpermit 91-27. We have requested renewal of this federal permit for similar work in 1992 and this renewal request is attached for your benefit. A copy of the renewed federal permit will be sent to you for your files when received.

If there are any questions, please contact Brad Loveless or Dan Haines at (316) 364-4168.

Very truly yours,

Forrest T. Rhodes
Vice President
Engineering & Technical Services

FTR/tlr

Attachments (2)

ıchment to ET 92-0022

APPLICATIO OR SCIENTIFIC, EDUCATION, OR E BITION PERMIT
(Collecting and Salvage)

Kansas Department of Wildlife and Parks
Fisheries and Wildlife Division
RR #2 Box 54A
Pratt KS 67124

FEE: $5.50

( ) NEW
(X) RENEWAL

PLEASE COMPLETE FULLY AND IN DETAIL.

Name of Applicant Brad S. Loveless for Wolf Creek Nuclear Operating Corporation

Address P.O. Box 411, Burlington, KS 66839

Date 1-6-92 Phone Number (316) 364-4168

Species to be collected, etc. (common names) See Attachment

Number of specimens involved See Attachment

Major area of activity See Attachment

Anticipated dates of activity See Attachment

ate specific purpose of activity See Attachment

Methods of collecting See Attachment

Place where specimens are to be housed See Attachment

Federal Permit No. PRT-715225 - Salvage,
PRT-704930, subpermit 91-27
Threatened Species

(Conservation Officer Signature)

This permit, which expires December 31, must be in possession while conducting the above activity. A $5.00 fee plus a $.50 service charge ($5.50 total) must be submitted with this permit application. Any applicant desiring to conduct the above activities on any Department of Wildlife and Parks lands must first obtain written permission from the Department in addition to the special permit prior to the initiation of any activities.

FAILURE TO COMPLY WITH THE CONDITIONS SET FORTH IN THE PERMIT WILL RESULT IN THE IMMEDIATE REVOCATION OF THE PERMIT. Subpermittees:

Don Eccles	Dan Haines	Ken Thrall
uce Reischmann	Mark Schreiber	Brian Winzenried
ece Hobby	Dan Williamson	Jeff Walton

(Signature of Applicant)

Species to be Collected, etc.

It is expected that all fish common to Wolf Creek Cooling Lake (WCCL) and the Neosho River drainage may be sampled. Only those species of commercial or recreational value will be kept for radiological analyses. These include but are not limited to such fish as largemouth bass, white crappie, white bass, channel catfish, buffalo, and carp.

Game bird and game mammal samples for radiological isotope analyses will be taken from readily obtainable species common to the Coffey County area. These include eastern cottontail, fox squirrel, white-tailed deer, greater prairie chicken, and northern bobwhite quail.

Salvage specimens will include wounded or dead nonendangered migratory birds which consist of, but are not limited to, various waterfowl, raptors, and other waterbirds subject to the conditions and requirements of WCNOC's Federal Fish and Wildlife Permit #PRT-715225.

Number of Specimens Involved

Only enough will be collected to complete biological and radiological environmental monitoring programs and facilitate the management of the WCCL fishery. The quantity of specimens to be handled is as follows:

Fisheries study:

Because of the quantitative nature of the gear types to be employed, the number of specimens involved will depend upon the concentration and species composition of fish present at the time of sampling. An adequate number of specimens will be sampled to accurately assess the fish populations in WCCL and if necessary, in the Neosho River in the vicinity of Wolf Creek Generating Station.

Radiological/Environmental:

Enough fish will be kept to satisfy Nuclear Regulatory Commission (NRC) radiological/environmental monitoring requirements. Each sample will consist of the minimum number of individual fish needed to yield 500-1000 grams of boneless flesh. The number and kind of samples needed will not exceed one sample of all commercially or recreationally important species monthly. These will be collected from WCCL and the Neosho River.

Game bird and game mammal samples will be collected annually. Each sample will consist of the minimum number of specimens needed to yield 500-1000 grams of boneless flesh. If available, road-killed birds and mammals will be used. Deer will not be collected unless a road kill is available from the appropriate areas or arrangements can be made with local legal hunters.

Major Area of Activities

Most of the sampling will occur in central Coffey County in the vicinity of WCCL and along the Neosho River. Major collecting locations on the Neosho River are immediately upstream (NW 1/4 of 12-22-15) and downstream (SE 1/4 of 12-22-15) of the Wolf Creek confluence. Work will also be completed at the Burlington City Dam (SW 1/4 of 23-21-15) and in the tailwater area of John Redmond Reservoir (W 1/2 of 9-21-15, and E 1/2 of 10-21-15). Monitoring will also be done on the Neosho River in southeastern Lyon County (S 1/2 10-20-13 and NE 1/4 15-20-13) near Hartford.

Game bird and mammal samples will be collected immediately north of the power plant in 6-21-16 and southeast in 16-21-16 and 17-21-16. Control samples will be collected in the vicinity of Hartford in east-central Lyon or west-central Coffey Counties on legal public hunting lands or on private property with consent from the landowner.

Purpose of Activity

The purpose of monitoring the cooling lake fishery is to provide data for making management decisions to reduce gizzard shad impingement problems and enhance station operability as a result. The WCCL monitoring programs will also provide adequate baseline data with which operational events can be compared in order to assess impacts. These involve both terrestrial and aquatic populations in the vicinity of WCCL.

A major purpose of the monitoring program on the Neosho River will be to determine the distribution and population density of the Asiatic clam (Corbicula fluminea). Because habitats are similar and collection gears will not discriminate, it is expected that various fishes including the Neosho madtom may be captured. Although this species will no longer be targeted, incidental catches will be recorded to document continued presence or absence above and below the Wolf Creek confluence. All will be immediately released alive to the river. All activities with regard to the threatened Neosho madtom will be performed in accordance with Federal Threatened Species Permit PRT-704930, subpermit 91-27 and subsequent renewals.

Collecting recreationally or commercially valuable fish species for the radiological/environmental studies will monitor operational radiological levels in the area of the power plant. Fish from the Neosho River, chiefly from the John Redmond tailwaters, will be used as control samples. Game bird and game mammal sampling will be used, as with the fish, to determine operational baseline data on potential pathways to humans of radiological isotopes.

Salvage investigation of wildlife mortality on the power plant grounds will be done to assess operational impacts to wildlife. This may include temporary possession of dead or wounded birds, chiefly migratory, that collide with station transmission lines or other facilities. These investigations will help determine proper mitigative strategies if excessive mortality develops.

Dates of Activity

The following table shows the time periods when the work is expected to be completed.

1991	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rad/Env. Fish Sample Collection	X	X	X	X	X	X	X	X	X	X	X	X
Rad/Env. Game Sample Collection	X										X	X
Wolf Creek Cooling Lake Monitoring	X	X	X	X	X	X	X	X	X	X	X	X
Asiatic Clam Monitoring									X	X	X	
Salvage/incidental mortality investigation	X	X	X	X	X	X	X	X	X	X	X	X

Methods of Collection

The following equipment will be used to collect samples:

Wolf Creek Cooling Lake:
- 6 x 50 foot bag seine with 1/4 inch mesh
- 6 x 15 foot straight seine with 1/8 inch mesh
- 8 x 100 foot monofilament gill nets w/1.0 inch mesh
- 8 x 100 foot monofilament gill nets w/1.5 inch mesh
- 8 x 100 foot monofilament gill nets w/2.5 inch mesh
- 8 x 100 foot monofilament gill nets w/4.0 inch mesh
- Large frame modified fyke nets
- Variable voltage AC/DC boat mounted shocker
- Otter trawl

Neosho River:
- 6 x 50 foot bag seine with 1/4 inch mesh
- 6 x 15-20 foot straight seine with 1/8 inch mesh
- Variable voltage AC/DC boat mounted shocker

Required game birds and game mammals will be collected using shotguns or .22 caliber rifles in the most efficient manner feasible for taking the sample.

Place Where Specimens are to be Housed

Fish collected during monitoring will be weighed and measured and returned to the water or disposed of properly. Voucher specimens may be preserved and stored in the Environmental Management laboratory in the Dwight D. Eisenhower Nuclear Training Center at Wolf Creek Generating Station. No Neosho madtoms will be kept. All radiological/environmental samples will be kept in the same lab before being shipped to contracted analytical laboratories.

SCIENTIFIC, EDUCATION, OR EXHIBITION PERMIT REPORT FORM
(Collecting and Salvage)

SC-067-91
Permit Number

WCNOC
Permit Holder Name

Date of Each Collection Month/Day	Number & Species Handled		Give each collection location including legal description (Quarter, section, township, and range numbers, and County)	Disposition of Specimens (Include Museum Voucher Numbers, if applicable)
	No.	Species (Common Name)		
1991	2362	Gizzard shad	Wolf Creek Cooling Lake (WCCL)	All specimens returned to WCCL unless noted otherwise
"	61	Common carp	"	3 used for radioisotopic analyses
	11	Golden shiner	"	
"	503	Red shiner	"	
"	20	Ghost shiner	"	
"	50	Bullhead minnow	"	
"	3	Fathead minnow	"	
"	50	Smallmouth buffalo	"	2 used for radioisotopic analyses
"	41	Bigmouth buffalo	"	
"	6	Yellow bullhead	"	
"	124	Channel catfish	"	5 used for radioisotopic analyses
"	4	Blue catfish	"	
"	32	Flathead catfish	"	
"	6	Blackstripe topminnow	"	
"	9	Mosquito fish	"	
"	394	Brook silversides	"	
"	551	White bass	"	12 used for radioisotopic analyses

ttachment to ET 92-0022

SCIENTIFIC, EDUCATION, OR EXHIBITION PERMIT REPORT FORM
(Collecting and Salvage)

SC-067-91
Permit Number

WCNOC
Permit Holder Name

Date of Each Collection Month/Day	Number & Species Handled		Give each collection location including legal description (Quarter, section, township, and range numbers, and County)	Disposition of Specimens (Include Museum Voucher Numbers, if applicable)
	No.	Species (Common Name)		
1991	4	Striped bass	Wolf Creek Cooling Lake (WCCL)	All specimens returned to WCCL unless noted otherwise
"	195	Wiper hybrid	"	
"	41	Green sunfish	"	
"	5	Orangespotted sunfish	"	
"	563	Bluegill	"	
"	4	Longear sunfish	"	
"	3	Hybrid sunfish	"	
"	334	Smallmouth bass	"	
"	242	Largemouth bass	"	
"	164	White crappie	"	
"	220	Black crappie	"	
"	9	Logperch	"	
"	221	Walleye	"	
"	68	Freshwater drum	"	

SCIENTIFIC, EDUCATION, OR EXHIBITION PERMIT REPORT FORM
(Collecting and Salvage)

SC-067-91
Permit Number

WCNOC
Permit Holder Name

Date of Each Collection Month/Day	Number & Species Handled		Give each collection location including legal description (Quarter, section, township, and range numbers, and County)	Disposition of Specimens (Include Museum Voucher Numbers, if applicable)
	No.	Species (Common Name)		
4-16-91	2	Smallmouth buffalo	John Redmond Spillway NW 1/4 10-21-15 Coffey Co.	Used for radioisotopic analyses
9-19-91	2	Smallmouth buffalo		"
[illegible]9-91	6	White bass		"
9-19-91	5	White crappie		"
11-20-91	18	Neosho madtom	Neosho River SE 1/4 12-22-15 Coffey Co.	Incidental Capture Returned alive
11-20-91	13	Neosho madtom	Neosho River NW 1/4 12-22-15 Coffey Co.	Incidental Capture Returned alive

SCIENTIFIC, EDUCATION, OR EXHIBITION PERMIT REPORT FORM
(Collecting and Salvage)

SC-067-91
Permit Number

WCNOC
Permit Holder Name

Date of Each Collection Month/Day	Number & Species Handled		Give each collection location including legal description (Quarter, section, township, and range numbers, and County)	Disposition of Specimens (Include Museum Voucher Numbers, if applicable)
	No.	Species (Common Name)		
			The migratory birds among the list below were	
			handled under U.S. Fish and Wildlife Service	
			Special Wildlife Permit Number PRT-715225	
1-2-91	1	American goldeneye	NE 1/4 7-21-16, Coffey County	Buried Probable powerline collision
1-4-91	1	Mallard	NE 1/4 7-21-16, Coffey County	Buried
1-17-91	7	Northern bobwhite	NE 1/4 6-21-16, Coffey County	Used for radioisotopic analyses
1-17-91	2	Eastern cottontail	NE 1/4 6-21-16, Coffey County	Used for radioisotopic analyses
1-17-91	7	Northern bobwhite	NW 1/4 16-21-16, Coffey County	Used for radioisotopic analyses
1-17-91	2	Eastern cottontail	NW 1/4 16-21-16, Coffey County	Used for radioisotopic analyses
3-5-91	1	Snowy owl	SE 1/4, 7-21-16, Coffey County	Unknown cause of death Partially scavenged
3-7-91	1	American coot	NE 1/4 7-21-16, Coffey County	Powerline collision, buried
3-14-91	1	American coot	NE 1/4 7-21-16, Coffey County	Powerline collision, buried
5-15-91	1	Double-crested cormorant	NE 1/4 7-21-16, Coffey County	Powerline collision, buried
7-23-91	1	Upland sandpiper	NE 1/4 7-21-16, Coffey County	Powerline collision, buried
9-27-91	32	Brown-headed cowbird	NE 1/4 7-21-16, Coffey County	Unknown cause of death Buried
10-3-91	1	Green-winged teal	NE 1/4 7-21-16, Coffey County	Powerline collision, buried

SCIENTIFIC, EDUCATION, OR EXHIBITION PERMIT REPORT FORM
(Collecting and Salvage)

SC-067-91
Permit Number

WCNOC
Permit Holder Name

Date of Each Collection Month/Day	Number & Species Handled		Give each collection location including legal description (Quarter, section, township, and range numbers, and County)	Disposition of Specimens (Include Museum Voucher Numbers, if applicable)
	No.	Species (Common Name)		
11-11-91	1	Red-tailed hawk	NE 1/4 7-21-16, Coffey County	Powerline collision Donated to Friends University
11-14-91	1	Ring-billed gull	NE 1/4 7-21-16, Coffey County	Unknown cause of death, buried
12-13-91	1	American kestrel	NE 1/4 7-21-16, Coffey County	Trapped in outbuilding, buried
12-19-91	1	White-tailed deer	Incidental mortality in NE 1/4 7-21-16	Used for radioisotopic analyses Sample given to KDHE
12-23-91	14	Northern bobwhite	SE 1/4 19-21-14, NW 1/4 34-21-14, Coffey Co.	Used for radioisotopic analyses 7 given to KDHE
12-23-91	4	Eastern cottontail	SE 1/4 19-21-14, NW 1/4 34-21-14, Coffey Co.	Used for radioisotopic analyses 2 given to KDHE
12-30-91	6	Northern bobwhite	NE 1/4 6-21-16, Coffey County	Used for radioisotopic analyses
12-30-91	2	Eastern cottontail	NE 1/4 6-21-16, Coffey County	Used for radioisotopic analyses
12-30-91	7	Northern bobwhite	NW 1/4 16-21-16, Coffey County	Used for radioisotopic analyses
12-30-91	2	Eastern cottontail	NW 1/4 16-21-16, Coffey County	Used for radioisotopic analyses

WOLF CREEK
NUCLEAR OPERATING CORPORATION

Forrest T. Rhodes
Vice President
Engineering & Technical Services

January 10, 1992

ET 92-0004

U.S. Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, CO 80225

Attention: Mr. Max Schroeder

Reference: Letter ET 91-0174, dated October 7, 1991, from Forrest T. Rhodes (WCNOC) to Dan Mulhern (USFWS)

Subject: Report of Activities and 1992 Renewal Request for Endangered/Threatened Species Permit PRT-704930, Subpermit 91-27

Dear Mr. Schroeder:

The purpose of this letter is to complete activity reporting requirements and request renewal of Wolf Creek Nuclear Operating Corporation's subpermit 91-27 under PRT-704930 for the incidental capture of the threatened Neosho madtom. The following specimens were captured from and released alive to the Neosho River during ecological monitoring performed as stated in our application (see Reference).

Date	Number	Number of Hauls	Habitat	Location
11-20-91	18	4	Sand/Gravel Riffle	SE 1/4 12-22-15, Coffey County, KS
11-20-91	13	4	Rock/Gravel Riffle	NW 1/4 12-22-15, Coffey County, KS
11-21-91	0	4	Gravel/Cobble Riffle Flat Rocks/Gravel Riffle	S 1/2 10-20-13, Lyon County, KS

Each haul consisted of kick-seining along approximately six linear meters of riffle habitat with a 6' x 15' straight seine with 1/4 inch mesh. No Neosho madtoms were killed or injured during our river monitoring activities.

The second purpose of this letter is to request renewal of this threatened species permit to allow similar ongoing monitoring to be completed during 1992. The monitoring activities presented in the reference will be identical as they relate to the Neosho madtom.

We hope that the data presented above will be of use in your Neosho madtom recovery efforts. If any questions arise, please contact Brad Loveless or Dan Haines at 316 364-4168.

Very truly yours,

Forrest T. Rhodes
Vice President
Engineering & Technical Services

FTR/tlr

cc: Mr. Dan Mulhern (USFWS)

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WCNOC (Wolf Creek Nuclear Operating Corporation). 2005. "Circulating/Service Water Treatment Chemicals and Limits," Form APF 07A-002-01, Rev. 0, submitted in email from R. L. Logsdon (WCNOC) to S. Connor (Tetra Tech NUS) April 5.

Water

Connor, Steven

From: Logsdon Ralph L [ralogsd@WCNOC.com]
Sent: Tuesday, April 05, 2005 5:11 PM
To: Connor, Steven
Cc: Hammond Robert A
Subject: RE: Chemical injections into circ water

Attachments: CHMLIST2.DOC

CHMLIST2.DOC (31 KB)

I believe the below attachment should answer most of your questions on the circ water. Ralph

-----Original Message-----
From: Connor, Steven [mailto:ConnorS@ttnus.com]
Sent: Tuesday, April 05, 2005 2:02 PM
To: Logsdon Ralph L
Cc: Hammond Robert A
Subject: Chemical injections into circ water

Ralph: during the plant tour, you identified several chemicals injected into CW. I have notes on some of them but they are sketchy. Can you catalog for me what is injected, how much, how frequent, and for what purpose?

Thank you.

Steve

Steven J. Connor
Technical Manager
TETRA TECH NUS, Inc.
900 Trail Ridge Road
Aiken, South Carolina 29803
Telephone: (803) 649-7963
FAX: (803) 642-8454
connors@ttnus.com
<http://www.ttnus.com/ <http://www.ttnus.com/> > <http://www.tetratech.com
<http://www.tetratech.com> >

CIRCULATING/SERVICE WATER TREATMENT CHEMICALS AND LIMITS

CHEMICAL	INJECTION POINT	FREQUENCY	APPROVED DISCHARGE CONCENTRATION
<u>ANTI-SCALANT AND DISPERSANT</u> CALGON THRUGUARD 404	CWSH	CW/SW - CONTINUOUS	OUTFALL 003 AND 006 5 PPM
<u>OXIDIZING BIOCIDE</u> NaOCl & CALGON 1383 (NaBr)	CWSH	CW -2 HOURS/DAY SW – 6 HOURS/DAY	OUTFALL 003 0.2 MG/L TRO OUTFALL 006 1.0 MG/L TRO
<u>NON-OXIDIZING BIOCIDE</u> CALGON H-130M	CWSH SW TO CW ESW TO CW ESW TO UHS	12-24 HOURS/DAY 3X/YEAR/TRAIN	IN PLANT CONCENTRATION >4 PPM BUT<5 PPM OUTFALL 003 ≤0.5 PPM OUTFALL 006 ≤0.5 PPM
CALGON EVAC	FIRE PROTECTION (FP) SYSTEM	CONTINUOUS	4-8 PPM IN FP YARD LOOP
<u>CORROSION INHIBITOR</u> CALGON CuproSTAT	CWSH SW TO USH SW TO CW	30 MINUTES ONCE A MONTH/TRAIN	OUTFALL 006 60 PPM OUTFALL 003 3.3 PPM

CWSH – CIRC WATER SCREENHOUSE
CW – CIRCULATING WATER
SW – SERVICE WATER
ESW – ESSENTIAL SERVICE WATER
UHS – ULTIMATE HEAT SINK
NaOCl – SODIUM HYPROCHLORITE
NaBr – SODIUM BROMIDE
OUTFALL 003 – CIRCULATING WATER SYSTEM DISCHARGE INTO WOLF CREEK COOLING IMPOUNDMENT (WCCI)
OUTFALL 006 – SERVICE AND ESSENTIAL SERVICE WATER SYSTEM DISCHARGE THROUGH ESSENTIAL SERVICE WATER SYSTEM PIPING INTO THE ULTIMATE HEAT SINK AREA OF WCCI

21

The 12/13/74 letter cited in Section 4.1 of the ER (WCGS, 1980) from KDHE to the Kansas Gas and Electric Company regarding 316(a) exemptions.

~~316~~ Start-up

State of Kansas

DEPARTMENT OF HEALTH & ENVIRONMENT

Topeka, Kansas

RECEIVED
OPERATING
DEC 17 1974

13 December 1974

Mr. Glenn Koester
Kansas Gas & Electric Co.
P.O. Box 208
Wichita, Kansas 67201

Re: Wolf Creek Generating Station

Dear Mr. Koester:

We have received your letter of 14 November 1974 wherein you provided status information on the contractual obligations for the Wolf Creek generating station. Supplemental to the information provided, copies of the actual contractual agreements are desirable for documentation purposes. This request of course excludes any confidential information.

It is our belief that the Wolf Creek generating station has indeed begun construction as defined in Section 306(a) of PL 92-500 and thus we concur with your conclusions. The federal standards of performance for "new sources" of the Electric Power Plant Generating Guidelines published in the Federal Register in October 1974, Volume 39, No. 196, Section 423.13(1) states that such facilities under construction as of the effective date of the above-referenced regulation shall be exempt from the provisions of Section 316(a) of PL 92-500, as construction was begun prior to the effective date. We are therefore exempting you from the requirements of Section 316(a) of PL 92-500.

We appreciate very much your cooperation in this matter.

Very truly yours,

Melville W. Gray

Melville W. Gray, P.E.
Director
Division of Environment

MWG:ht
cc: Ralph Langemeier
South Central District Office

22

WCNOC (Wolf Creek Nuclear Operating Corporation). 1987. "*Naegleria fowleri* Test Results," LI 87-0627, interoffice correspondence from Gregg Wedd to Distribution, October 16.

Water quality

WOLF CREEK
NUCLEAR OPERATING CORPORATION

INTEROFFICE CORRESPONDENCE

TO: Distribution * LI 87-0627

FROM: Greg Wedd

DATE: October 16, 1987

SUBJECT: Naeglaria fowleri Test Results

* G. Boyer (WC-AD)
D. Dullum (WC-OS)
B. Ernst (WC-SF)
J. Hicks (WC-HR)
O. Maynard (WC-LI)
M. Nichols (WC-PS)

Attached are the results from lake water and lake bottom tests for the pathenogenic amoeba, Naeglaria fowleri. Testing was done in response to ITIP #240 concerning worker safety. Naeglaria fowleri does not occur commonly and are difficult to ingest, but when ingested they are usually fatal.

Test results indicated that while conditions in the discharge cove led to very high concentrations of thermophilic (heat-loving) amoebae, none of the pathenogenic species were detected. Because of the high densities of other amoebae, the determination that WCCL harbors no N. fowleri cannot be made with 100 percent certainty. However, our conclusion is that based on this thorough effort, there is very little chance that N. fowleri is present in the cooling lake. Therefore, risk to WCGS workers due to N. fowleri appears to be quite low.

Greg R Wedd

GRW/BSL/rrw

cc: [redacted]
RMS

IMAGED-03/03/2005

87-02076
42129-W

Microbial Monitoring

177 Woodland Circle
Route 3

Clinton, TN 37716
615/483-7303
615/457-4143

September 20, 1987

Mr. Brad Loveless
Education Facility
Wolf Creek Nuclear Operating Corporation
P. O. Box 411
Burlington, Kansas 66839

RECEIVED
SEP 28 1987

Dear Brad:

Please find enclosed data on the results of our analysis of your samples for Naegleria fowleri. As I mentioned to you in our recent phone conversation we did not isolate the pathogenic Naegleria. However, the heated areas have an abundance of thermophilic amoebae which indicates conditions are probably appropriate for supporting the presence of the pathogen. Indeed, high levels of other thermophilic amoebae can sometimes interfere with detecting the pathogen.

Samples of water or sediment are placed directly on agar plates spread with E. coli or concentrated by filtration before plating. The plates are incubated at 43-44°C to select for the pathogen. Amoebic outgrowths are observed for growth patterns indicative of the pathogen. Outgrowths suggestive of Naegleria are tested for their ability to form flagella.

Suspicious outgrowths are also tested for pathogenicity by intranasal inoculation of weanling mice. Moribund mice are sacrificed and brain tissue tested on E. coli plates for the presence of N. fowleri.

As seen in the enclosed data, thermophilic Naegleria were detected in 100, 10, and 1 ml volumes of water from heated sites. Thermophilic Naegleria were not detected in the intake water, even in the 100 ml samples.

There are three species of thermophilic Naegleria - two are pathogenic and one species is not pathogenic. The predominating thermophilic Naegleria in your heated waters is the nonpathogenic species. We did not detect pathogenic Naegleria in these samples. However, the high numbers of the nonpathogenic Naegleria might interfere with detecting small numbers of the pathogenic Naegleria since the former may overgrow the E. coli plates obliterating the possible presence of the pathogen.

If you have any questions concerning the enclosed data please give me a call.

Sincerely,

R. L. Tyndall

Results of Analysis of Samples from Wolf Creek Plant Site for the presence of pathogenic *Naegleria*[a]

SAMPLE	VOLUME	GROWTH AT 43°C	MORPHOLOGY	FLAGELLATION	PATHOGEN
Intake	100 ml	+(2/4)	NN	NT	NA
H_2O	10 ml	-	NA	NA	NA
Rep 1	1 ml	-	NA	NA	NA
Intake	100 ml	+(1/4)	NN	NT	NA
H_2O	10 ml	-	NA	NA	NA
Rep 2	1 ml	-	NA	NA	NA
Intake	100 ml	-	NA	NA	NA
H_2O	10 ml	-	NA	NA	NA
Rep 3	1 ml	-	NA	NA	NA
Lime Sludge					
Pond Cove	100 ml	+(5/5)	NP	+(5/5)	NT
H_2O	10 ml	+(4/4)	NP	+(4/4)	NT
Rep 1	1 ml	+(4/4)	NP	+(4/4)	NT
Lime Sludge					
Pond Cove	100 ml	+(4/4)	NP	+(4/4)	NT
H_2O	10 ml	+(5/5)	NP	+(5/5)	NT
Rep 2	1 ml	+(2/5)	NN, NP	+(2/5)	-(1/1)
Lime Sludge					
Pond Cove	100 ml	+(4/4)	NP	+(4/4)	NT
H_2O	10 ml	+(4/4)	NP	+(4/4)	NT
Rep 3	1 ml	+(1/4)	NP	+(1/4)	NT
Stringtown					
Cove	100 ml	+(5/5)	NP	+(5/5)	NT
H_2O	10 ml	+(4/4)	NP	+(4/4)	NT
Rep 1	1 ml	+(4/4)	NP	+(4/4)	NT
Stringtown					
Cove	100 ml	+(4/4)	NP	+(4/4)	NT
H_2O	10 ml	+(5/5)	NP	+(5/5)	NT
Rep 2	1 ml	+(2/5)	NP	+(2/5)	NT
Stringtown					
Cove	100 ml	+(4/4)	NP	+(4/4)	NT
H_2O	10 ml	+(4/4)	NP	+(4/4)	NT
Rep 3	1 ml	+(4/4)	NP	+(4/4)	NT

Intake	100 mg	-	NA	NA	NA
Sed	10 mg	-	NA	NA	NA
Rep 1	1 mg	-	NA	NA	NA
Intake	100 mg	+(1/5)	NN	NT	NA
Sed	10 mg	-	NA	NA	NA
Rep 2	1 mg	-	NA	NA	NA
Lime Sludge					
Sed	100 mg	+(5/5)	NN, NP	+(1/5)	NT
Rep 1	10 mg	+(5/5)	NN	-(5/5)	NA
	1 mg	+(2/5)	NN	-(2/5)	NA
Lime Sludge					
Sed	100 mg	+(4/4)	NN	-(4/4)	NT
Rep 2	10 mg	+(4/4)	NN	-(4/4)	NT
	1 mg	+(3/4)	NN	-(3/4)	-(1/4)
Stringtown					
Sed	100 mg	+(5/5)	NP	+(5/5)	NT
Rep 1	10 mg	+(5/5)	NN, NP	+(1/5)	NT
	1 mg	+(3/5)	NN	-(3/5)	NA
Stringtown					
Sed	100 mg	+(4/4)	NN, NP	+(1/4)	-(1/4)
Rep 2	10 mg	+(3/4)	NN	-(3/4)	NA
	1 mg	+(1/4)	NN	-(1/4)	NA

[a]Four or five replicates of each dilution were plated. Number in parenthesis represents the number of positive or negative for the test parameter over the subset of five that were tested.

Sed = Sediment
NA = Not applicable
NT = Not tested
NN = Not *Naegleria*
NP = Nonpathogenic *Naegleria*
P = Pathogenic *Naegleria*

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KGE 1988 is EA 1988

See Request 002 for a copy of EA 1988

THE EMPORIA STATE

RESEARCH STUDIES

THE GRADUATE PUBLICATION OF THE EMPORIA STATE UNIVERSITY

23

Observations On Neosho River Larval Fish In Coffey County, Kansas

Greg R. Wedd

The Emporia State Research Studies

EMPORIA STATE UNIVERSITY
EMPORIA, KANSAS

Observations On Neosho River Larval Fish In Coffey County, Kansas

Greg R. Wedd

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EMPORIA STATE UNIVERSITY
EMPORIA, KANSAS

Papers published in this periodical are written by faculty members of the Emporia State University and by either undergraduate or graduate students whose studies are conducted in residence under the supervision of a faculty member of the University.

Observations On Neosho River Larval Fish In Coffey County, Kansas

by
Greg R. Wedd*

ABSTRACT

The 1981 larval fish drift of the Neosho River upstream and downstream of John Redmond Reservoir in Coffey County, Kansas was studied. Field data were collected from 25 April through 31 July. A total of 27,905 eggs, larvae, and juvenile fish, representing 11 families and 30 taxa, was collected from three sampling points. Members of the families Catostomidae (48.5%) and Clupeidae (48.3%) dominated the assemblage at Hartford whereas Clupeidae was solely dominant at both John Redmond (98.0% diurnally and 95.2% nocturnally) and Burlington, although to a lesser degree at Burlington (81.4%). Larval fish densities at Hartford peaked at $1246.7/100m^3$ on 28 May while maximum densities for both diurnal and nocturnal John Redmond collections peaked at over $5000/100m^3$ on 13 June, and the maximum level at Burlington occurred at $1766.4/100m^3$ on 19 June. No statistically significant differences were found in mean daily total concentrations or day/night John Redmond data. Morphological data were compiled and are presented in tabular form for 14 taxa. These data generally compared favorably with published accounts, thereby supporting the taxonomic assignments made and documenting regional variation. The *Pomoxis* larvae identified had eye-gas bladder distances (as % total length) from 13 to 19, although *Pomoxis annularis* was the sole representative of this genus in the study area.

* This study originated as a master's thesis under the direction of Dr. Robert F. Clarke in the Division of Biological Sciences at Emporia State University. The author is currently employed by Kansas Gas & Electric Company in the Environmental Management group of Nuclear Services.

INTRODUCTION

The purpose of this research was to describe the 1981 larval fish drift above and below John Redmond Reservoir, a mainstream impoundment of the Neosho River in Coffey County, Kansas. Larval fish present in drift samples were identified, quantified, and characterizations made of their seasonal occurrence, diel patterns, and developmental phases. This study also presents morphological data for selected taxa, provides explanations of generic and species assignments made, and discusses evidences which support these assignments. Additionally, a discussion of the potential value of early life history data is provided.

The study was conducted because descriptions of the larval fish drift occurring in most Kansas rivers have not been accomplished. This is despite the fact that the period of time following spawning and extending through early life history stages is very important in the development of North American freshwater fish populations.

The importance of this period was realized by some early researchers and, as a result, attempts were made to provide identification guides to assist research in this field. Fish (1932) provided one of the earliest works of this nature with a regional descriptive morphological study covering 62 species. Later studies emphasized gross morphological features such as body shape, gut development, pigmentation, fin ray/spine development and counts (May and Gasaway 1967; Mansueti and Hardy 1967; Tabor 1969). Preliminary keys and guides were the results of these works. However, identification to species was still often precluded by close phylogenetic relationships and the lack of early life history descriptions for many species.

The lack of concise reference materials resulted in neglect in the study of fish early life histories by many fishery managers. As a result, the period of life following spawning to the appearance in seine or trawl collections of juvenile fish took on nearly mystical qualities in the minds of some managers. The lack of information concerning this stage in development for many fish populations reflects this attitude.

Several factors have contributed to this situation, the first being the difference in collection methods for larval fish. Collection techniques are more similar to those used by limnologists than by fishery managers. Sampling gear utilized consists of nets of the types used for zooplankton collections, however, these nets are typically larger in diameter and mesh size. The methods by which such gear are used have only been limited by the ingenuity of the

researcher. Nets used to collect larval fish have been manually positioned, mounted on bridge abutments (Potter et al. 1978), towed by boat (Hoyt et al. 1979), and boom-mounted on boats (Tarplee et al. 1979).

Techniques for larval fish identification also differ substantially from the methods used on adult fish. Many of the morphological features diagnostic for adult fish are absent during larval phases and other structures, invisible in adults, are prominent in larvae. Structures such as the cleithrum, auditory vesicle, yolk, myomeres and urostyle all are used in larval fish identification (Figure 1). Additionally, the counts, ratios, and proportions of various distances or enumerable structures, such as head length, preanal length, postanal length, preanal and postanal myomeres play an important role in the classification of larval fish.

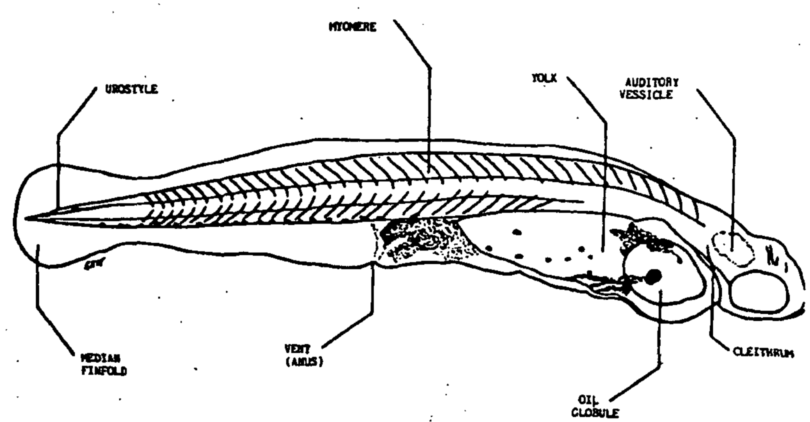


Figure 1. Features useful in the identification of larval fish.

Throughout the infancy of fish early life history studies, a variety of classification systems for developmental phases evolved. Titcomb (1910) developed one of the earliest systems which consisted of the simple differentiation of "fry, advanced fry and fingerlings." Later schemes emphasized the presence of yolk material but failed to define precise criteria for the separation of developmental stages (Hubbs 1943; May and Gasaway 1967; Mansueti and Hardy 1967). The controversy which resulted from the partisan use of the various schemes served to widen the gap between researchers and field personnel.

Not until the late seventies were attempts made to standardize terminology. Snyder (1976) proposed a system which minimized the importance of the presence of yolk material and classed larvae as protolarvae, mesolarvae, metalarvae and juveniles. With the advent of the most recent systems and efforts by the Early Life History Section of the American Fisheries Society, terminology reached a semblance of standardization (Snyder, 1981a). This terminology has achieved improved precision, practicality, and ease of use for field personnel. Additionally, there has been an increase in the comparability of published works since its inception (Fuiman 1979; Fuiman and Witman 1979; Conner et al. 1980; Yeager and Baker 1982).

Studies undertaken recently have been directed at detailed descriptions of closely related species. For example, Fuiman (1979), Fuiman and Witman (1979), Yeager and Baker (1982) and Snyder (1981b) have completed descriptions for members of the family Catostomidae. Meristics and fine morphological features have received special attention in these works. Certain recent studies define a few diagnostic characteristics which may be used to segregate closely related species (Conner 1979; Chatry and Conner 1980). The use of such data is now permitting expeditious identification of larval fish to low taxonomic levels.

The increasing utility of reference materials is also assisting the expansion of early life history studies from simple baseline cataloging to assessments of factors influencing year-class development. Studies performed by Kindschi et al. (1979), Cada and Hergenrader (1980), and Martin et al. (1981) explored the role which environmental factors, such as physical conditions and water levels, play in the development of year classes. The relationship of flow stages to the occurrence of various lotic species was explored by Gallagher and Conner (1980) through a detailed spatio-temporal study of Mississippi River larval fish.

Despite the expansion of early life history investigations and the completion of studies covering larval fish ecology for many areas, Kansas larval fish populations have not been studied. No studies of Kansas larval fish populations were found in the literature, with the exception of work completed as part of Kansas Gas and Electric Company environmental monitoring (Bliss 1978, 1979, 1980).

DESCRIPTION OF STUDY AREA

This study was conducted on river locations in the immediate vicinity of John Redmond Reservoir, a mainstream impoundment of the Neosho (Grand) River in Coffey County, Kansas. John Redmond Reservoir is a major flood control impoundment located northwest of Burlington. It has a surface area of 3,800 ha at conservation pool elevation of 316.7 m MSL. John Redmond Reservoir was formed by impoundment of the Neosho River, which has its headwaters in Morris County, Kansas. The Neosho flows in a southeasterly direction through southeast Kansas and northeastern Oklahoma. The total drainage of the Neosho is approximately 16,300 km^2, with the Kansas portion measuring roughly 15,000 km^2. Throughout its course, the Neosho follows a well defined channel with banks ranging from 4.5 to 9.0 m in height along its lower reaches.

Three river locations were utilized during this study (Figure 2). Location numbers utilized were established by previous studies performed as part of Kansas Gas and Electric Company monitoring. For ease of interpretation, the location descriptions start with Hartford and proceed downstream.

Location 2, Hartford (S.W. ¼ of Sec. 14, T. 20 S., R. 13 E.): This location was delineated at its upstream edge by the old Hartford river bridge and extended 300 m downstream. The river at this location varied in width from 30 to 40 m with a mud, gravel, and rubble bottom and steep mud banks. Location 2 was in the area where the Neosho transforms from a lotic to lentic environment by flood pool elevations of John Redmond Reservoir.

Location 1, John Redmond Reservoir tailwaters (W. ½ of N.W. ¼ of Sec. 10, T. 21 S., R. 15 E.): Location 1 was located immediately below John Redmond Reservoir in the spillway area. It began at a point approximately 70 m below where the two outlet channels merge and extended downstream along the south bank of the river for 300 m. Flow at this location was entirely dependent upon discharges from John Redmond Reservoir. The width of the river at this point was highly variable, ranging from 7 to 90 m. The river bottom consisted of bedrock and rubble with riprap and mud banks.

Location 3, Burlington (S.E. ¼ of N.W. ¼ Sec. 23, T. 21 S., R. 15 E.): This location consisted of a 300 m stretch of the Neosho bordered on its downstream edge by the Burlington City Dam. The river at this point pooled upstream of the dam and, during low flow, formed a small impoundment. Periods of high flow resulted in complete overtopping of the dam and a corresponding loss of quiescent conditions. The bottom at this location was bedrock covered by thick mud.

Physical Conditions

The middle Neosho River drainage had experienced a moderate drought during the latter part of the year preceeding the study. The drought persisted in 1981, with the Neosho drainage receiving below average rainfall during the first 16 weeks of the year. The remainder of 1981 saw above average precipitation (Figure 3).

The flow pattern of the Neosho River in the study area was characterized by a four month period of reduced flows, followed by a three-five-fold increase in June which lasted through July, and normal to slightly below average flow for the remainder of the year.

The average daily inflows of the Neosho to John Redmond Reservoir (JRR) appear in Table 1. With the exception of four dates, inflow values did not exceed 200 cfs during the first 16 weeks of 1981. Inflows increased in the second half of May and peaked in July when the daily inflow averaged 2,632 cfs.

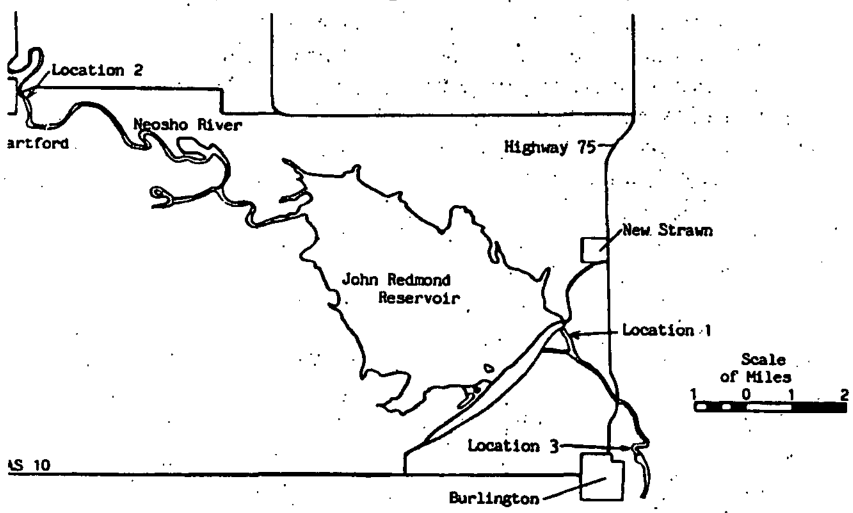
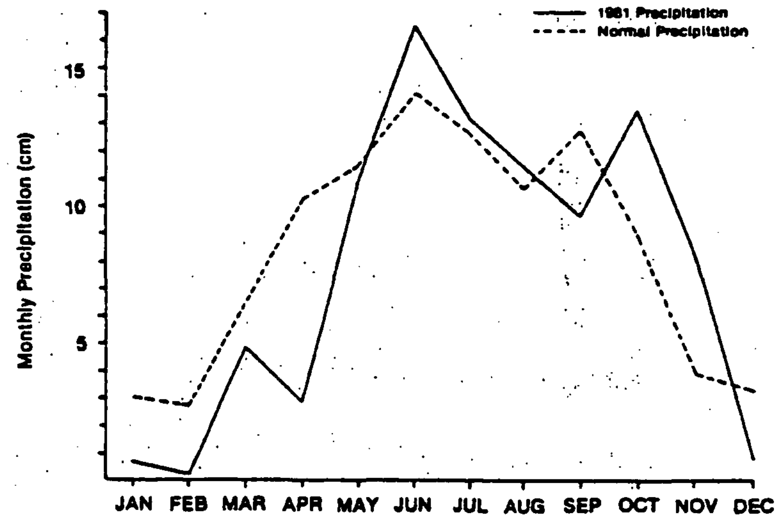


Figure 2. The Neosho River and John Redmond Reservoir area, showing sample collection points (Location 2: Hartford, Location 1: John Redmond Reservoir tailwaters, and Location 3: Burlington).



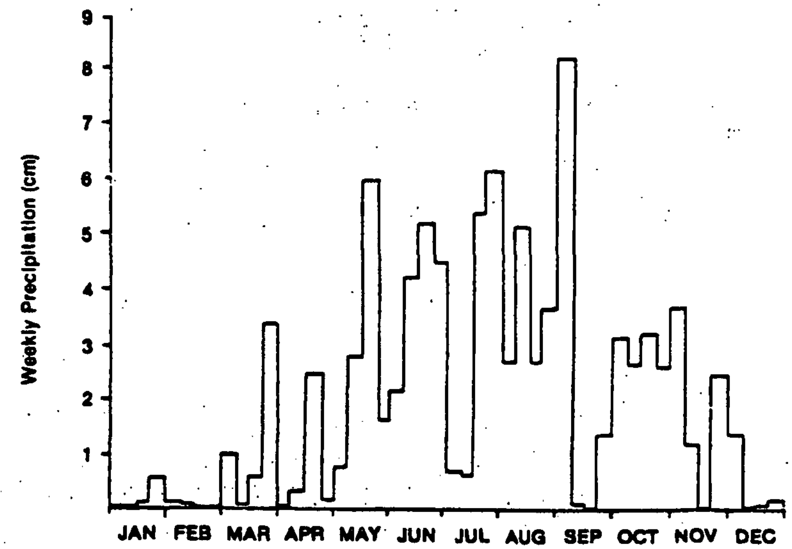


Figure 3. Precipitation at John Redmond Reservoir, January - December, 1981 (NOAA, 1981) (Redrawn from King, 1981).

Table 1. Mean daily inflow (cfs) of the Neosho River into the John Redmond Reservoir, [illegible].

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	50	50	50	55	30	1,240	1,770	940	8,460	200	7,880	5,100
2	25	50	25	85	30	1,120	825	1,630	7,150	50	13,500	3,700
3	25	50	25	70	30	1,680	3,210	2,250	2,980	100	16,400	3,700
4	25	50	150	60	50	950	11,900	2,970	1,200	250	14,100	1,500
5	25	50	75	55	20	1,570	14,000	2,900	500	400	11,400	1,100
6	25	25	50	50	20	1,120	11,900	1,720	200	400	5,120	1,000
7	50	25	50	50	50	460	4,240	1,080	400	100	2,540	1,000
8	50	25	50	55	75	505	2,400	310	400	150	2,200	1,000
9	50	25	100	45	200	460	1,750	625	740	800	6,500	900
10	100	25	50	65	100	130	1,400	1,410	485	500	11,600	900
11	100	25	50	125	20	925	2,400	1,130	400	300	9,900	900
12	50	25	75	90	75	1,340	1,500	870	500	300	5,500	900
13	50	25	60	135	400	1,150	565	1,000	380	370	5,180	900
14	50	25	50	125	70	720	1,150	800	365	1,800	3,840	800
15	50	25	50	70	30	8,590	1,310	520	340	620	2,300	800
16	50	25	30	55	80	8,060	325	450	200	1,530	1,360	800
17	50	25	130	140	1,120	2,240	1,000	480	100	6,840	1,200	800
18	50	25	80	120	4,780	1,330	800	330	250	5,930	1,000	800
19	50	100	50	100	3,545	1,870	600	275	150	3,100	900	1,000
20	50	100	30	190	2,735	1,810	800	200	200	1,900	1,100	1,100
21	50	100	45	100	1,390	860	600	300	150	400	1,000	1,200
22	50	50	30	140	975	680	500	250	70	1,500	1,400	1,000
23	50	25	20	10	4,520	1,110	450	300	275	100	1,200	1,000
24	50	25	100	100	895	830	350	200	225	100	1,100	1,200
25	50	25	285	75	1,105	705	300	500	560	200	1,200	1,200
26	50	25	150	65	490	750	700	560	480	400	1,200	1,200
27	50	25	100	55	655	9,510	2,100	230	460	500	1,200	1,300
28	50	50	200	75	815	14,500	3,810	300	450	400	1,200	1,600
29	50	·	340	100	795	7,680	4,200	250	360	400	1,500	1,800
30	50	·	310	20	1,890	2,450	3,210	565	635	550	3,500	1,800
31	500	·	130	·	2,410	·	1,530	5,000	·	915	·	1,520
Mean	64	39	95	83	949	2,545	2,632	979	969	1,003	4,601	1,404

Table 2 gives the mean daily releases from JRR. Discharge flow rates generally mirrored inflow values, although they tended to lag behind one to two weeks. Reservoir releases also increased during late May and peaked in July when the mean outflow was 3,449 cfs.

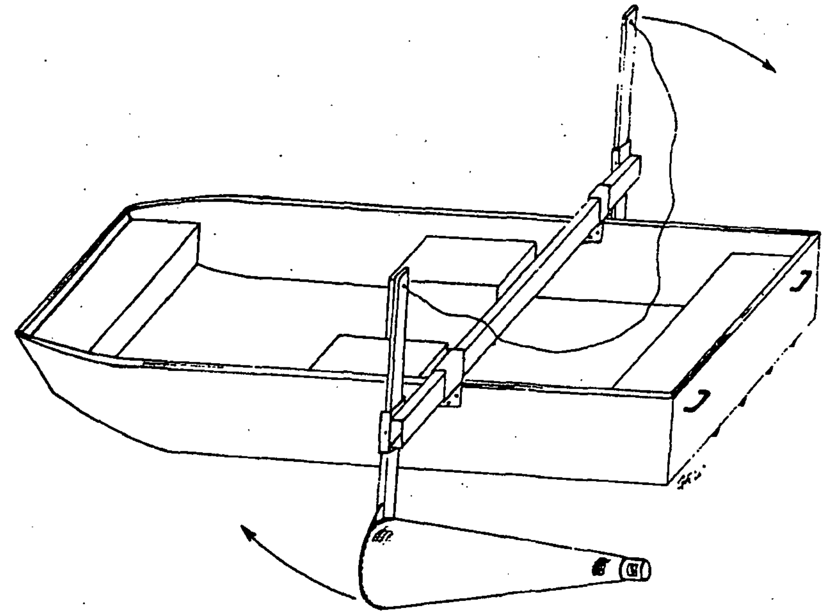


Figure 4. Twin push net assembly utilized throughout the study (patterned after Tarplee et al. 1979).

MATERIALS AND METHODS

Three collection locations in the Neosho River, one upstream and two downstream of John Redmond Reservoir (JRR) (Figure 2), were established for sampling on a weekly basis throughout the study period of 1 April through 31 July. Duplicate nocturnal samples were scheduled to be taken at all locations throughout the study with diurnal sampling also performed at Location 1. Diurnal collections at Location 1 were accomplished during the late afternoon. Nocturnal sampling was initiated at Location 2 (Hartford) no earlier than one-half hour after sunset, with Location 1 (JRR) collections following approximately one and one-half hours later, and Location 3 (Burlington) sampling initiated roughtly 40 minutes after boat recovery at JRR.

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	19	135	145	61	32	1,442	5,928	2,112	267	220	240	3,730
2	19	117	145	29	34	2,010	7,280	2,100	1,873	220	2,100	5,282
3	19	86	145	29	34	2,010	6,942	2,079	4,290	220	7,252	4,196
4	19	86	145	29	34	2,010	6,977	2,088	4,208	220	9,640	1,701
5	19	86	145	29	34	2,010	7,350	2,112	4,048	220	10,270	1,080
6	19	86	145	29	34	2,010	7,688	2,113	3,900	220	10,270	1,080
7	19	86	145	29	34	2,010	7,688	1,718	3,770	220	9,765	776
8	19	86	145	29	34	1,170	7,408	1,078	2,749	220	7,905	540
9	19	43	145	29	34	440	7,093	1,058	1,139	220	7,508	540
10	19	19	145	27	34	440	5,476	1,060	430	220	9,563	540
11	19	19	145	29	34	440	3,773	1,065	378	220	10,125	753
12	19	19	145	29	34	355	3,713	1,065	430	220	9,925	1,080
13	19	19	145	29	34	250	2,536	1,065	430	220	7,080	1,080
14	54	19	145	29	34	250	1,725	1,065	307	220	3,920	1,333
15	99	19	145	29	34	250	1,856	1,058	240	240	3,902	1,620
16	98	19	145	29	34	1,483	1,780	1,038	240	240	3,258	1,283
17	94	131	145	29	34	2,500	1,755	424	240	250	2,160	1,080
18	94	184	145	29	35	2,486	1,735	75	240	270	1,496	1,070
19	148	175	145	29	36	2,452	1,700	75	240	1,122	1,080	1,055
20	180	132	145	29	37	2,446	1,247	75	240	2,000	1,080	1,050
21	157	132	145	29	142	2,404	420	75	229	2,776	1,080	1,613
22	145	132	145	29	230	2,367	674	75	220	3,920	1,080	2,070
23	145	132	145	28	245	2,317	840	75	220	2,329	1,080	2,050
24	145	132	145	29	250	2,296	669	163	220	679	1,080	2,030
25	145	139	117	29	250	2,258	420	240	220	675	1,080	2,010
26	145	145	96	29	718	1,744	420	240	220	502	1,080	1,990
27	145	145	96	29	1,130	1,167	788	240	220	228	1,080	1,970
28	155	145	96	29	1,130	1,303	2,197	240	220	230	1,080	2,524
29	161	·	96	29	1,130	2,841	3,030	240	220	230	1,080	2,840
30	130	·	96	29	1,130	4,453	3,070	240	220	230	1,721	2,787
31	135	·	96	·	1,130	·	2,746	248	·	230	·	2,092
Mean	84	95	134	30	263	1,720	3,449	858	1,062	620	4,332	1,769

Larval fish collections were accomplished through the use of a boat-mounted twin net assembly patterned after Tarplee et al. (1979). The push net apparatus (Figure 4) utilized twin 0.5 x 1.5 m conical nets made of 0.560 mm mesh Nytex bolting cloth. Each net terminated in a 16.8 x 32.4 cm flow-through bucket with 0.411 mm mesh stainless steel screen.

The means of collection consisted of positioning the boat in an area of adequate flow and maintaining this position with the nets lowered. If flow velocity was inadequate for proper control, the boat was advanced through the sample area with the nets in the down position. Upon completion of a collection, the nets were rotated to the up position and the collected material washed completely into the buckets. Bucket contents were then further strained through the use of a 0.600 mm brass sieve prior to preservation with ten percent buffered formalin acetate.

Volumes of 35 to 60 m^3 per sample were used throughout the study as target values. The quantity of water filtered was measured by calibrated General Oceanics flowmeters (Model 2030R) mounted in the mouth of each net. Boat velocity was also measured for all collections through the use of a calibrated General Oceanics remote read-out flowmeter (Model 2031). Boat velocity measurements provided a back-up for in-net flowmeters. Data on several physical parameters were also recorded at the time of collection including date, time, current velocity, and water temperature.

Preserved samples were transported to laboratory facilities, where sorting was accomplished with the aid of a viewer/magnifier. Each replicate was picked twice to assure complete sorting. Larval fish found were transferred to ten percent buffered formalin phosphate and stored in the dark.

Identification of larval fish was accomplished through the use of Fish (1932); Hogue et al. (1976); Mansueti and Hardy (1967); May and Gasaway (1967), as well as appropriate family, generic, or species descriptions. Determinations of larval fish developmental phases were made as defined by Snyder (1981b) (Figures 5 and 6) as follows:

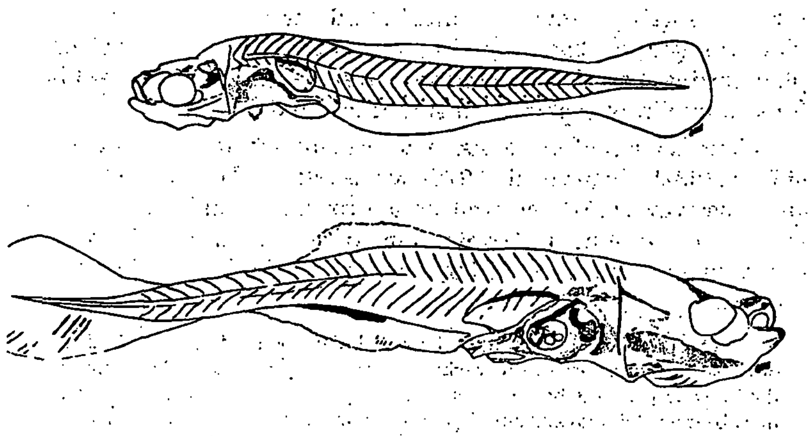
"Larval Period - The period of bony fish development characterized by obvious fin morphogenesis following hatching or parturition. Transition to the juvenile period is based on the following three criteria, each of which must be met: 1) finfold and atrophying fins, if any (very rare), must be absorbed beyond recognition; 2) the full adult complement of fin spines (actinotrichia) and rays (lepidotrichia), including secondary rays, must be distinctly formed (visually well defined) in all fins; and 3) segmentation must be evident in at least a few of the rays of each fin that is characterized by segmented rays in the adult.

Protolarval Phase - The larval phase of bony fish development characterized by the absence of distinct spines or rays associated with the future median fins (dorsal, anal or caudal fins). Transition to the mesolarval phase is based on the appearance of at least one distinct spine or ray in any of the median fins. Pectoral and pelvic fins or fin buds may be present.

Mesolarval Phase - The larval phase of bony fish development characterized by the morphogenesis of distinct principal rays in the median fins. Transition to the metalarval phase is based on the following two criteria, each of which must be met, except in species lacking pelvic fins: 1) the full adult complement of principal rays must be distinctly formed in the median fins; 2) the pelvic fins or fin buds must be evident.

Metalarval Phase - The larval phase of bony fish development characterized by the full adult complement of principal rays in the median fins and the presence of pelvic fins or fin buds (except in species lacking pelvic fins). Transition to the juvenile period is as specified in the definition for the larval period."

The definitions for developmental phase established by Snyder 1981b) were selected for use in this study due to the precision and eproducibility of determinations made through their use. Previous lefinitions based on retention of yolk material resulted in variable lassification of families in relation to developmental advancenent. The establishment of critera based on terminology unrelated o yolk retention permits increased consistency in relation to morhological features common to the majority of freshwater fish.



igure 5. Representative protolarval and mesolarval phase fish (*Pomoxis annularis* shown).

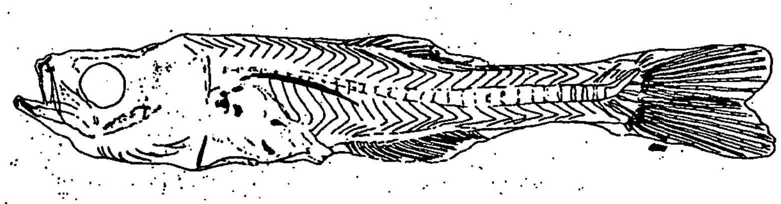


Figure 6. Representative metalarval phase fish (*Pomoxis annularis* shown).

Head, preanal, postanal, standard, and total lengths were measured on many of the sub-juvenile, non-clupeid larval fish identified (Figure 7). Head length was defined as the distance from the tip of the snout to the posterior margin of the cleithrum or the distance from the tip of the snout to the posterior margin of the operculum, if present. Other measurements, such as eye-gas bladder distance, head depth, etc., were recorded when necessary for identification.

Total preanal and postanal myomeres (Figure 7) were determined and recorded for the majority of sub-juvenile, non-clupeid larvae. Postanal myomeres were determined according to Siefert (1969) as follows:

"Postanal myomeres include all complete myomeres posterior to an imaginary vertical line drawn through the body at the posterior end of the anus... Remaining myomeres, including those bisected by the line, are considered preanal."

As discussed by Snyder (1981b), this technique produces myomere counts which nearly approximate the number of vertebrae to the bisecting line. All morphological determinations were recorded on the larval fish identification sheet. Measurements and meristics were documented through the use of an American Optics microscope with calibrated micrometer and polarizer or neutral density filter.

Raw data were compiled through the use of an Apple III computer. The Apple Visicalc III program was used for data processing including summation and mean, variance, and standard deviation determinations. The production of figures was accomplished through the use of an Apple LISA computer which utilized LISA file and LISA draw software. Mean daily larval fish concentrations for all locations, including JRR diurnal and nocturnal data, were tested through AOV for significant differences ($P_{0.05}$). Total mean diurnal and nocturnal concentrations were also analyzed for significant differences by the student's $t_{0.05}$ - test.

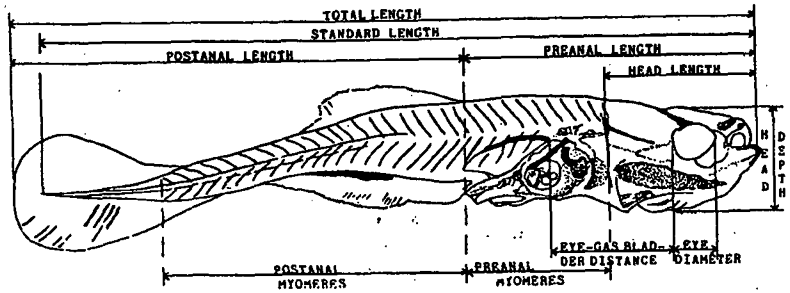


Figure 7. Selected anatomical and morphological distances and counts useful in the identification of larval fish.

RESULTS

Larval fish sampling on the Neosho River in 1981 was not initiated in early April as originally planned due to delays in equipment fabrication. The initial collection occurred on 25 April and sampling continued on a weekly basis through 31 July. Ichthyoplankton collections were accomplished on a total of 15 dates.

A combination of two problems resulted in incomplete sampling of all locations on some of the 15 dates. The first problem was high flow at Location 3 which, as described in the study plan, created hazardous conditions, precluding collections on four occasions. The second was a recurring bearing problem on the boat trailer which resulted in incomplete circuits on some dates. Due to these situations, Location 3 was sampled only nine times, while Location 1 (nocturnal) collections were made 13 times, Location 2, 14 times, and Location 1 (diurnal) collections were made on all 15 dates. A total of 51 samples, each consisting of two replicates, was collected despite the existence of these problems.

Physical Parameters

Measurement of field parameters was accomplished on all dates as planned, with the exception of 18 July when water temperatures were not recorded.

The General Oceanic flowmeters used from the beginning of the study for in-net measurement of water volumes filtered were removed for scheduled calibration on 13 July. They were found to be out-of-calibration at that time and were replaced. The replacement flowmeters served throughout the remainder of the study and were in-calibration after termination of sampling.

A comparison of in-net flow values provided by the out-of-calibration meters and boat speeds provided by the in-calibration back-up remote flowmeter was performed. Analysis of these data permitted the determination that the in-net flowmeters failed on or after the 5 June collections. Based on this determination, flow measurments made during the first six collection efforts were used for water volume calculations while boat speeds, as measured by the remote meter, were used for the 5 June through 10 July computations.

Spatial and Temporal Variations in Abundance and Species

In this study, larval fish were collected at all locations on all dates except for the 15 May John Redmond Reservoir (JRR) diurnal and 21 May Hartford nocturnal samples. A total of 27,905 fish of all phases was collected in 1981. This total consisted of 23,194 larvae, 2,501 eggs, and 2,210 juveniles. Excluding unidentified eggs, protolarvae, and mesolarvae, a total of 30 taxa representing 11 families was identified from the larvae collected. Tables follow which detail collection dates, times, water temperatures, current velocities, taxa collected, densities, and seasonal composition for larvae from all locations. A brief summary of the information in these tables is provided by location as follows.

Location 2: Hartford

Larval fish were collected at this location on all sampling dates except for 21 May. Efforts at Hartford resulted in a total collection of 4,837 fish of all phases. This total was comprised of 2,499 eggs, 2,330 larvae, and eight juvenile fish.

Eighteen taxa, excluding unidentified eggs, protolarvae, and mesolarvae, representing seven families were found to occur at this location (Table 3). Members of the families Clupeidae and Catostomidae dominated the larval fish complement; each comprising approximately 48% of all larvae (Figure 8). No other family except Cyprinidae, comprised more than 0.3% of the catch at Hartford.

Location 2 larval fish concentrations were variable throughout the study, ranging from a minimum of $9.4/100m^3$ to a maximum of $1,246.7/100m^3$. The total concentration of larval fish at Hartford exhibited a primary peak on 28 May which was roughly nine times higher than a secondary peak which occurred on 26 June (Figure 9).

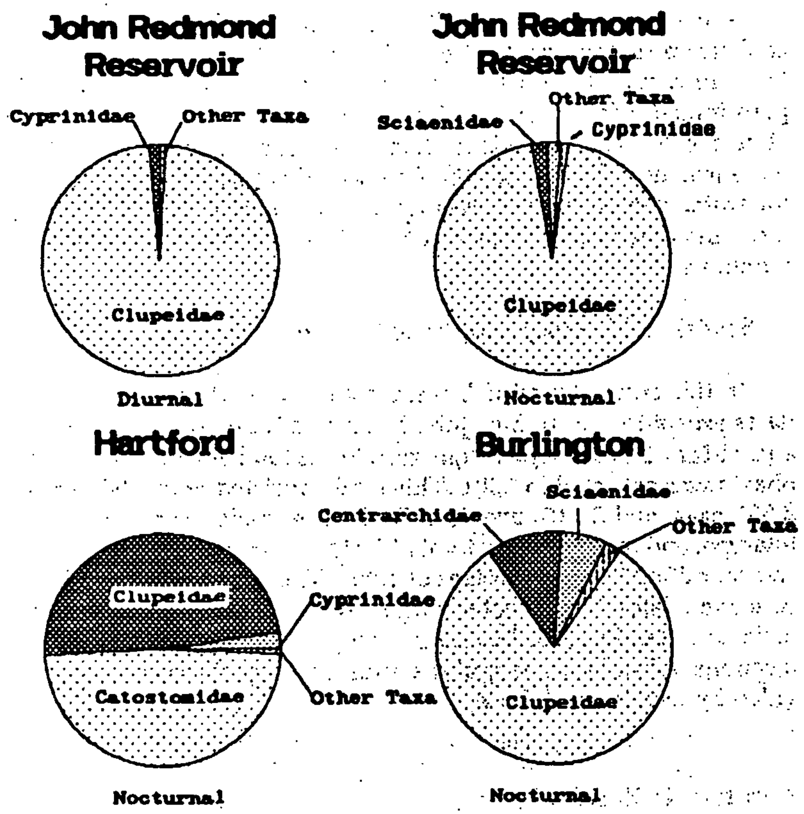


Figure 8. Annual relative abundance of larval fish collected at all locations in 1981.

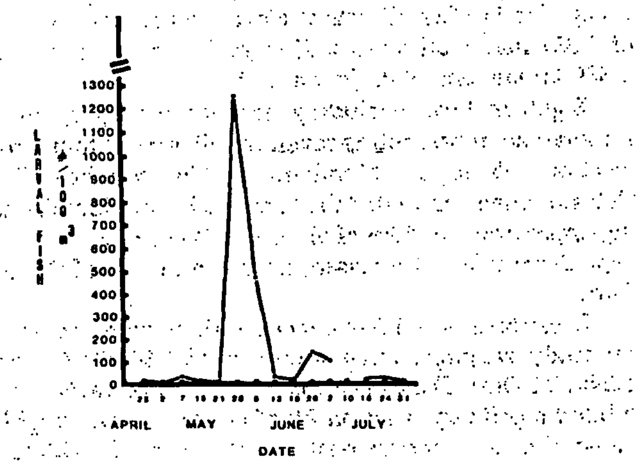


Figure 9. Total concentrations of larval fish collected in 1981 at Location 2, Hartford.

Table 3. Density of eggs, protolarvae, mesolarvae, metalarvae, and juvenile fish collected at Location 2, Hartford in 1981: nocturnal samples.

MONTH		APRIL	MAY					JUNE				JULY				
DATE		25	02	07	15	21	28	05	11	19	26	02	10	18	24	31
TIME (MILITARY)		2000	2100	2110	2110	2120	2120	2120	2135	2125	2135	2125	-b	2130	2120	2120
WATER TEMPERATURE (C)		17.0	20.0	19.5	17.0	15.5	21.5	21.5	24.5	27.0	26.0	25.5	-	-c	28.5	26.0
CURRENT VELOCITY (M/SEC)		-a	-a	-a	-a	0.60	0.20	0.85	0.40	0.70	-a	0.40	-	0.30	-a	0.75
SAMPLE VOLUME (m^3) (sum of both replicates)		79.1	95.4	107.8	92.4	115.7	116.7	94.2	106.0	94.2	117.8	94.2	-	139.6	124.0	122.6
Egg							1698.1		322.6		12.7	169.8				
Unknown PRTL									6.3					3.3	0.0	
Unknown MSL									0.9							
Lepisosteidae																
Lepisosteus sp.	MSL								0.9							
	MTL										0.0					
Clupeidae																
Dorosoma cepedianum	PRTL	5.14	4.2	31.1	9.6		904.9		3.8		5.1	2.1				
	MTL		4.1	1.9												
Cyprinidae																
Cyprinus carpio	PRTL						6.3	9.6	2.8	1.1		7.4				
	MSL							3.2								
Unknown Cyprinid	PRTL									1.1					0.0	3.5
	MSL														0.0	
Notropis sp.	PRTL								2.0							
(Th. *Phenacobius*)	PRTL	2.5														
	MSL	10.1														
(Th. *Pimephales*)	PRTL											2.1				
Catostomidae																
Unknown Catostomid	PRTL								1.9							
Ictiobinae																
(Th. *Carpiodes carpio*)	PRTL										0.0	63.9		14.4	20.0	
(Th. *Ictiobus*)	PRTL						137.5	499.4		14.9	123.9					
	MTL								10.4		7.6					
Ictiobus (Th. *bubalus*)	MSL														0.0	
Ictiobus (Th. *cyprinellus*)	(J)											1.1				
Ictaluridae																
Ictalurus punctatus	MTL															1.7
Noturus sp.	MTL															1.6
	(J)															1.6
Centrarchidae																
Lepomis sp.	PRTL								5.6							
	(J)									1.1						
Lepomis (Th. *cyanellus*)	MTL									1.1						
	(J)															1.6
Lepomis macrochirus	(J)															0.0
Percidae																
Percina sp.	MSL		1.1													
TOTAL EGGS (#/100 m^3)		0.0	0.0	0.0	0.0	0.0	1698.1	0.0	322.6	0.0	12.7	169.8	-b	0.0	0.0	0.0
TOTAL JUVENILES (#/100 m^3)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.1	-	0.0	0.0	4.0
TOTAL LARVAE (#/100 m^3)		17.7	9.4	33.0	9.6	0.0	1246.7	460.2	34.8	18.2	138.2	95.5	-	16.6	23.2	5.0
TOTAL COLLECTED (#/100 m^3)		17.7	9.4	33.0	9.6	0.0e	2944.8	460.2	357.4	19.3	150.9	264.4	-	14.6	23.2	9.8

a = Below Detection Limit
b = Samples Not Collected Due to Equipment Malfunction
c = Not Measured
d = All Values Represent the Mean of Two Replicates
e = No Fish Collected

PRTL = Protolarvae
MSL = Mesolarvae
MTL = Metalarvae
(J) = Juvenile
Th. = Thought to be (See Discussion)

Location 1: John Redmond Reservoir Tailwaters

With the exception of 15 May, larval fish were collected on all dates at Location 1. A total of 19,950 fish of all phases was collected at JRR as a result of diurnal and nocturnal collections. This total consisted of 7,969 diurnally collected and 11,981 nocturnally collected fish. The diurnal collection total included 1 egg, 6,773 larvae, and 1,195 juvenile fish while 1 egg, 11,566 larvae, and 414 juvenile fish comprised the nocturnal catch.

A total of 21 taxa, representing ten families, occurred at JRR, excluding unidentified eggs and protolarvae (Tables 4 and 5). Not all 21 taxa appeared both diurnally and nocturnally, however. Only 13 taxa occurred diurnally while 19 were present nocturnally. Taxa present in daylight samples but not present in collections made after dark were unknown cyprinid, Cyprinidae (thought to be *Pimephales*), *Ictiobus* sp., *Ictalurus punctatus*, Cyprinodontidae (thought to be *Fundulus notatus*), unknown centrarchid, *Percina* sp., and Percidae (thought to be *Stizostedion*). Conversely, unknown catostomid and *Labidesthes sicculus* were the only two nocturnally collected taxa not found in diurnal samples.

In addition to variability in the taxa present, larval fish also occurred in variable numbers diurnally and nocturnally. Table 6 presents the day/night (D/N) ratio of JRR larval fish.

Table 4. Density of eggs, protolarvae, mesolarvae, metalarvae, and juvenile fish collected at Location 1, John Redmond Reservoir spillway in 1981: diurnal samples.

MONTH		APRIL			MAY				JUNE					JULY		
DATE		25	03	07	15	21	28	05	13	19	26	02	10	18	24	31
TIME (MILITARY)		1730	1830	1820	1725	1735	1725	1830	1650	1825	1720	1730	1800	1843	1715	1745
WATER TEMPERATURE (C)		19.5	21.5	18.0	18.5	17.0	20.5	23.5	25.5	22.0	25.0	25.0	28.5	-b	27.0	25.0
CURRENT VELOCITY (M/SEC)		-b	-b	-b	-b	-b	0.65	0.95	-b	0.90	0.60	1.25	0.65	0.90	0.30	0.70
SAMPLE VOLUME (m^3) (sum of both replicates)		104.7	113.3	136.3	140.5	104.1	87.0	100.0	94.2	106.0	104.0	106.0	106.0	123.2	120.2	116.3
Egg							1.2									
Unknown PRTL		1.0c	0.9													
Clupeidae																
Dorosoma cepedianum	PRTL	5.7	73.3	68.3		3.8	96.4	110.0	86.0	0.9			3.8			
	MSL			11.1		3.8	8.0	507.0	3953.5	47.2			5.7		29.1	37.1
	MTL								1305.7	520.8	76.4	0.9	13.2			4.3
	(J)									6.6	657.6	14.2	384.8	1.6	10.8	9.1
Cyprinidae																
Cyprinus carpio	PRTL					0.9	4.7	2.0					0.9			
	MSL															
	MTL															
	(J)									0.9	0.9	2.8				
Unknown Cyprinid	PRTL															
	MSL															
Notropis sp.	PRTL								7.4							
	MSL								12.7							
	MTL								1.1		0.9		0.9			
	(J)										0.9		0.9			
Notropis (Th. *buchanani*)	PRTL												11.3			
	MSL												11.3	3.4	10.8	
	MTL												0.9	3.2	1.7	11.2
	(J)												0.9		3.1	0.9
(Th. *Pimephales*)	PRTL															
Catostomidae																
Unknown Catostomid	PRTL												0.9			
Ictiobinae																
(Th. *Ictiobus*)	PRTL															
	MSL								2.1							
	MTL															
	(J)															
Ictiobus sp.	MTL															
	(J)															
Ictiobus (Th. *cyprinellus*)	(J)											7.6				
Ictaluridae																
Ictalurus punctatus	MSL															
	(J)															
Cyprinodontidae																
(Th. *Fundulus notatus*)	PRTL															
Atherinidae																
Labidesthes sicculus	PRTL						1.1									
Percichthyidae																
Morone chrysops	PRTL						19.1									
	MSL							3.0								
	MTL															
	(J)									1.9	2.8	6.6				0.8
Centrarchidae																
Unknown Centrarchid	PRTL															
Lepomis sp.	PRTL								6.4							
	MSL												0.9			
Pomoxis sp.	PRTL					0.9										
	MTL									0.9						
Pomoxis annularis	PRTL							9.0								
	MSL															
	MTL															
	(J)										3.6	0.9				
Percidae																
Percina sp.	PRTL															
(Th. *Stizostedion*)	MSL															
Sciaenidae																
Aplodinotus grunniens	PRTL			0.8				5.0								
	MSL							2.0								0.8
	MTL															
	(J)									0.9	0.9	4.7				
TOTAL EGGS (#/100 m^3)		0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL JUVENILES (#/100 m^3)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.3	665.0	30.8	388.6	1.6	14.1	6.8
TOTAL LARVAE (#/100 m^3)		6.7	74.2	80.2	0.0	9.4	129.9	634.0	5274.9	569.8	77.3	0.9	49.8	5.6	41.6	53.4
TOTAL COLLECTED (#/100 m^3)		6.7	74.2	80.2	0.0d	9.4	131.1	634.0	5274.9	580.1	743.3	37.7	438.4	7.2	55.7	60.2

a = Below Detection Limit
b = Not Measured
c = All Values Represent the Mean of Two Replicates
d = No Fish Collected

PRTL = Protolarvae
MSL = Mesolarvae
MTL = Metalarvae
(J) = Juvenile
Th. = Thought to be (See Discussion)

Table 5. Density of eggs, protolarvae, mesolarvae, metalarvae, and juvenile fish collected at Location 1, John Redmond Reservoir spillway in 1981: nocturnal samples.

MONTH		APRIL			MAY				JUNE					JULY		
DATE		25	02	07	15	21	28	05	13	19	26	02	10	18	24	31
TIME (MILITARY)		2125	2345	2200	2215	2250	2240	2300	2330	2300	-b	2300	-b	2250	2225	2245
WATER TEMPERATURE (C)		18.0	19.0	18.0	15.5	15.0	20.8	21.5	25.0	22.0	-	25.0	-	-c	26.4	26.0
CURRENT VELOCITY (M/SEC)		-a	-a	-a	-a	-a	0.60	0.90	0.10	0.95	-	1.50	-	0.75	0.25	0.80
SAMPLE VOLUME (m^3) (sum of both replicates)		84.2	106.7	111.0	113.6	105.2	114.9	106.0	112.0	112.0	-	106.0	-	118.8	127.3	104.9
Egg																
Unknown PRTL							0.9									
Clupeidae																
Dorosoma cepedianum	PRTL	32.0d	34.4	18.9		2.9	140.1	146.2	53.6						1.6	
	MSL		0.9	0.9	0.9		29.6	3701.9	6007.1	6.2				2.5	13.2	22.0
	MTL							1.9	1341.1	697.3						6.6
	(J)									271.4		7.6		12.9	0.6	7.6
Cyprinidae																
Cyprinus carpio	PRTL	24.0	12.2		0.9	1.9	11.4									
	MSL		0.9					43.4								
	MTL									0.9						
	(J)											1.9				
Unknown Cyprinid	PRTL			0.9				0.9	1.8							
	MSL								9.8							
Notropis sp.	PRTL								1.8							
	MSL								6.2	0.9						
	MTL								0.9							
	(J)															
Notropis (Th. *buchanani*)	PRTL															
	MSL														3.1	1.0
	MTL													0.8	3.9	4.7
	(J)															1.0
(Th. *Pimephales*)	PRTL								10.7							
Catostomidae																
Unknown Catostomid	PRTL															
Ictiobinae																
(Th. *Ictiobus*)	PRTL							11.3								
	MSL							4.7	11.6	2.7						
	MTL									0.9						
	(J)															
Ictiobus sp.	MTL								1.8							
	(J)								1.8							
Ictiobus (Th. *cyprinellus*)	(J)											5.7				
Ictaluridae																
Ictalurus punctatus	MSL											0.9				0.9
	(J)									0.9		3.6			0.8	0.9
Cyprinodontidae																
(Th. *Fundulus notatus*)	PRTL								0.9							
Atherinidae																
Labidesthes sicculus	PRTL															
Percichthyidae																
Morone chrysops	PRTL		3.0				95.2	0.9								
	MSL							2.8		0.9						
	MTL								0.9							
	(J)								1.8	6.2		1.9				
Centrarchidae																
Unknown Centrarchid	PRTL								0.9							
Lepomis sp.	PRTL						0.9	0.9	7.1							
	MSL															
Pomoxis sp.	PRTL				0.9											
	MTL								0.9							
Pomoxis annularis	PRTL					1.8	2.6									
	MSL						1.7	0.9								
	MTL							0.9								
	(J)															
Percidae																
Percina sp.	PRTL		0.9	0.9					6.2							
(Th. *Stizostedion*)	MSL			0.9												
Sciaenidae																
Aplodinotus grunniens	PRTL							35.6	12.5	3.7				3.3	3.4	
	MSL							42.4	42.0	16.1				6.7	6.4	2.8
	MTL								1.8	5.4		1.9			0.8	4.7
	(J)									8.0		27.4		0.8		1.0
TOTAL EGGS (#/100 m^3)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-b	0.0	-b	0.0	0.0	0.0
TOTAL JUVENILES (#/100 m^3)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	286.5	-	47.3	-	13.5	9.4	10.5
TOTAL LARVAE (#/100 m^3)		46.8	43.1	21.5	2.7	7.6	281.4	3990.0	5419.6	634.0	-	2.8	-	13.3	31.4	42.7
TOTAL COLLECTED (#/100 m^3)		46.8	43.1	21.5	2.7	7.6	282.4	3990.0	5423.2	920.5	-	50.1	-	26.8	40.8	53.2

a = Below Detection Limit
b = Samples Not Collected Due to Equipment Malfunction
c = Not Measured
d = All Values Represent the Mean of Two Replicates

PRTL = Protolarvae
MSL = Mesolarvae
MTL = Metalarvae
(J) = Juvenile
Th. = Thought to be (See Discussion)

Dorosoma cepedianum, the sole member of the family Clupeidae, dominated the diurnal JRR larval fish complement, comprising 98.0% of all larvae (Figure 8). Although they comprised only 1.2% of the catch, members of the family Cyprinidae were the next most common diurnally collected larvae. No other family present diurnally consisted of more than 0.3% of the total catch.

Table 6. Diurnal/nocturnal ratios of larval fish collected in 1981 at John Redmond Reservoir.

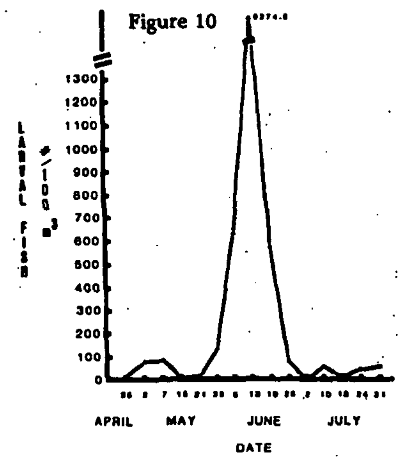
MONTH DATE	APRIL 25	MAY 02	07	15	21	28	JUNE 05	13	19	26	JULY 02	10	16	24	31
TAXA															
Unknown PROL	1/0[a]	1/0													
Clupeidae															
Dorosoma cepedianum	6/19	81/27	45/11	0/1	3/3	91/195	617/4081	4941/5938	603/676	81/-	1/0	24/-	6/3	35/13	24/15
Cyprinidae															
Cyprinus carpio	0/20	0/14		0/1	1/3	4/13	2/45		0/1			1/-			
Unknown Cyprinid			0/1				0/1	0/13							
Notropis sp.								2/1	0/1	1/-		1/-			
Notropis (Th. *buchanani*)												25/-	7/1	15/9	13/6
(Th. *Pimephales*)								0/13							
Catostomidae															
Unknown Catostomid												1/-			
Ictiobinae															
(Th. *Ictiobus*)							0/17	2/13	0/4						
Ictiobus sp.								0/5							
Ictaluridae															
Ictalurus punctatus											0/2				0/1
Cyprinodontidae															
(Th. *Fundulus notatus*)								0/1							
Atherinidae															
Labidesthes sicculus						1/0									
Percichthyidae															
Morone chrysops		0/4				17/100	1/4	0/3	0/1						
Centrarchidae															
Unknown Centrarchid								0/1							
Lepomis sp.						0/1	0/1	1/6				1/-			
Pomoxis sp.				0/1	1/0				0/1						
Pomoxis annularis					0/2	0/5	1/2	0/1							
Percidae															
Percina sp.		0/1	0/1					0/7							
(Th. *Stizostedion*)			0/1												
Sciaenidae															
Aplodinotus grunniens			1/0				7/87	0/63	0/27		0/3		0/12	0/13	1/8

a = All Values Expressed as Ratios Reduced to Lowest Common Denominator
Th. = Thought to be (See Discussion)

In nocturnal samples *D. cepedianum* also was dominant, representing 95.2% (Figure 8). No other taxa comprised more than 2.0% of the total catch, although members of Cyprinidae, Percichthyidae, and Sciaenidae exhibited total annual relative abundances of 1.2, 1.0, and 2.0%, respectively.

Both diurnal and nocturnal larval fish densities reached maximum levels near 5,000/100m³ in 1981 at JRR. The patterns of occurrence were similar, with both diurnal and nocturnal larvae exhibiting a catch curve similar to a Gaussian distribution.

The maximum diurnal larval fish density occurred on 13 June at 5,274.9/100m³ and was flanked by two periods of densities below 10.0/100m³ (Figure 10). These periods of diminished larval fish occurrence were preceded and followed by periods when ichthyoplankton achieved densities between 50 and 100/100m³. The minimum diurnal concentration occurred on 15 May when no larvae were collected.



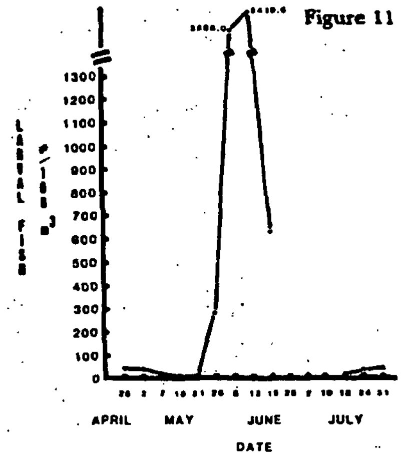


Figure 10. Total concentrations of larval fish collected in 1981 at Location 1, John Redmond Reservoir tailwaters: diurnal samples.

Figure 11. Total concentrations of larval fish collected in 1981 at Location 1, John Redmond Reservoir tailwaters: nocturnal samples.

Maximum nocturnal densities at JRR were achieved during the first two June sampling dates. Larval fish densities on these dates, 5 and 13 June, were 3,998.0 and 5,419.6/100m³; roughly six to eight times higher than the next highest concentration (Figure 11). A value of 2.7/100m³ on 15 May was the minimum larval fish concentration nocturnally at JRR.

Location 3: Burlington

Larval fish were found at Burlington on all nights that sampling was performed. A total of 3,118 fish of all phases appeared in 0.5 m nets at this location. This total consisted of 2,525 larvae, no eggs, and 593 juvenile fish. Excluding unidentified protolarvae, 14 taxa, representing seven families, were identified from Location 3 larvae (Table 7). *Dorosoma cepedianum* also dominated the annual relative abundance at Burlington, but to a lesser degree than at JRR, comprising 81.4% of all larvae. Other important families included Centrarchidae at 10.1%, Sciaenidae at 6.4%, and Cyprinidae at 1.1%. No other family comprised more than 1.0% of the Location 3 catch (Figure 8).

Larval fish concentrations varied from 6.3/100m³ on 18 July to a maximum of 1,766.4/100m³ on 19 June. The graph of densities at

Table 7. Density of eggs, protolarvae, mesolarvae, metalarvae, and juvenile fish collected at Location 3, Burlington in 1981: nocturnal samples.

DATE 81		APRIL 25	MAY 02	07	15	21	28	JUNE 05	13	19	26	JULY 02	10	18	24	31
TIME (MILITARY)		2100	2130	2110	2150	2150	2143	-b	-c	2125	-c	-b	-c	2130	2125	-b
WATER TEMPERATURE (C)		18.5	19.5	19.5	17.0	15.5	20.0	-	-	22.0	-	-	-	-d	21.0	-
CURRENT VELOCITY (M/SEC)		-d	-d	-d	-d	-d	0.15	-	-	0.40	-	-	-	-d	-d	-
SAMPLE VOLUME (m^3) (sum of both replicates)		92.7	111.3	92.9	105.5	139.1	121.2	-	-	117.0	-	-	-	128.0	130.1	-
Unknown PRTL							0.8									
Clupeidae																
Dorosoma cepedianum	PRTL		5.4	15.0	23.7	5.0	58.6									
	MSL		1.0		0.9					404.1				0.8	0.8	
	MTL									1212.6						
	(J)									435.3						
Cyprinidae																
Cyprinus carpio	PRTL	1.1a	0.1				7.4									
	MSL									0.8						
Unknown Cyprinid	MSL									0.8						
	MTL														0.8	
(Th. Notemigonus crysoleucas)	PRTL		0.9													
Notropis sp.	(J)														1.6	
Notropis (Th. buchanani)	MSL														1.6	
	MTL														3.4	
	(J)													1.5	0.8	
Ictaluridae																
Ictalurus punctatus	MTL														3.1	
	(J)														36.0	
Atherinidae																
Labidesthes sicculus	PRTL				3.0											
	(J)													1.7	0.8	
Percichthyidae																
Morone chrysops	PRTL						10.7									
	MSL	2.1														
	MTL									0.8						
	(J)									3.4						
Centrarchidae																
Lepomis sp.	MTL													0.8		
Micropterus sp.	MTL						0.8									
Pomoxis sp.	PRTL	1.3		5.4	44.4	13.7	1.6									
	MSL									0.8						
Pomoxis annularis	PRTL	51.7	22.5	21.7	52.2	12.9	1.6									
	MSL		3.6	3.2		0.7										
	(J)									1.7						
Sciaenidae																
Aplodinotus grunniens	PRTL													0.7		
	MSL									93.9				4.0		
	MTL									30.5					2.3	
	(J)						3.3			15.3						
TOTAL EGGS (#/100 m^3)		0.0	0.0	0.0	0.0	0.0	0.0	-b	-c	0.0	-c	-b	-c	0.0	0.0	-b
TOTAL JUVENILES (#/100 m^3)		0.0	0.0	0.0	0.0	0.0	3.3	-	-	456.7	-	-	-	3.2	39.2	-
TOTAL LARVAE (#/100 m^3)		56.2	42.3	44.3	125.0	32.2	81.5	-	-	1766.4	-	-	-	6.3	11.0	-
TOTAL COLLECTED (#/100 m^3)		56.2	42.3	44.3	125.0	32.2	84.8	-	-	2223.1	-	-	-	9.5	50.2	-

a = Below Detection Limit
b = Samples Not Collected Due to High Flow
c = Samples Not Collected Due to Equipment Malfunction
d = Not Measured
e = All Values Represent the Mean of Two Replicates

PRTL = Protolarvae
MSL = Mesolarvae
MTL = Metalarvae
(J) = Juvenile
Th. = Thought to be (See Discussion)

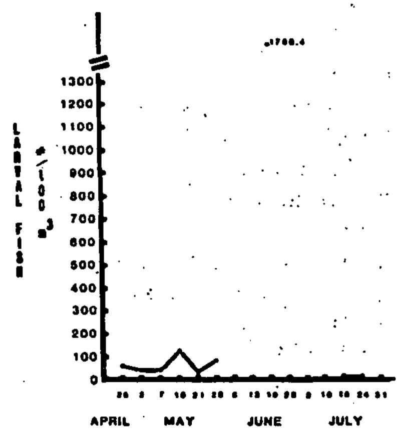


Figure 12. Total concentrations of larval fish collected in 1981 at Location 3, Burlington.

this location also appeared to exhibit a Gaussian distribution, although data gaps make the curve less distinct (Figure 12).

Morphometrical Data

Certain morphological data necessary for identification of larval fish were collected throughout the identification process. These data consisted of measurements and counts for diagnostic features. The morphometrical features quantified were not identical for all taxa, although a limited number were common to all.

With three exceptions, morphometrical data are presented in tabular form for those taxa occurring in sufficient numbers to permit meaningful interpretation. *Dorosoma cepedianum*, *Morone chrysops*, and *Aplodinotus grunniens* were the three taxa not included in the morphometrical tables. Data for these species were not presented on the basis that they present distinctive morphological characteristics which have been extensively studied. Table 8 provides definitions for the abbreviations used in the following tables. Tables 9 through 22 present morphometrical data for the 14 taxa determined to represent worthwhile information.

Table 8. Definitions of morphometrical abbreviations.

Abbreviation	Definition
TL	Total Length
SL	Standard Length
Ptnl L	Postanal Length
Prnl L	Preanal Length
Egb D	Eye-gas Bladder Distance
PFL	Pectoral Fin Length
Ed	Eye Diameter
HD	Head Depth
HL	Head Length
N/A	Not Applicable

Table 9. Means, ranges, and standard deviations for morphometrical data on Cyprinidae: *Cyprinus carpio*.

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	6.9 ± 0.6	5.2 - 8.1	86	12.3 ± 2.2	7.5 - 15.4	22	N/A	19.1	1	25.3 ± 2.8	21.4 - 28.2	4
SL	6.6 ± 0.5	5.0 - 7.7	83	10.8 ± 1.6	7.0 - 13.2	22	N/A	15.2	1	19.4 ± 2.4	16.5 - 22.0	4
Ptnl L	2.2 ± 0.2	1.5 - 2.6	85	4.1 ± 0.8	2.4 - 5.2	22	N/A	7.5	1	9.9 ± 1.2	8.6 - 11.5	4
Prnl L	4.7 ± 0.4	3.2 - 5.5	85	8.1 ± 1.4	5.1 - 10.2	22	N/A	11.6	1	14.9 ± 1.8	12.8 - 16.7	4
HL	1.5 ± 0.2	1.0 - 1.8	81	3.1 ± 0.7	2.0 - 4.0	22	N/A	7.0	1	6.8 ± 1.0	5.9 - 8.1	4
LENGTHS (%TL)												
HL	21.0 ± 2.0	15.0 - 25.0	81	25.0 ± 2.0	21.0 - 27.0	22	N/A	37.0	1	27.0 ± 2.0	24.0 - 29.0	4
Prnl L	68.0 ± 3.0	58.0 - 75.0	85	66.0 ± 1.0	65.0 - 69.0	22	N/A	61.0	1	59.0 ± 3.0	55.0 - 62.0	4
RELATIONSHIPS												
Prnl L/HL (#)	3.2 ± 0.3	2.8 - 4.4	81	2.7 ± 0.2	2.4 - 3.0	22	N/A	1.7	1	2.2 ± 0.3	2.0 - 2.6	4
Prnl L/Ptnl L (#)	2.1 ± 0.2	1.4 - 2.9	85	2.0 ± 0.1	1.8 - 2.2	22	N/A	1.6	1	1.5 ± 0.1	1.4 - 1.6	4
MYOMERES												
Preanal	25.0 ± 1.0	23.0 - 27.0	80	26.0 ± 1.0	24.0 - 28.0	22		-				
Postanal	12.0 ± 1.0	9.0 - 14.0	80	11.0 ± 1.0	9.0 - 14.0	22		-		12.0 ± 1.0	12.0 - 13.0	4
Total	37.0 ± 1.0	34.0 - 40.0	80	37.0 ± 1.0	35.0 - 39.0	22		-				

Table 10. Means, ranges, and standard deviations for morphometrical data on Cyprinidae: *Notropis* sp.

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	6.0 ± 0.5	5.6 - 7.0	12	8.2 ± 0.7	7.1 - 9.6	16	11.3 ± 0.8	10.4 - 12.0	4	12.5 ± 1.0	11.8 - 13.2	2
SL	5.7 ± 0.4	5.2 - 6.6	12	7.5 ± 0.5	6.6 - 8.4	16	9.3 ± 0.6	8.8 - 9.8	4	10.2 ± 0.8	9.6 - 10.8	2
Ptnl L	2.2 ± 0.3	1.6 - 2.6	12	3.2 ± 0.3	2.6 - 3.8	16	5.2 ± 0.6	4.5 - 5.9	4	5.8 ± 0.6	5.4 - 6.3	2
Prnl L	3.9 ± 0.3	3.4 - 4.5	12	5.1 ± 0.4	4.6 - 5.8	16	6.1 ± 0.4	5.9 - 6.6	4	6.6 ± 0.4	6.4 - 6.9	2
HL	1.2 ± 0.3	0.9 - 1.6	12	1.5 ± 0.2	1.0 - 1.8	16	2.2 ± 0.2	2.0 - 2.4	4	2.6 ± 0.1	2.5 - 2.6	2
LENGTHS (%TL)												
HL	20.0 ± 5.0	15.0 - 29.0	12	18.0 ± 2.0	12.0 - 20.0	16	20.0 ± 1.0	18.0 - 21.0	4	20.0 ± 1.0	20.0 - 21.0	2
Prnl L	64.0 ± 4.0	61.0 - 71.0	12	62.0 ± 1.0	60.0 - 64.0	16	54.0 ± 2.0	51.0 - 57.0	4	53.0 ± 1.0	52.0 - 54.0	2
RELATIONSHIPS												
Prnl L/HL (#)	3.4 ± 0.8	2.1 - 4.4	12	3.5 ± 0.5	3.2 - 5.2	16	2.8 ± 0.2	2.5 - 3.0	4	2.6 ± 0.0	2.6	2
Prnl L/Ptnl L (#)	1.8 ± 0.3	1.5 - 2.5	12	1.6 ± 0.1	1.5 - 1.8	16	1.2 ± 0.1	1.0 - 1.3	4	1.1 ± 0.1	1.1 - 1.2	2
MYOMERES												
Preanal	23.0 ± 1.0	22.0 - 24.0	12	23.0 ± 1.0	21.0 - 24.0	16	21.0 ± 1.0	19.0 - 22.0	4	20.0 ± 0.0	20.0	2
Postanal	12.0 ± 1.0	9.0 - 14.0	12	12.0 ± 1.0	11.0 - 13.0	16	12.0 ± 1.0	11.0 - 14.0	4	12.0 ± 1.0	12.0 - 13.0	2
Total	35.0 ± 2.0	31.0 - 37.0	12	35.0 ± 1.0	33.0 - 36.0	16	34.0 ± 2.0	31.0 - 36.0	4	32.0 ± 1.0	32.0 - 33.0	2

Table 11. Means, ranges, and standard deviations for morphometrical data on Cyprinidae: *Notropis* sp. (Thought to be *buchanani*).

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	5.8 ± 0.7	4.8 - 7.1	12	8.7 ± 1.0	6.8 - 10.6	35	11.5 ± 1.2	9.6 - 14.4	28	14.8 ± 2.7	11.0 - 17.7	9
SL	5.5 ± 0.7	4.4 - 6.9	12	7.6 ± 0.7	6.3 - 9.0	35	9.5 ± 0.8	8.0 - 11.2	28	12.1 ± 2.5	8.6 - 16.4	9
Ptnl L	2.1 ± 0.2	1.8 - 2.4	12	3.6 ± 0.5	2.6 - 4.8	35	5.3 ± 0.8	4.1 - 7.2	27	7.4 ± 1.8	4.8 - 9.4	9
Prnl L	3.6 ± 0.6	3.0 - 5.0	12	5.1 ± 0.5	4.2 - 5.8	35	6.2 ± 0.6	5.5 - 8.5	27	7.4 ± 0.9	6.2 - 8.4	9
HL	1.0 ± 0.2	0.8 - 1.4	12	1.6 ± 0.2	1.2 - 2.2	35	2.3 ± 0.3	1.9 - 2.8	28	3.0 ± 0.5	2.2 - 3.6	9
LENGTHS (%TL)												
HL	17.0 ± 2.0	15.0 - 20.0	12	19.0 ± 1.0	17.0 - 21.0	35	20.0 ± 1.0	19.0 - 22.0	28	20.0 ± 1.0	20.0 - 21.0	9
Prnl L	63.0 ± 3.0	61.0 - 70.0	12	59.0 ± 2.0	55.0 - 62.0	35	54.0 ± 3.0	49.0 - 66.0	27	51.0 ± 4.0	47.0 - 56.0	9
RELATIONSHIPS												
Prnl L/HL (#)	3.8 ± 0.4	3.4 - 4.8	12	3.1 ± 0.2	2.6 - 3.6	35	2.6 ± 0.6	2.3 - 3.3	28	2.5 ± 0.2	2.3 - 2.8	9
Prnl L/Ptnl L (#)	1.7 ± 0.2	1.6 - 2.4	12	1.4 ± 0.1	1.2 - 1.6	35	1.2 ± 0.2	0.9 - 2.0	27	1.0 ± 0.2	0.9 - 1.3	9
MYOMERES												
Preanal	22.0 ± 1.0	21.0 - 23.0	11	22.0 ± 1.0	20.0 - 24.0	35	20.0 ± 1.0	19.0 - 22.0	25	20.0 ± 1.0	18.0 - 21.0	9
Postanal	13.0 ± 1.0	11.0 - 14.0	11	12.0 ± 1.0	10.0 - 14.0	35	11.0 ± 1.0	10.0 - 14.0	25	13.0 ± 1.0	11.0 - 14.0	9
Total	35.0 ± 1.0	34.0 - 36.0	11	33.0 ± 1.0	31.0 - 36.0	35	32.0 ± 1.0	30.0 - 34.0	25	32.0 ± 1.0	31.0 - 34.0	9

Table 12. Means, ranges, and standard deviations for morphometrical data on Cyprinidae: (Thought to be *Phenacobius*).

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	8.0 ± 0.1	8.0 - 8.1	2	9.7 ± 0.8	8.7 - 11.4	8	None Identified			None Identified		
SL	7.6 ± 0.1	7.5 - 7.6	2	9.0 ± 0.6	8.2 - 10.1	8						
Ptnl L	2.9 ± 0.1	2.9 - 3.0	2	3.6 ± 0.4	3.2 - 4.3	8						
Prnl L	5.1 ± 0.0	5.1	2	6.1 ± 0.5	5.5 - 7.1	8						
PFL	N/A	1.3	1	N/A	1.3	1						
HL	1.4 ± 0.4	1.1 - 1.6	2	2.0 ± 0.2	1.7 - 2.4	8						
LENGTHS (%TL)												
HL	17.0 ± 5.0	14.0 - 20.0	2	21.0 ± 1.0	20.0 - 22.0	8						
Prnl L	63.0 ± 1.0	63.0 - 64.0	2	63.0 ± 1.0	61.0 - 65.0	8						
RELATIONSHIPS												
Prnl L/HL (#)	3.9 ± 1.0	3.2 - 4.6	2	3.0 ± 0.1	2.8 - 3.2	8						
Prnl L/Ptnl L (#)	1.7 ± 0.1	1.7 - 1.8	2	1.7 ± 0.1	1.6 - 1.8	8						
TL/PFL	N/A	7.4	1	N/A	6.2	1						
MYOMERES												
Preanal	25.0 ± 1.0	24.0 - 26.0	2	25.0 ± 1.0	24.0 - 26.0	8						
Postanal	11.0 ± 1.0	11.0 - 12.0	2	12.0 ± 1.0	9.0 - 13.0	8						
Total	36.0 ± 2.0	35.0 - 38.0	2	37.0 ± 1.0	35.0 - 38.0	8						

Table 13. Means, ranges, and standard deviations for morphometrical data on Cyprinidae: (Thought to be *Pimephales*).

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	4.5 ± 0.4	4.0 - 5.9	14	None Identified			None Identified			None Identified		
SL	4.2 ± 0.4	3.8 - 5.6	14									
Ptnl L	1.8 ± 0.2	1.6 - 2.3	14									
Prnl L	2.7 ± 0.3	2.3 - 3.6	14									
HL	0.9 ± 0.1	0.8 - 1.2	14									
LENGTHS (%TL)												
HL	19.0 ± 2.0	17.0 - 23.0	14									
Prnl L	59.0 ± 2.0	54.0 - 62.0	14									
RELATIONSHIPS												
Prnl L/HL (#)	3.1 ± 0.3	2.6 - 3.4	14									
Prnl L/Ptnl L (#)	1.5 ± 0.1	1.4 - 1.6	14									
MYOMERES												
Preanal	20.0 ± 1.0	19.0 - 22.0	14									
Postanal	12.0 ± 1.0	11.0 - 14.0	14									
Total	33.0 ± 1.0	31.0 - 35.0	14									

Table 14. Means, ranges and standard deviations for morphometrical data on Catostomidae: Ictiobinae; (Thought to be *Carpiodes carpio*).

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	6.6 ± 0.5	5.4 - 7.7	57	None Identified			None Identified			None Identified		
SL	6.3 ± 0.5	5.1 - 7.3	57									
Ptnl L	1.8 ± 0.2	1.4 - 2.1	57									
Prnl L	4.8 ± 0.4	3.9 - 5.7	57									
PFL	N/A	0.8	1									
HD	0.7 ± 0.1	0.6 - 0.8	11									
HL	1.2 ± 0.1	1.0 - 1.6	56									
LENGTHS (%TL)												
HL	19.0 ± 1.0	16.0 - 27.0	56									
Prnl L	73.0 ± 2.0	70.0 - 78.0	57									
DEPTHS (%TL)												
HD	11.0 ± 1.0	10.0 - 12.0	11									
RELATIONSHIPS												
HD/HL (%)	61.0 ± 3.0	56.0 - 64.0	11									
Prnl L/HL (#)	3.9 ± 0.3	2.6 - 4.5	56									
Prnl L/Ptnl L (#)	2.7 ± 0.2	2.3 - 3.5	57									
TL/PFL (#)	N/A	8.9	1									
MYOMERES												
Preanal	28.0 ± 1.0	26.0 - 30.0	52									
Postanal	8.0 ± 1.0	5.0 - 12.0	53									
Total	36.0 ± 1.0	32.0 - 41.0	52									

Table 15. Means, ranges, and standard deviations for morphometrical data on Catostomidae: Ictiobinae; (Thought to be *Ictiobus*).

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	7.1 ± 0.6	5.3 - 8.8	151	11.3 ± 2.2	8.4 - 16.5	40	N/A			N/A		
SL	6.7 ± 0.6	5.0 - 8.6	153	10.3 ± 1.3	8.2 - 13.0	40						
Ptnl L	1.9 ± 0.3	1.1 - 2.5	152	3.6 ± 1.1	2.3 - 6.2	40						
Prnl L	5.2 ± 0.4	4.1 - 6.6	152	8.1 ± 1.2	6.3 - 10.7	40						
PFL	0.8 ± 0.1	0.8 - 0.9	5	-	-	-						
HD	0.8 ± 0.0	0.8	3	-	-	-						
ED	0.5 ± 0.1	0.4 - 0.5	37	-	-	-						
HL	1.4 ± 0.2	1.0 - 1.8	118	2.5 ± 0.6	1.7 - 4.1	40						
LENGTHS (%TL)												
HL	19.0 ± 1.0	16.0 - 24.0	120	21.0 ± 1.0	19.0 - 27.0	40						
Prnl L	73.0 ± 2.0	70.0 - 81.0	152	70.0 ± 3.0	62.0 - 74.0	40						
DEPTHS (%TL)												
HD	11.0 ± 0.0	11.0	3	-	-	-						
RELATIONSHIPS												
ED/TL (%)	7.0 ± 1.0	6.0 - 8.0	37	-	-	-						
HD/HL (%)	62.0 ± 1.0	62.0 - 63.0	3	-	-	-						
Prnl L/HL (#)	3.9 ± 0.3	3.1 - 4.6	119	3.3 ± 0.3	2.7 - 3.8	40						
Prnl L/Ptnl L (#)	2.7 ± 0.3	2.3 - 4.4	152	2.4 ± 0.3	1.6 - 2.8	40						
TL/PFL (#)	8.6 ± 0.5	8.1 - 9.3	5	-	-	-						
MYOMERES												
Preanal	28.0 ± 1.0	27.0 - 30.0	149	28.0 ± 1.0	27.0 - 30.0	40						
Postanal	8.0 ± 1.0	5.0 - 10.0	149	7.0 ± 1.0	6.0 - 9.0	40						
Total	36.0 ± 2.0	33.0 - 38.0	150	36.0 ± 1.0	33.0 - 38.0	40						

Table 16. Means, ranges, and standard deviations for morphometrical data on Catostomidae: Ictiobinae; *Ictiobus* sp.

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	N/A			N/A			19.7 ± 2.1	18.0 - 22.0	3	27.3 ± 5.3	18.4 - 35.5	7
SL							15.3 ± 1.7	14.0 - 17.2	3	20.3 ± 3.8	14.2 - 26.2	7
Ptnl L							7.2 ± 0.5	6.6 - 7.6	3	11.1 ± 2.4	6.6 - 14.4	7
Prnl L							12.5 ± 1.7	11.4 - 14.4	3	16.2 ± 2.9	11.8 - 21.1	7
HL							4.5 ± 0.3	4.2 - 4.8	3	7.1 ± 1.8	4.8 - 10.0	6
LENGTHS (%TL)												
HL							23.0 ± 1.0	22.0 - 24.0	3	26.0 ± 1.0	25.0 - 28.0	6
Prnl L							63.0 ± 2.0	61.0 - 65.0	3	60.0 ± 2.0	59.0 - 64.0	7
RELATIONSHIPS												
Prnl L/HL (#)							2.8 ± 0.2	2.5 - 3.0	3	2.3 ± 0.1	2.1 - 2.5	6
Prnl L/Ptnl L (#)							1.7 ± 0.2	1.6 - 1.9	3	1.5 ± 0.1	1.4 - 1.8	7
MYOMERES												
Preanal							26.0 ± 1.0	25.0 - 27.0	3	29.0 ± 1.0	28.0 - 30.0	3
Postanal							7.0 ± 2.0	5.0 - 9.0	3	7.0 ± 1.0	6.0 - 8.0	6
Total							34.0 ± 1.0	33.0 - 34.0	3	35.0 ± 1.0	35.0 - 36.0	3

Table 17. Means, ranges, and standard deviations for morphometrical data on Atherinidae: *Labidesthes sicculus*.

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	6.5 ± 1.5	4.0 - 7.7	5	None Identified			None Identified			28.2 ± 6.8	23.4 - 33.0	2
SL	6.6 ± 0.6	6.0 - 7.2	4							23.4 ± 5.9	19.2 - 27.6	2
Ptnl L	4.6 ± 1.2	2.7 - 5.6	5							16.0 ± 3.6	13.4 - 18.5	2
Prnl L	1.8 ± 0.3	1.8 - 2.1	5							12.2 ± 3.2	10.0 - 14.5	2
HL	1.2 ± 0.1	1.0 - 1.3	4							5.5 ± 1.4	4.5 - 6.5	2
LENGTHS (%TL)												
HL	17.0 ± 1.0	15.0 - 19.0	5							20.0 ± 0.0	20.0	2
Prnl L	29.0 ± 2.0	27.0 - 33.0	5							43.0 ± 1.0	43.0 - 44.0	2
RELATIONSHIPS												
Prnl L/HL (#)	1.7 ± 0.2	1.5 - 1.9	4							2.2 ± 0.0	2.2	2
Prnl L/Ptnl L (#)	0.4 ± 0.1	0.4 - 0.5	5							0.8 ± 0.0	0.8	2
MYOMERES												
Preanal	8.0 ± 1.0	7.0 - 9.0	5							-	-	-
Postanal	31.0 ± 2.0	28.0 - 33.0	5							-	-	-
Total	39.0 ± 2.0	35.0 - 40.0	5							-	-	-

Table 18. Means, ranges, and standard deviations for morphometrical data on Centrarchidae: *Lepomis* sp.

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	5.3 ± 0.6	4.6 - 7.4	18	N/A	7.9	1	N/A	9.2	1	N/A	17.0	1
SL	5.1 ± 0.6	4.4 - 7.2	18	N/A	6.9	1	N/A	7.8	1	N/A	13.6	1
Ptnl L	2.9 ± 0.6	2.4 - 5.2	18	N/A	4.2	1	N/A	4.9	1	N/A	10.1	1
Prnl L	2.4 ± 0.2	2.2 - 2.7	18	N/A	3.7	1	N/A	4.3	1	N/A	6.9	1
HD	0.7 ± 0.1	0.6 - 0.8	11	N/A	1.2	1	N/A	1.5	1	-	-	1
HL	0.9 ± 0.2	0.8 - 1.9	18	N/A	1.6	1	N/A	2.0	1	N/A	4.0	1
LENGTHS (%TL)												
HL	18.0 ± 6.0	11.0 - 39.0	18	N/A	20.0	1	N/A	22.0	1	N/A	24.0	1
Prnl L	45.0 ± 4.0	30.0 - 48.0	18	N/A	47.0	1	N/A	47.0	1	N/A	41.0	1
DEPTHS (%TL)												
HD	13.0 ± 2.0	8.0 - 16.0	11	N/A	15.0	1	N/A	16.0	1	-	-	-
RELATIONSHIPS												
HD/HL (%)	74.0 ± 12.0	67.0 - 88.0	11	N/A	7.5	1	-	-	-	-	-	-
Prnl L/HL (#)	2.6 ± 0.4	1.2 - 3.0	18	N/A	2.3	1	N/A	2.2	1	N/A	1.7	1
Prnl L/Ptnl L (#)	0.8 ± 0.1	0.4 - 0.9	18	N/A	0.9	1	N/A	0.9	1	N/A	0.7	1
MYOMERES												
Preanal	13.0 ± 1.0	12.0 - 14.0	18	N/A	13.0	1	N/A	13.0	1	-	-	-
Postanal	16.0 ± 1.0	13.0 - 17.0	18	N/A	14.0	1	N/A	14.0	1	N/A	14.0	1
Total	29.0 ± 1.0	27.0 - 31.0	18	N/A	27.0	1	N/A	27.0	1	-	-	-

Table 19. Means, ranges, and standard deviations for morphometrical data on Centrarchidae: *Lepomis macrochirus*.

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	5.0 ± 0.5	4.4 - 5.4	3	None Identified			None Identified			N/A		
SL	4.8 ± 0.5	4.2 - 5.2	3									
Ptnl L	2.8 ± 0.5	2.3 - 3.2	3									
Prnl L	2.1 ± 0.1	2.1 - 2.2	3									
HD	0.7 ± 0.1	0.6 - 0.8	3									
HL	0.9 ± 0.1	0.8 - 1.0	3									
LENGTHS (%TL)												
HL	19.0 ± 1.0	18.0 - 20.0	3									
Prnl L	43.0 ± 4.0	41.0 - 48.0	3									
DEPTHS (%TL)												
HD	14.0 ± 1.0	14.0 - 15.0	3									
RELATIONSHIPS (%)												
HD/HL (%)	75.0 ± 5.0	70.0 - 80.0	3									
Prnl L/HL (#)	2.3 ± 0.3	2.1 - 2.6	3									
Prnl L/Ptnl L (#)	0.8 ± 0.1	0.6 - 0.9	3									
MYOMERES												
Preanal	12.0 ± 1.0	12.0 - 13.0	3									
Postanal	15.0 ± 0.0	15.0	3									
Total	27.0 ± 1.0	27.0 - 28.0	3									

Table 20. Means, ranges, and standard deviations for morphometrical data on Centrarchidae: *Promoxis* sp.

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	4.8 ± 0.4	4.4 - 6.2	32	12.7 ± 0.4	12.4 - 13.0	2	N/A			None Identified		
SL	4.6 ± 0.4	4.2 - 6.0	32	10.4 ± 0.3	10.2 - 10.6	2						
Ptnl L	2.8 ± 0.2	2.6 - 3.5	29	7.5 ± 0.4	7.2 - 7.8	2						
Prnl L	1.8 ± 0.1	1.6 - 2.1	29	N/A	5.2	2						
Egb D	0.7 ± 0.1	0.6 - 0.8	26	1.6 ± 0.3	1.4 - 1.8	2						
HL	0.9 ± 0.1	0.8 - 1.1	27	N/A	3.2	2						
LENGTHS (%TL)												
HL	19.0 ± 1.0	17.0 - 20.0	27	25.0 ± 1.0	25.0 - 26.0	2						
Egb D	14.0 ± 1.0	13.0 - 15.0	26	13.0 ± 1.0	11.0 - 14.0	2						
Prnl. L	39.0 ± 1.0	36.0 - 43.0	29	41.0 ± 1.0	40.0 - 42.0	2						
RELATIONSHIPS												
Prnl L/HL (#)	2.1 ± 0.1	1.9 - 2.4	27	N/A	1.6	2						
Prnl L/Ptnl L (#)	0.6 ± 0.1	0.6 - 0.8	29	0.7 ± 0.0	0.7	2						
MYOMERES												
Preanal	11.0 ± 1.0	8.0 - 13.0	29	12.0 ± 1.0	11.0 - 13.0	2						
Postanal	20.0 ± 1.0	18.0 - 22.0	28	18.0 ± 1.0	18.0 - 19.0	2						
Total	32.0 ± 1.0	26.0 - 33.0	28	30.0 ± 2.0	29.0 - 32.0	2						

Table 21. Means, ranges and standard deviations for morphometrical data on Centrarchidae: *Pomoxis annularis.*

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	5.5 ± 0.9	4.4 - 8.0	91	9.0 ± 1.8	8.0 - 13.6	9	N/A	12.1	1	21.6 ± 3.6	18.4 - 26.8	6
SL	5.2 ± 0.8	4.0 - 7.3	87	8.4 ± 1.3	7.6 - 11.6	9	N/A	9.8	1	17.0 ± 2.5	14.8 - 20.5	6
Ptnl L	3.3 ± 0.5	2.1 - 4.6	86	5.5 ± 1.1	4.8 - 8.2	9	N/A	6.1	1	12.8 ± 2.4	10.4 - 16.2	6
Prnl L	2.1 ± 0.3	1.6 - 3.0	86	3.5 ± 0.7	3.1 - 5.4	9	N/A	6.0	1	8.8 ± 1.4	7.4 - 10.6	6
Egb D	0.9 ± 0.2	0.7 - 1.3	69	1.5 ± 0.4	1.0 - 2.4	9	N/A	2.4	1	-	-	
HL	1.0 ± 0.2	0.8 - 1.5	82	1.8 ± 0.5	1.5 - 3.2	9	N/A	3.8	1	5.8 ± 0.8	4.9 - 7.1	6
LENGTHS (%TL)												
HL	17.0 ± 6.0	16.0 - 29.0	91	20.0 ± 2.0	17.0 - 24.0	9	N/A	31.0	1	27.0 ± 2.0	24.0 - 30.0	6
Egb D	16.0 ± 1.0	15.0 - 19.0	91	17.0 ± 2.0	13.0 - 19.0	9	N/A	20.0	1	-	-	
Prnl L	39.0 ± 2.0	35.0 - 57.0	86	39.0 ± 2.0	36.0 - 42.0	9	N/A	50.0	1	41.0 ± 2.0	39.0 - 45.0	6
RELATIONSHIPS												
Prnl L/HL (%)	2.1 ± 0.1	1.6 - 2.4	82	1.9 ± 0.1	1.7 - 2.1	9	N/A	1.6	1	1.5 ± 0.1	1.5 - 1.7	6
Prnl L/Ptnl L (%)	0.7 ± 0.1	0.6 - 1.3	-	0.6 ± 0.0	0.6 - 0.7	9	N/A	1.0	1	0.7 ± 0.1	0.6 - 0.8	6
MYOMERES												
Preanal	12.0 ± 1.0	9.0 - 13.0	83	12.0 ± 0.0	11.0 - 12.0	9	N/A	11.0	1	13.0 ± 1.0	12.0 - 14.0	3
Postanal	20.0 ± 1.0	18.0 - 22.0	82	20.0 ± 1.0	19.0 - 22.0	9	N/A	19.0	1	19.0 ± 1.0	18.0 - 21.0	6
Total	31.0 ± 1.0	29.0 - 34.0	82	32.0 ± 1.0	30.0 - 34.0	9	N/A	30.0	1	32.0 ± 2.0	31.0 - 34.0	3

Table 22. Means, ranges, and standard deviations for morphometrical data on Percidae: *Percina* sp.

	PROTOLARVAE			MESOLARVAE			METALARVAE			JUVENILES		
	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N	MEAN ± SD	RANGE	N
SIZE - DISTANCE (mm)												
TL	5.7 ± 0.2	5.6 - 6.2	9	N/A	11.4	1	None Identified			None Identified		
SL	5.5 ± 0.2	5.4 - 6.0	9	N/A	10.6	1						
Ptnl L	2.5 ± 0.1	2.4 - 2.8	9	N/A	4.9	1						
Prnl L	3.2 ± 0.1	3.0 - 3.4	9	N/A	6.5	1						
HL	0.8 ± 0.1	0.8 - 1.0	9	N/A	2.4	1						
LENGTHS (%TL)												
HL	15.0 ± 1.0	14.0 - 16.0	9	N/A	21.0	1						
Prnl L	56.0 ± 1.0	55.0 - 58.0	9	N/A	57.0	1						
RELATIONSHIPS (%)												
Prnl L/HL	3.8 ± 0.2	3.4 - 4.1	9	N/A	2.7	1						
Prnl L/Ptnl L	1.3 ± 0.1	1.2 - 1.4	9	N/A	1.3	1						
MYOMERES												
Preanal	21.0 ± 1.0	20.0 - 23.0	9	N/A	23.0	1						
Postanal	19.0 ± 2.0	17.0 - 22.0	9	N/A	16.0	1						
Total	40.0 ± 2.0	38.0 - 45.0	9	N/A	39.0	1						

DISCUSSION

Studies investigating the larval fish assemblages for lotic and eservoir/riverine systems of a large size, such as the Missouri ivers, have been reported (Walberg 1971; Gallagher and Conner 980). These studies were complicated; however, by extra-riverine nputs to these large systems. The present study characterized an nnual middle Neosho River larval fish population, relatively free rom extra-riverine inputs, in a comprehensive manner. Larval fish atterns observed in this study permit separation of larvae produc-d above, originating in, and produced downstream of John Red-nond Reservoir (JRR).

Although no significant difference was found through AOV esting between the total mean larval fish concentrations at the ree locations (including JRR diurnal and nocturnal data), some tatements about the Neosho River/JRR larval fish populations can e made.

The larval fish complement of the Neosho River/JRR system as characterized as one which was dominated by *Dorosoma cepe-ianum,* except at Location 2 where *D. cepedianum* and atostomidae larvae were co-dominants. A limited number of other milies were noteworthy, although of diminished importance ompared to shad and suckers, including the Location 2 yprinidae, Location 1 Sciaenidae and Centrarchidae, and ciaenidae at Location 3. More detailed discussions of Neosho iver/JRR larval fish are provided by location as follows:

ocation 2: Hartford

The larval fish data from this location characterized the lochthonous input to JRR from the Neosho River. The larval drift Location 2 was dominated nearly equally by Catostomidae and lupeidae. The only other family represented at levels above 0.3% absolute abundance was Cyprinidae at 2.1%.

The Catostomidae component of the assemblage was ominated by the *Ictiobus* taxa which occurred in numbers on five ites. Larvae of these *Ictiobus* taxa comprised a source of in-viduals for recruitment in this commercially important genus. Ic-obinae larvae, thought to be *Carpiodes carpio,* were present in wer concentrations for a four week period. These larvae also presented a source of potentially recruitable individuals, though in this case for river carpsucker, an undesirable rough sh. The Catostomidae drift was also of interest due to the lack of *oxostoma* and *Cycleptus* larvae. Delayed initiation of sampling possibly explained the absence of *Cycleptus* larvae but the lack of *Moxostoma* in the drift was not explained by study methodology.

Gizzard shad were an early and continuing component of the Hartford drift. Shad larvae were also eligible for recruitment but these fish were entering a lake which JRR release data indicated already had a population. Low shad concentrations leaving JRR (20-25/100m^3), however, might indicate river spawning shad were giving their young an edge over lake spawned larvae which increased two weeks later.

Cyprinidae larvae were represented primarily by *Cyprinus carpio* which occurred from late May though early July. Common carp entering JRR represent an undesirable input of recruitable rough fish. Cyprinidae larvae, thought to be *Phenacobius,* was the only other minnow present in numbers.

The game fish component was comprised solely of *Ictalurus punctatus,* which was present on only one date. No other gamefish were collected at Hartford, although both *Morone chrysops* and *Pomoxis annularis* were expected. No explanation for the lack of larvae of these two species was offered, since the young of both should have been present during the collection period.

Location 1: John Redmond Reservoir Tailwaters

The composition of Location 1 larval fish data was representative of ichthyoplankton losses from JRR and production in the immediate tailwaters area. The diurnal larval fish drift at this location was dominated by shad originating in JRR. Also occurring were Cyprinidae larvae, principally *Notropis* sp. thought to be *buchanani,* which probably were produced in the tailwaters. The gamefish portion of the diurnal larval fish population was represented by *Morone chrysops,* which occurred in low numbers, and two *Pomoxis* taxa which were present sporadically in low numbers. *Dorosoma cepedianum* was also the main component of the nocturnal complement, although Sciaenidae and Cyprinidae occurred in low percentages. The nocturnal gamefish drift was limted to four varieties, *Ictalurus punctatus, M. chrysops, Pomoxis* taxa, and Percidae thought to be *Stizostedion,* which all occurred in low concentrations.

No significant difference was found between total mean daily diurnal and nocturnal concentrations when the student $t_{0.05}$ test was performed. However, variability in diurnal/nocturnal numbers did occur. For the majority of JRR taxa, diurnally collected larvae were fewer in number than those nocturnally collected. The relationship of higher nocturnal numbers was most apparent for *D.*

cepedianum, *Cyprinus carpio*, Ictiobinae thought to be *Ictiobus*, *M. chyrsops*, and *Aplodinotus grunniens*. Only *Notropis* sp. and *Notropis* sp. (thought to be *buchanani*) exhibited distinctly higher diurnal numbers than nocturnal values.

The large numbers of shad entering the Neosho River at this point was of interest due to the lack of habitat available to this population. The limited size of the Neosho and the limited duration of survival for early life stage fish under stress conditions certainly resulted in high mortality of discharged shad larvae.

The Catostomidae taxa collected at Location 1 included those found at Location 2 except for Ictiobinae thought to be *Carpiodes carpio*. The lack of river carpsucker larvae was not expected, since this species is a common component of the adult fish population at this location (Bliss 1978, 1979, 1980). The presence of three other taxa was also noteworthy. Cyprinodontidae thought to be *Fundulus notatus*, *Labidesthes sicculus*, and Percidae thought to be *Stizostedion*, were taxa collected which had not been previously identified in Neosho River larval fish studies (Bliss 1978, 1979, 1980).

Location 3: Burlington

The larval fish complement of this location was reflective of ɔoth JRR releases and riverine reproduction. The generally similar concentrations and catch periods for most taxa to JRR data was supportive of this position. Although *Dorosoma cepedianum* was still he dominant taxa at this location, it dominated less than at Locaion 1. Centrarchidae and Sciaenidae were other important families it this location.

Centrarchidae larvae collected included *Lepomis* sp., *Micropterus* sp., and *Pomoxis* taxa. The two *Pomoxis* taxa, *Pomoxis* p. and *Pomoxis annularis* were the second most abundant larvae at his location. However, *Pomoxis* taxa exhibited an earlier occurence and higher densities than at JRR. These two factors would inicate *Pomoxis* production in the Neosho downstream of Location 1 ı the "lake" formed by the Burlington city dam. The existence of roduction from this area provided a source of recruitable inividuals to bolster the downstream and JRR tailwaters fisheries. roduction in this area would probably be most beneficial during eriods of low flow when *Pomoxis* losses from JRR were minimal. his position was supported by catches of *Notropis* sp., *Notropis* sp. ıought to be *buchanani*, and *Morone chrysops* which present vidence that this area was an effective nursery.

The lack of Catostomidae larvae was somewhat contradictory to the previous discussion until the life history of the suckers was considered. Catostomidae larvae, as a group, tend to move to backwaters, oxbows, and tributaries during middle development stages.

Morphological Basis for Identification

Identifications for larval fish are contingent on ratios, percentages, and numbers of certain features. Although the relationships of these structures are diagnostic, questions can still persist due to regional variations (Conner 1979). Fourteen of the 30 taxa identified in this study were morphometrically analyzed in sufficient numbers to permit statistical analysis or represented information useful enough to warrant inclusion. The presentation of these 14 tables (Tables 9 through 22) of morphological data serves to document regional variations and/or demonstrates areas requiring additional study for the taxa included.

As noted earlier in this paper, data for *Dorosoma cepedianum*, *Morone chrysops*, and *Aplodinotus grunniens* were not included in tabular form because of the distinctive, well documented morphologies of these species. Several other taxa occurred in insufficient numbers for presentation in tabular form and these taxa were discussed in the text. The relationship of data collected in this study with data in the literature, along with the rationale for assignments made, was provided for most taxa by family in the following discussion.

Lepisosteidae

Collections of this family were limited to two individuals, both from Location 2. Both presented distinctive morphologies which simplified identification, including heterocercal tail, elongated snout, and narrow head. Hogue et al. (1976) identified *Lepisosteus* sp. as possessing 39-44 preanal myomeres and 11-16 postanal myomeres. The single individual which could be meristically counted possessed 15 postanal myomeres.

Clupeidae

Gizzard shad was the sole representative of this family in the study area and was the most commonly collected taxa in this study. Morphological data were not collected for this species because of its distinctive appearance (Hogue et al. 1976).

Cyprinidae

Cyprinus carpio

Common carp larvae presented a distinctive appearance in the form of a "Y" of melanophores running laterally to the area anterior to the gill arches. Hogue et al. (1976) and Snyder (1981b) presented morphometrical descriptions of this species. The data collected in this study (Table 9) compared favorably with Snyder (1981b) except for a slightly larger range for some features. The *C. carpio* data in Table 9 also compared favorably to Hogue et al. (1976) and Conner et al. (1980).

Notemigonus crysoleucas

This species was represented by a single individual collected at Burlington. Identification was based on the unique double row of ventral melanophores (Faber 1980 and Buynak and Mohr 1980).

Notropis sp.

The larvae assigned to this taxon fell into the *Notropis* genus by general characteristics. Head length (HL) and Prnl L (% TL) exhibited wider ranges but were generally close to *Notropis lutrensis* data provided by Snyder (1981b). Myomere counts for this taxa from this study (Table 10) were also nearly identical to Snyder's *N. lutrensis* data. While it might be reasonable to place the *N. lutrensis* label on these fish based on this comparison, the *Notropis* sp. was retained due to possible intermixing of other species and lack of specific references. These other species, particularly *N. stramineus* possibly present at Hartford, accounted for the wider ranges observed for some features.

Notropis sp. thought to be *buchanani*

Hogue et al. (1976) identified a Cyprinidae group c which contained "postlarvae" having 19-20 preanal myomeres and 13-14 postanal myomeres. Pigmentation in this group was sparse, restricted dorsally to a few melanophores on the head and the bases of dorsal and caudal fins, as well as a single ventral row of melanophores extending posterior behind the anus on either side of the anal fin, then merging to a single row continuing to the caudal fin. The eye was round in group c and the anal fin had eight rays. Hogue identified *N. volucellus* and *N. buchanani* as possible members of this group.

Protolarval and mesolarval preanal myomere data in this taxon were higher than cited by Hogue; however, metalarval and juvenile

preanal myomere counts matched very closely (Table 11). Postanal myomere counts compared favorably with Hogue group c data, although slightly lower, and total myomere data were similar, although somewhat higher.

Despite some variability in the meristical data *Notropis* sp. were placed in this taxon based on three main points. Larvae in this taxon had round eyes, exhibited the distinctive pigmentation pattern described by Hogue, and possessed eight anal rays in later stages. The common occurrence of *N. buchanani* at Location 1 (Bliss 1978, 1979, 1980), the lack of *N. volucellus*, and the distinctly different morphology from *Notropis* sp. also supported the assignment of this label to these larvae.

Cyprinidae thought to be *Phenacobius*

Larvae of this taxon were identified from Hartford on only one date. The appearance of these larvae bore a striking resemblance to Hogue unidentified Cyprinidae group a, except the postanal myomere count was slightly low (Table 12). Group a was thought by Hogue to contain the stargazing minnows *(Phenacobius uranops)*.

The assignment of these larvae to this taxon was based on the elliptical eyes, sub-terminal mouth, and a double row of pigment ventrally. Although *P. uranops*, did not occur in the study area, the group a description was thought adequate for the taxon assignment made based on similarities within other genera cited in the literature.

Cyprinidae thought to be *Pimephales*

The assignment of *Pimephales* to larvae in this group was based on the similarity of these fish to Hogue Cyprinidae group b, including club shaped yolk, elliptical eye, and pigmented yolk. Also, meristics data (Table 13) were very similar to the values cited by Hogue for *P. promelas*.

Catostomidae

Ictiobinae thought to be *Carpiodes carpio* and Ictiobinae thought to be *Ictiobus* .

The assignment of the subfamily Ictiobinae to the Catostomidae larvae of the above taxa was made with confidence. As summarized by Fuiman (1979), the family Catostomidae consists of three subfamilies described by Miller (1958); Cycleptinae; Ictiobinae, and Catostominae. Cycleptinae was represented as a naturally occurring species by only *Cycleptus elongatus*. This taxon exhibits a distinctive morphology (Conner et al. 1980), and was not collected in 1981. The subfamily Catostominae was represented by three or four *Moxostoma* species in the study area. The preanal myomere counts for all *Moxostoma* sp. (Fuiman 1979, Fuiman and Whitman 1979, and Snyder 1979) exceed the mean values for both Ictiobinae taxa described in this study. The assignment of the subfamily Ictiobinae was therefore made.

The differentiation of *Carpiodes carpio* and *Ictiobus* early phases were not made as confidently, though. All morphometrical data were essentially identical (Tables 14 and 15); however, differentiation of these two taxa was made through the identification features described by Yaeger and Baker (1982). These features included the complete overlap of myomere counts, elliptical eye and flattening of the head in *C. carpio* larvae (>8.0 mm), and the typically more diffuse midlateral line of melanophores on early protolarvae *C. carpio* larvae (<8.0 mm).

Ictiobus sp.

This taxon was identifiable with certainty only in metalarval and juvenile fish (Table 16) and was defined by characteristics of Yaeger and Baker (1981).

Ictiobus thought to be *bubalus*

This taxon was represented by a single individual. The assignment was tentative, as described by Yaeger and Baker (1982), but was made based on the complete formation of the hypural complex at 10.5 mm TL. In *Ictiobus cyprinellus,* the hypural complex was only evident at 10.5 mm TL and completely formed at 13.0 mm TL.

Ictiobus thought to be *cyprinellus*

A single juvenile buffalofish was the sole representative of this taxon. Assignment to this taxon was made by features prominent at 3.9 mm TL, particularly the terminal mouth.

Ictaluridae

Ictalurus punctatus

This species was present as readily identifiable individuals due to the distinctive notched caudal fin. No morphometrical data were compiled for this taxon.

Noturus sp.

Two individuals in poor condition represented this taxon at Location 2 on 31 July. These individuals were a metalarva and a juvenile which exhibited the overhung snout and slightly notched adipose fin of the *Noturus* genus. The poor condition of these fish precluded identification to species but they were not believed to be *N. placidus*, and were possibly *N. flavus*.

Cyprinodontidae

Fundulus notatus

This family was represented by a single larva, thought to be *Fundulus notatus*. Assignment to this taxon was based on the description of Jones and Tabery (1980) for *Fundulus diaphanus*. Data collected on this fish closely compared with morphometrical values provided for *F. diaphanus*.

Atherinidae

Labidesthes sicculus

Larvae of this species presented a unique morphology not easily confused with any other taxon found in the study area. Morophometrical data for this taxon (Table 17) compared favorably with values cited by Rassmussen (1980) for this species in Florida.

Percichthyidae

Morone chrysops

Although this species was a common component of the larval assemblage in the study area, morphometrical data for it were not compiled.

Centrarchidae

Lepomis sp.

Larval fish were assigned to this genus primarily by postanal myomere counts in the range of 14-18 (Conner 1979). Secondarily, larvae assigned here did not have head depth (HD % TL) values which clearly fell into one of the Conner (1979) types (Table 18). The lack of additional segregation within this taxon was to be expected since as stated by Conner "many traditional characters that have been used to diagnose sunfish larvae are very environmentally plastic." Further differentiation of *Lepomis* sp. larvae would require extensive study to verify the validity of data presented for the various "types" in relation to Kansas populations.

Lepomis sp. thought to be *cyanellus*

Only two individuals were assigned to this taxon. In both cases the individuals were collected from Hartford and had HD (% TL) values clearly within the range cited by Conner (1979) for *Lepomis cyanellus*. These assignments must be qualified in view of factors affecting sunfish identification, as previously mentioned.

Lepomis macrochirus

The three larvae classified as bluegill exhibited HD (% TL) values which clearly fell within Conner (1979) bluegill type (Table 19). The qualifications cited above also applied to this taxon.

Micropterus sp.

The single metalarva in this taxon clearly fits the *Micropterus* description of Conner (1979). A postanal myomere count of ≤17 and the dark mid-lateral band of pigment provided conclusive identification.

Pomoxis sp. and *Pomoxis annularis*

The assignment of larvae to the genus *Pomoxis* was made per Conner (1979) by a postanal myomere count of >19 and the morphological similarity of two fish which had a count of 18. Conner cited the inclusion of individuals having 18 postanal myomeres in *Pomoxis* by Hogue et al. (1976), as causing misidentification of *Lepomis* larvae. However, no *Lepomis* larvae enumerated in this study had >17 postanal myomeres and the sole *Micropterus* had a count of 16. These data indicated that *Pomoxis* protolarvae and mesolarvae within the study area occassionally included individuals with 18 postanal myomeres (Tables 20 and 21) contrary to Conner (1979) which stated only mesolarvae through juvenile *Pomoxis* had 18.

Chatry and Conner (1980) identified the EgbD (% TL) as the method of segregating *P. annularis* from *P. nigromaculatus* larval fish. Specifically, EgbD (% TL) of <15.0% in larvae <13.0 mm TL was cited for *P. nigromaculatus* larvae while values >15.0% were given as diagnostic for *P. annularis* (Figures 9 and 10).

The differentiation of *Pomoxis* sp. versus *Pomoxis annularis* was made in the lab at the time of identification through the use of a hand calculator. Differences in hand calculational rounding off and computer calculations resulted in larvae with eye-gas bladder distance (Egbd % TL) values of 15% falling in both *Pomoxis* sp. and *Pomoxis annularis* (Tables 20 and 21).

This situation created confusion in relation to the proper label for *Pomoxis* larvae and was further complicated by the fact that *P. nigromaculatus* adults were not collected in the Neosho River in 1981 (King 1981) and also were not collected in the three years previous to 1981 (Bliss 1978, 1979, 1980).

Although *P. nigromaculatus* occurred in the Neosho and was occasionally caught by anglers, evidence would indicate that all 1981 *Pomoxis* larvae were *P. annularis*. Given this conclusion, the 15% value found by Chatry and Conner (1980) for segregation of these two species should be used with caution in the study area.

Percidae

Percina sp.

Percina larvae identified in this study fit both the general description of Hogue et al. (1976) group b, which included *Percina caprodes*, and the *Percina caprodes* data presented by Cooper (1978). These *Percina* larvae did not fit the general *Estheostoma blennioides* description of Baker (1979).

Diagnostic features for these larvae included an overall slender appearance, prominent anterior oil globule, and small head (Figure 1). The small head was particularly useful in the separation of *Percina* from *Etheostoma* and *Stizostedion* larvae.

Percidae thought to be *Stizostedion*

One individual Percidae larva was collected early in the study which did not fit the *Percina* description of Cooper (1978), the Percidae group b of Hogue et al. (1976), or the Baker (1979) *Etheostoma blennioides* description. The large size at collection, HL/TL ratio of <3.0, and large head placed this larva in Percidae thought to be *Stizostedion*.

Sciaenidae

Aplodinotus grunniens

Data on the morphological features of the freshwater drum were not collated due to the distinctive characteristics of this species.

SUMMARY

The 1981 larval fish assemblage of the Neosho River, above and below John Redmond Reservoir (JRR), in Coffey County was described. Morphometrical data were compiled for selected taxa and were compared to published accounts.

1. A total of 27,905 eggs, larvae, and juvenile fish representing 11 families and 30 taxa was collected from the three locations sampled.

2. Nocturnal efforts at Location 2: Hartford resulted in the collection of 2,499 eggs, 2,330 larvae, and eight juvenile fish from seven families and 18 taxa. Members of the families Catostomidae and Clupeidae dominated the larval fish drift at this location. Larval fish densities ranged from a minimum of none on 21 May to a maximum of 1246.7/100mm³ on 28 May.

3. Diurnal and nocturnal efforts at Location 1: JRR tailwaters resulted in the collection of one egg, 6,773 larvae, and 1,195 uvenile fish representing 21 taxa from ten families. Thirteen taxa were collected diurnally, while 19 were present nocturnally. Most :axa were collected in higher densities nocturnally, except for the Votropis taxa of the family Cyprinidae. *Dorosoma cepedianum* lominated the drift of both collection periods, comprising 98.0% ind 95.2% of the annual relative abundance respectively. Both liurnal and nocturnal densities reached peak levels near ;,000/100m³ on 13 June.

4. Larval fish were collected at Location 3: Burlington on all ampling dates. No eggs, 2,525 larvae, and 593 juvenile fish from 4 taxa representing seven families were collected at this location. *)orosoma cepedianum* also dominated the annual relative abunance at Burlington, comprising 81.4%, but other important amilies included Centrarchidae at 10.1% and Sciaenidae at 6.4%. arval fish concentrations varied from 6.3/100m³ on 18 July to 766.4/100m³ on 19 June.

5. The larval fish populations identified represent the llochthonus input into JRR at Hartford; at JRR tailwaters they enerally characterized those fish released from the reservoir, and : Burlington these data represented both releases from JRR and roduction in the area below the impoundment.

6. Morphometrical data were presented in tabular form for 14 .xa. These data generally compared favorably with published tax- a accounts thereby supporting taxonomic assignments made.

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As cited in Enclosure 3 to WM 06-0046 (November 17, 2006): the 2005 WCNOC Monitoring Report and 2006 Plan.

WOLF CREEK GENERATING STATION

Wolf Creek Lake

2005 FISHERY MONITORING REPORT AND 2006 PLAN

Prepared by:	**Dan Haines**	2/16/06 **Date**
Supervisor Regulatory Support Approval:	**Robert Hammond**	02/17/06 **Date**
Manager Regulatory Affairs Approval:	**Kevin Moles**	02/21/06 **Date**

EXECUTIVE SUMMARY

Monitoring during 2005 demonstrated that the fishery in Wolf Creek Lake remained in good condition with no adverse trends identified. Fish predation pressure on the gizzard shad population continued to prevent excessive shad impingement problems at the circulating water intake. Fishery monitoring activities in 2006 as outlined in this report will continue to measure long-term trends and help Wolf Creek Generating Station prepare for any short term changes, particularly for any changes in the potential for shad impingement events.

Public angling on the lake did not impact the fishery's function of supporting plant operations. The catch and release philosophy promoted when the lake was opened for the public has been compatible with gizzard shad control objectives. Monitoring data from 2004 warranted management activities to improve the fishery for public use. The following were recommended to the Kansas Department of Wildlife Parks (KDWP):

1. Increase of the creel limit for crappie greater than 14 inches from two to ten fish per day to increase angler use and increase harvest of older crappie.

2. Increase the catfish creel limit from five to ten fish per day to be consistent with statewide creel limits. Catfish are not considered a significant predator of gizzard shad.

3. Decrease the wiper length limit from 24 to 21 inches to increase harvest of older fish.

The KDWP accepted and changed the following beginning for 2006:

1. Crappie creel limits were not changed due to perceptions of angler dissatisfaction.

2. Increased catfish creel limit to ten per day.

3. Decreased wiper length limit from 24 to 21 inches.

Based on 2005 monitoring, the following are recommended:

1. Maintain current 2006 creel and/or length regulations through 2007.

2. Investigate walleye age structure, total annual mortality, and mortality caps to determine if current size and creel regulations are appropriate.

3. Stock a 2006 wiper year-class within budget constraints, and budget for a 2007 stocking at a rate of 10 two-inch fish per acre (50,000).

2005 FISHERY MONITORING REPORT AND 2006 PLAN

INTRODUCTION

This report presents the results of fishery monitoring activities on Wolf Creek Lake (WCL). Data are summarized in table form to document long-term trends and demonstrates that the fishery has functioned as desired through 2005. The goal is to increase public safety and plant operating efficiency by reducing the potential for excessive gizzard shad young-of-year (YOY) impingement on the Circulating Water System intake screens. Shad impingement problems to date have not occurred due largely to the characteristics of the current fishery.

Public use of the fishery is also important to maintain community relations and local economic benefits. Consequently, maintaining and/or enhancing public enjoyment of the fishery that is compatible with the shad impingement control are other important goals of this program. Creel and length limits were determined jointly with the Kansas Department of Wildlife and Parks (KDWP). The catch-and-release strategy employed appears to have succeeded with no detrimental changes to the fishery observed through 2005.

Fishery monitoring activities in 2006 will be similar to 2005 to maintain long-term trending. Short-term changes will also be detected to ensure WCGS can be prepared if impingement potential increases.

METHODS

The monitoring methods used during 2005 allowed for continued analyses of important long-term trends. Gill netting was used at long-term sites on WCL (Figure 1). Spring electrofishing effort targeted smallmouth and largemouth bass habitat by shocking in shoreline transects until a minimum number of fish or a designated length of shore was sampled. Small-mesh gill netting replaced shoreline seining in 1998 to better assess young-of-year (YOY) gizzard shad densities and recruitment (Boxrucker et al ~1991). Important species to the fishery were targeted when expected to be efficiently sampled.

Sampling efforts are listed in Table 1. Fish sampled were weighed to the nearest gram, and measured (total length, TL) to the nearest millimeter. Proportional stock density (PSD, Anderson 1980), incremental relative stock density (RSD, Gablehouse 1984), and relative weight (W_r, Wege and Anderson 1978) were indices applied. Length-weight equations adopted by KDWP were used.

The 2006 efforts will be completed as scheduled in Table 2. These efforts are the same as for 2005. Anglers using the lake park report the number of fish caught and released, the number kept for personal use, and angler satisfaction. These creel sheets are collected and tabulated by Coffey County. Data from the census sheets will be used to determine if harvest rates change dramatically and to measure angler success.

Increasing walleye size variability and maximum size is advantageous to diversified shad control, as well as angler compatibility and success. Consequently, walleye age structure, total annual mortality, and mortality caps will be determined using methods similar to Quist et. al. (2004). The current management objective is to produce larger walleye (>26 inches total length) by encouraging harvest of smaller walleye from a stable population with good recruitment, thus reducing intraspecific competition allowing surviving individuals to grow larger. A slot limit prohibiting harvest of fish between 18 and 26 inches was set to accomplish this. Assessing mortality caps will determine if walleye die of natural mortality before reaching 26 inches, if harvest of smaller individuals is necessary, if decreasing interspecific competition for available prey would be effective, and if regulating length of harvest is applicable given current lake biology and angler impacts. University graduate students will be solicited and supported with research grant funding to complete this task. Available scale and fishery data will be used.

RESULTS AND PLANS

The fishery in Wolf Creek Lake continued to function as desired. It exhibited signs of low prey densities, which is preferred to minimize fish impingement at the circulating water intake. The potential for excessive gizzard shad impingement remained small due to relatively low YOY densities going into the winter months. The shad appear to be limited by predation, as indicated by the population indices of the predator species. Gizzard shad typically has been an important forage species in most reservoirs (Carlander 1969, Pflieger 1975, Stein and Johnson 1987, Colvin 1993). For shad to be compatible with WCGS operation, low YOY shad densities must be maintained. Periodic recruitment of shad young to reproducing adults also must occur to maintain the predators, which in turn control shad numbers. These conditions currently exist in WCL, and benefit WCGS.

Catch densities of remained similar to past years for adult gizzard shad, white bass and wiper; increased for white crappie, and decreased for smallmouth bass and walleye (Table 3). Fall densities of small gizzard shad remained low. Density changes for smallmouth bass is likely due to sampling variation. Walleye changes may be due to sampling variation because catch densities were within past ranges. Increased angler harvest for two consecutive years may also have contributed (Table 7)

Fish length frequencies in 2005, as shown by the PSD/RSD indices (Table 4), showed no major changes to past years, except for gizzard shad. A higher PSD indicates fewer shad recruiting to mid-size due in part to predation, and an older population existing. Continued recruitment and growth of important species were evident with most showing good percentages of mid-sized individuals (RSDS-Q, RSD Q-P, and RSD M-T size ranges). For wipers, the sizes increased slightly showing continuing maturation of the latest 2001 year-class stocking. Because of this, budgeting for potential wiper stocking in 2006 is recommended to ensure continued presence. There was a small shift to larger walleye, possibly due to the current regulations, but this shift is not definitive. Walleye research referenced earlier should determine any relationships.

Body conditions as indicated by W_r indices (Table 5) remained similar to past years for gizzard shad, smallmouth bass, and white crappie; increased for white bass, wiper; and decreased for walleye. All species showed adequate body conditions to maintain their populations. Large increases or decreases in body condition were not evident for most species. The white bass increase may be attributable to decreasing wiper competition, as the 2001 year-class matures. Overall, this indicates that no large changes in prey availability occurred, primarily gizzard shad densities.

No detrimental impacts due to angler harvest of the predator populations controlling gizzard shad have been observed. Harvest rates were slightly lower, but still similar for most species, except walleye (Table 6 and 7). Harvest of walleye under 18 inches nearly doubled in 2004, and slightly more in 2005. Because the population indices for catch frequency, length frequency, and body conditions remained similar to past years, influence by angler harvest was not apparent.

There are no fish creel and length limit changes recommended for 2007. The current smallmouth bass and walleye slot limits were imposed to increase body condition and growth. These limits should remain in effect until more data is collected to assess their impacts. The current minimum length limit (12 inches) for white bass was set to protect younger wipers. Since a wiper year class stocking is planned for 2006 and 2007, the white bass minimum length should remain in effect. The crappie is an important littoral predator of gizzard shad in the absence of high largemouth densities, so the minimum length limit (14 inches) was set to protect a majority of the larger individuals. A large proportion of crappie were near the limit (PSD M-T of 28, Table 4), consequently the limit should remain the same.

PLAN RESULTS

To ensure continued WCGS support and public use, the fishery program will accomplish the following:

1. Continue monitoring as outlined.
2. Maintain current 2006 creel and/or length regulations through 2007.
3. Investigate walleye age structure, total annual mortality, and mortality caps to determine if current size and creel regulations are appropriate.
4. Stock a 2006 wiper year-class within budget constraints, and budget for a 2007 stocking at a rate of 10 two-inch fish per acre (50,000).

Thank you very much.

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Table 1. Fishery sampling effort by gear type used at Wolf Creek Lake during 2005.

Gear	Date	[1] Location	Effort	Water Temp °F
Electrofishing [2]	5/27	NA	[3] 0.75	72
Standard Gill Netting [4]	10/11	2	[5] 1	66-69
		9	1	77-86
	10/12	6	1	65-67
		8	1	64-65
	10/13	2	1	68
		9	1	70-85
	10/14	6	1	67
		8	1	64
Small Mesh Gill Netting [6]	10/26	6	[7] 2	59-62
		8	2	59
	10/27	6	2	60
		8	2	57
Fyke Netting	10/26	2	[8] 1	56
		6	1	62
		8	1	59
	10/27	2	1	60
		6	1	60
		8	1	57

(1) See Figure 1 for locations.
(2) Equipment consisted of a boat-mounted Smith-Root unit operated at 220v, 9-10 amp, DC current pulsed 120 cycles/second
(3) Shock effort shown as hours water was energized.
(4) Standard gill nets consisted of a complement of four 8'x100' monofilament nets, one each of 1", 1.5", 2.5", and 4" uniform mesh.
(5) Standard gill netting effort listed as number of net-complement-nights set.
(6) Small-mesh gill nets consisted of a complement of two 8'x100' monofilament nets, one with 0.5", and the second with 0.75" uniform mesh.
(7) Small-mesh gill netting effort listed as number of small-mesh-complement-nights set.
(8) Fyke netting effort listed as number of trap-net-nights.

Table 2. Fish Sampling Schedule at Wolf Creek Lake during 2006.

	Minimum Information Needed to Assess Fishery	Method	Preferred Time Frame
1.	Gizzard shad recruitment through winter	Electrofishing	April/May
2.	White crappie population characteristics and health	Fyke netting/ Gill netting	October/November
3.	Largemouth bass population characteristics and health	Electrofishing	April/May
4.	Smallmouth bass population characteristics and health	Electrofishing	April/May
5.	White bass population characteristics and health	Gill netting	October
6.	Wiper survival and health	Gill netting	October
7.	Walleye population characteristics and health	Gill netting	October
8.	Gizzard shad YOY reproduction and densities going into winter	Small Mesh Gill Netting	September/October

Table 3. Catch-per-unit-of-effort (CPUE) of selected fish species in Wolf Creek Lake. Fall gill net, Fyke net, and electrofishing data were not collected in 2001 due to the September 11 events.

	Gizzard Shad	Gizzard Shad (YOY)	White bass	Wiper	Smallmouth Bass	Largemouth Bass	White Crappie	Walleye
1983	(1) 7		(1) 23	(1) 15		(2) 24.5	(3) 0	(1) 4
1984	25		18	11		45.0	6	29
1985	3		6	22		45.3	5	26
1986	32		25	14	(2) 1.3	34.5	5	9
1987	10		18	21	8.5	18.8	12	16
1988	12		28	26	10.5	22.0	9	19
1989	18		17	23	14.8	32.3	4	22
1990	10		34	12	12.0	14.0	5	13
1991	14		45	22	20.5	5.5	4	19
1992	19		17	9	10.8	8.3	6	22
1993	11		52	8	15.0	5.0	5	12
1994	9		61	11	12.5	2.0	4	23
1995	25		29	11	6.3	2.0	5	16
1996	9	(4) 22.9	19	3	10.8	0.3	9	20
1997	19	77.0	60	8	5.5	1.3	4	28
1998	18	39.9	45	6	10.5	1.5	3	16
1999	15	9.9	37	4	11	3.3	6	14
2000	18	29.4	36	13	21.5	3.0	(5) 9	28
2001	-	-	-	-	-	2.0	-	-
2002	11	3.5	32	4	2.0	1.0	6	8
2003	10	1.9	54	9	8.0	2.0	7	14
2004	12	5.5	33	6	34	0.8	-	20
2005	11	0.3	37	4	16	0.0	13	9

(1) Data from fall standard gill netting. Units equal number per gill-net-complement-night ≥ stock size.
(2) Data from spring electrofishing. Units equal number per hour shocked ≥ stock size. Shocking efforts starting in 2004 targeted prime habitats rather than standard locations as completed during prior years.
(3) Data from spring Fyke netting. Units equal number per trap-net-night ≥ stock size.
(4) Data from smallmesh gill net. Units equal number per net complement of one 0.5 and one 0.75 mesh net.
(5) Data beginning in 2000 were from fall Fyke netting. Netting not completed during 2004 due to adverse weather. Units equal number per trap-net-night ≥ stock size.

Table 4. Proportional Stock Density (PSD) and Relative Stock Density (RSD) for selected fish species at Wolf Creek Lake. Stock (S), quality (Q), preferred (P), memorable (M), and trophy (T) size ranges are per Gablehouse (1984). Fall gill net, Fyke net, and electrofishing data were not collected in 2001 due to the September 11 events.

Species	Index	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
Gizzard	PSD	85	90	100	70	81	93	59	69	84	75	94	81	30	-	87	49	47	83
shad [1][2]	RSD-P	15	10	0	30	19	7	41	31	16	25	6	19	70	-	13	51	53	17
White	PSD	77	85	27	59	80	31	89	63	56	57	59	45	65	-	48	33	53	41
bass [1][2]	RSD S-Q	23	15	73	41	20	69	11	37	44	43	41	55	35	-	52	67	47	59
	RSD Q-P	9	7	2	10	36	5	12	8	51	4	11	3	4	-	10	1	5	3
	RSD P-M	39	62	21	34	35	24	55	45	0	53	45	40	55	-	34	29	43	32
	RSD M-T	29	15	4	15	9	2	22	11	4	< 1	2	2	7	-	4	3	5	5
	RSD T+							< 1				1							<1
Wiper[1]	PSD	100	97	96	100	100	100	100	85	30	88	89	100	100	-	100	100	100	100
	RSD S-Q		3	4					15	70	12	11			-				
	RSD Q-P	1	10	14			3				32	11			-	24			3
	RSD P-M	42	40	28	47	39	21	6	4		33	73	91	58	-	31	20	65	55
	RSD M-T	58	50	53	53	61	76	92	81	30	23	5	9	42	-	45	80	33	39
	RSD T+			1	1			2							-			2	
Smallmouth	PSD	29	37	40	61	40	44	40	52	58	50	52	77	70	-	88	83	66	50
Bass[4], [5 after 2003]	RSD S-Q	71	63	60	39	60	56	60	48	42	50	48	23	30	-	13	17	34	50
	RSD Q-P	8	25	10	22	26	17	20	28	28	23	29	34	28	-	38	17	22	17
	RSD P-M	17	10	27	32	13	20	12	20	26	18	21	36	40	-	50	63	36	25
	RSD M-T	4	5	4	6	1	7	8	4	5	9	2	7	2	-		4	8	8
	RSD T+				1														
Largemouth	PSD	92	99	97	100	82	85	88	100	100	60	50	100	100	88	50	100	[7]	[7]
Bass [5]	RSD S-Q	8	1	3		18	15	12			40	50		50	13	25			
	RSD Q-P	19	28	19	5	12	10	13	13		20	17		50	38	25	17		
	RSD P-M	72	71	80	95	71	71	75	88	100	40	33	100		50	50	83		
	RSD M-T																		
	RSD T+																		

Table 4. (cont.)

Species	Index	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05
White crappie [6][8]	PSD	99	100	100	100	100	95	100	100	99	100	100	100	82	-	98	99	97	87
	RSD S-Q	1					5			1				18	-	2	1	3	13
	RSD Q-P	2	12	9	3	3	2	8		1	9	9	9	43	-	34	48	32	53
	RSD P-M	4	10	13	7	26	14	44	11	12	15	12	13	11	-	11	29	15	6
	RSD M-T	85	60	70	87	63	75	41	87	72	71	74	77	28	-	52	21	47	28
	RSD T+	10	21	10	3	8	4	7	1	6	5	5	1	1	-	1	1	3	
Walleye [1]	PSD	94	93	96	77	93	90	52	83	73	31	55	74	78	-	47	60	69	62
	RSD S-Q	6	7	4	23	7	10	48	17	27	69	45	26	22	-	53	40	31	38
	RSD Q-P	81	80	95	59	74	67	41	82	67	28	51	74	75	-	40	57	66	54
	RSD P-M	14	13	1	18	19	22	10	1	6	3	4		3	-	8	3	3	7
	RSD M-T																		
	RSD T+																		

(1) Data from fall gill netting.
(2) Corrected for gill net efficiency (Willis et al 1985)
(3) Data from spring electrofishing.
(4) Data from fall electrofishing.
(5) Data from spring Fyke netting.
(6) Data from spring Fyke netting 1999 and earlier, from fall Fyke netting 2000 and later.
(7) Insufficient data to calculate.
(8) 2004 data from fall gill netting.

Table 5. Relative weight (W_r) of selected fish species in Wolf Creek Lake. W_r formulas from KDWP were used. Per Wege and Anderson (1978), W_r values of 100 and higher represent fish at or above the 75 percentile, values of 93 to 100 are between the 50 and 75 percentile, values of 86 to 93 are between the 25 and 50 percentile, and values less than 86 are below the 25 percentile. Fall gill net, Fyke net, and electrofishing data were not collected in 2001 due to the September 11 events.

	Gizzard Shad	White bass	Wiper	Bluegill	Smallmouth Bass	Largemouth Bass	White Crappie	Walleye
1983	[1] 85	[1] 78	[1] 90	[2] 107		[2] 97	[4] 107	[1] 78
1984	87	94	86	103		98	93	82
1985	88	89	78	102		97	94	83
1986	85	86	84	111		93	93	81
1987	89	93	89	105	[3] 97	88	89	80
1988	90	94	85	108	92	92	102	81
1989	104	95	80	96	92	87	88	88
1990	100	99	82	121	104	84	98	85
1991	93	93	78	111	91	79	99	86
1992	93	92	88	102	91	84	95	86
1993	93	94	88	92	91	80	85	85
1994	93	90	75	104	86	75	97	85
1995	88	97	88	124	90	89	105	85
1996	89	106	100	121	100	57	104	94
1997	89	97	89	105	81	90	99	88
1998	81	90	83	83	86	91	95	76
1999	82	93	83	105	90	78	97	81
2000	76	86	77	106	85	78	[5] 88	80
2001	-	-	-	102	-	84	-	-
2002	87	88	75	110	82	89	[5] 95	77
2003	85	88	68	116	88	83	96	86
2004	81	87	72	107	84	[5]	[1] 91	86
2005	83	95	80	[5]	84	[5]	89	81

(1) Data from fall gill netting.
(2) Data from spring electrofishing.
(3) Data from spring Fyke netting.
(4) Data from fall Fyke netting.
(5) Insufficient sample size to calculate.

Table 6. Selected fish species caught and released by anglers at Wolf Creek Lake.

	# Anglers		Chan. catfish	White bass	Wiper hybrid	Smallmouth Bass	LM Bass	Crappie	Walleye	All fish
1999	9008	No.	6928	15,171	3503	17,482	3885	7382	31,027	86,464
		#/hour	0.15	0.32	0.07	0.37	0.08	0.15	0.65	1.82
		#/acre	1.36	2.98	0.69	3.43	0.76	1.45	6.10	16.99
2000	6865	No.	5191	7838	2267	12,579	4918	5536	21,599	61,102
		#/hour	0.15	0.23	0.07	0.36	0.14	0.16	0.63	1.77
		#/acre	1.02	1.54	0.45	2.47	0.97	1.09	4.24	12.00
2001	7449	No.	5623	8777	1810	10,136	4736	7457	20,911	60,417
		#/hour	0.16	0.25	0.05	0.28	0.13	0.21	0.59	1.70
		#/acre	1.10	1.72	0.35	1.99	0.93	1.47	4.11	11.87
2002	4227	No.	3949	3623	1649	8097	874	4563	11,785	31,807
		#/hour	0.19	0.17	0.08	0.38	0.04	0.22	0.56	1.65
		#/acre	0.77	0.71	0.32	1.59	0.17	0.90	2.31	6.84
2003	4751	No.	6057	8489	6838	8527	3193	5739	6740	45,895
		#/hour	0.25	0.34	0.27	0.35	0.13	0.23	0.27	1.86
		#/acre	1.19	1.67	1.34	1.67	0.63	1.13	1.32	9.02
2004	5674	No.	7175	6748	4553	8989	3096	6386	10,016	47,229
		#/hour	0.23	0.22	0.15	0.29	0.10	0.21	0.33	1.55
		#/acre	1.41	1.33	0.89	1.77	0.61	1.25	1.97	9.28
2005	5287	No.	10,619	8048	2683	7785	1420	4370	9457	44,629
		#/hour	0.37	0.28	0.09	0.27	0.05	0.15	0.33	1.54
		#/acre	2.09	1.58	0.53	1.53	0.28	0.86	1.86	8.77

Table 7. Selected fish species harvested by anglers at Wolf Creek Lake.

	# Anglers		Chan. catfish	White bass	Wiper hybrid	Smallmouth Bass		LM Bass	Crappie	Walleye		All fish
				>12"	>24"	<13"	>18"	>21"	>14"	>18"		
1999	9008	No.	1628	1149	7	356	116	14	725	1669		6007
		#/hour	0.03	0.02	<0.01	0.01	<0.01	<0.01	0.01	0.03		0.13
		#/acre	0.32	0.23	<0.01	0.07	0.02	<0.01	0.14	0.33		1.15
2000	6865	No.	2258	859	3	198	20	10	316	533		4366
		#/hour	0.07	0.02	<0.01	0.01	<0.01	<0.01	0.01	0.01		1.13
		#/acre	0.44	0.17	<0.01	0.04	<0.01	<0.01	0.06	0.10		1.35
						<13"	>16"			<18"	>18"	
2001	7449	No.	2779	1046	12	126	69	4	415	1609	36	6291
		#/hour	0.08	0.03	<0.01	0.01	<0.01	<0.01	0.01	0.05	<0.01	0.18
		#/acre	0.55	0.21	<0.01	0.02	0.01	<0.01	0.08	0.32	0.01	1.23
2002	4227	No.	1161	378	7	85	62	7	184	862	326	3841
		#/hour	0.08	0.02	<0.01	<0.01	<0.01	<0.01	0.01	0.04	0.01	0.18
		#/acre	0.23	0.07	<0.01	0.02	0.01	<0.01	0.04	0.17	0.06	0.83
						<16"	>20"			<18"	>26"	
2003	4751	No.	2457	1233	16	364	24	1	234	1244	26	5638
		#/hour	0.10	0.05	<0.01	0.01	<0.01	<0.01	0.01	0.05	<0.01	0.49
		#/acre	0.48	0.24	<0.01	0.07	<0.01	<0.01	0.05	0.24	<0.01	0.93
2004	5674	No.	2989	1494	18	371	0	3	386	2327	7	7662
		#/hour	0.10	0.05	<0.01	0.01	0	<0.01	0.01	0.08	<0.01	0.25
		#/acre	0.59	0.29	<0.01	0.07	0	<0.01	0.07	0.46	<0.01	1.51
2005	5287	No.	2541	1281	8	303	10	6	325	2441	8	6981
		#/hour	0.09	0.04	<0.01	0.01	<1.01	<0.01	0.01	0.08	<0.01	0.24
		#/acre	0.50	0.25	<0.01	0.06	<0.01	<0.01	0.06	0.48	<0.01	1.37

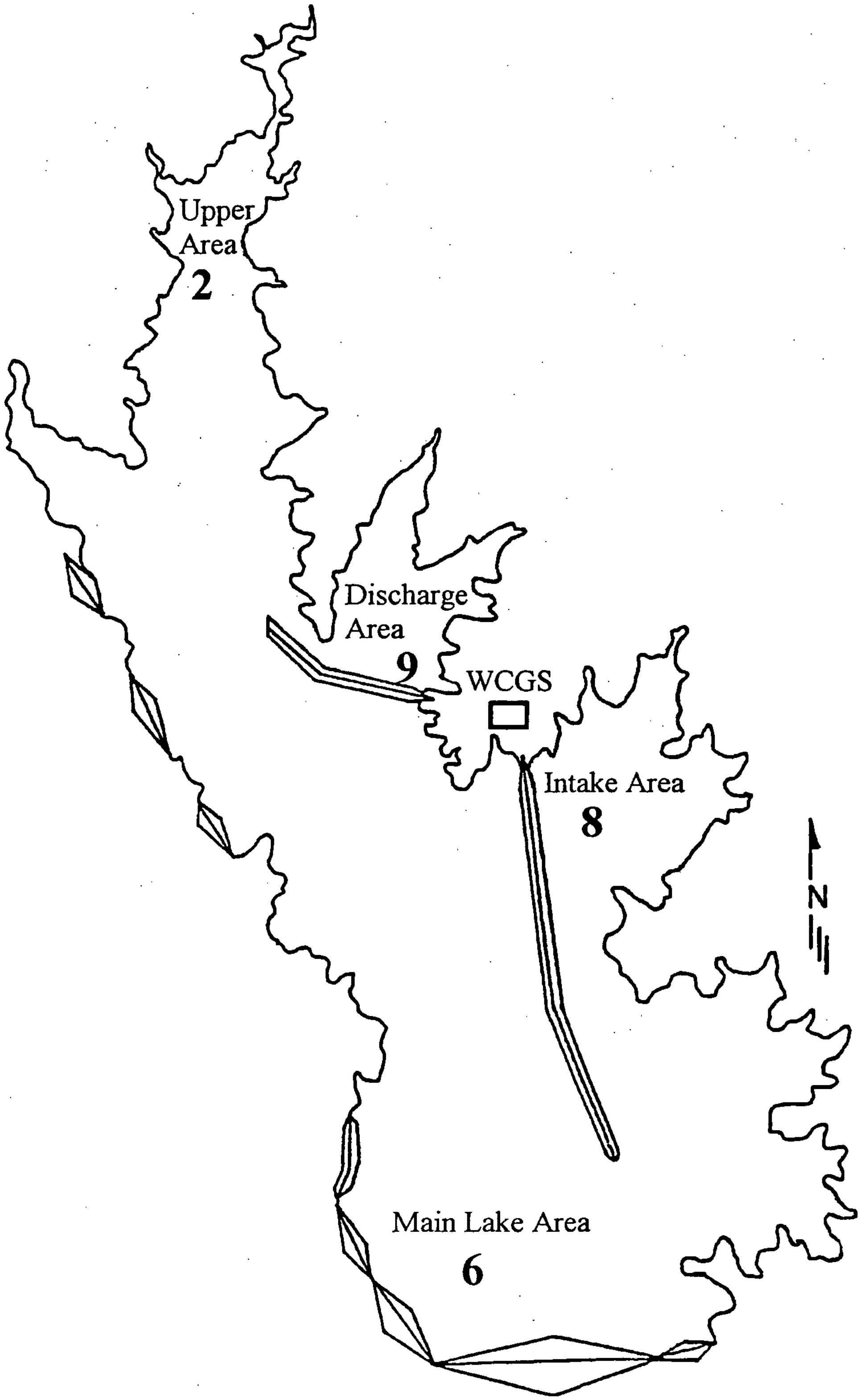

Figure 1. Fishery sampling location on Wolf Creek Lake.

25 a & b

As cited in Enclosure 4 to WM 06-0046 (November 17, 2006): Koester 1974 and Koester 1986

Start up

KANSAS GAS AND ELECTRIC COMPANY
P. O. Box 208 Wichita, Kansas 67201

November 14, 1974

Mr. Mel Gray
Director of Environmental Health
State Department of Health and Environment
Forbes Air Force Base, Bldg. 740
Topeka, Kansas 66620

Dear Mr. Gray:

As you know, Kansas Gas and Electric Company is currently undertaking to construct and operate a nuclear electric generating unit in Coffey County, Kansas. The tentative on-line date for that unit is now considered to be 1982.

In that regard, Kansas Gas and Electric Company is attempting to comply with all applicable laws as well as rules and regulations promulgated by state and federal agencies. Among those laws, rules and regulations is the Federal Water Pollution Control Act, 33 U.S.C. § 1251, et seq., as amended by PL 93-207, December 28, 1973 and PL 93-243, January 2, 1974.

Kansas Gas and Electric Company is in the process of preparing its Application for Permit to Discharge Wastewater, pursuant to the Federal Water Pollution Control Act. A portion of the application speaks to the standards regarding thermal discharges as required by Section 316(a) of the Act.

The Act, in Section 306(b)(B) provides that the administrator shall propose and publish regulations establishing Federal standards of performance for "new sources" within the designated categories, including steam electric power plants. The administrator has published the said regulations, the same occurring Tuesday, October 8, 1974, Federal Register, Vol. 39, No. 196. Section 423.13(1) provides as follows:

> There shall be no discharge of heat from the main condensers except: . . . (3) Heat may be discharged where the owner or operator of a unit otherwise subject to this limitation can demonstrate that a cooling pond or cooling lake is used or is under construction as of the effective date of this regulation to cool recirculated cooling water before it is recirculated to the main condensers. (emphasis added)

KG&E submits that it qualifies for this exception insofar as KG&E would otherwise be required to comply with the provisions of Section 316(a) of the Act, on the basis that "construction" occurred prior to the effective date of the federal regulation.

> Section 306(a) of the Act states that:
>
> (5) The term "construction" means any placement, assembly, or installation of facilities or equipment (<u>including contractual obligations to purchase such facilities or equipment</u>) at the premises where such equipment will be used, including preparation work at such premises. (emphasis added)

KG&E qualifies for the exception, based on the "construction" portion thereof as defined in the Act in that, prior to the publication of the proposed regulations, KG&E was contractually obligated to purchase facilities, equipment, and land for the site as designated in Attachments I and II to this letter.

Kansas Gas and Electric Company would therefore accordingly request that you, on behalf of the Kansas State Department of Health and Environment, and the Environmental Protection Agency, grant Kansas Gas and Electric Company the requested exception, based on the foregoing reasons, from the requirements as set forth in Section 316(a) of the Act.

Sincerely yours,

GLENN L. KOESTER

Glenn L Koester

GLK/kp

Attachment

COPY FOR

bcc: Messrs M Miller
E Hall
N Pinkstaff
J Arterburn
G Boyer
R Vohs
R Foster

ATTACHMENT I

The following approximate acreage acquired at the Wolf Creek Site:

Land Acquired to October 25, 1974 6,394 ac

ATTACHMENT II

Contracts and Commitments for Wolf Creek Generating Station Prior to March 4, 1974, and prior to November 7, 1974 -

Prior to March 4, 1974	
NSSS	$ 65,500,000
T/G	47,000,000
Engr (Bechtel)	25,500,000
Engr (S&L)	4,600,000
W Fuel	28,500,000
KG&E Expenses to Date	4,250,000
	$175,350,000
March 4 - November 7, 1974	
AEC Enrichment	$ 14,700,000
Containment Liner Plate	6,700,000
Daniel	5,500,000
Expenses (KG&E)	6,800,000
Steam Generator Pump Drives	1,000,000
	$ 34,700,000
TOTAL	$210,050,000

FORM 110

KGE THE ELECTRIC COMPANY

KANSAS GAS AND ELECTRIC COMPANY
P. O. Box 208 Wichita, Kansas 67201

LICENSING ROUTING

NRCLK	
KMLNRC	✓
TE 40090-A	✓
TE 40694 w/a	✓
TE	
Atwood	
Chernoff	
Goode	
Imbler	
Maynard	✓
Pendergrass	✓
Petersen	
Passwater	
Records Management	
Chronological-H.C.	✓

bcc: 6/18/86 NAPetrick
CJRoss/MEvans
CTerrill/CLRoss
KRBrown/WCadman 501 GO
RLRives/620 GO
RTerrill 702 GO
JABailey WCGS
JPippin MS3-01
WGEales MS6-03
EWCreel/MJohnson MS7-01
WLMutz MS7-03
RWHolloway
DNO
FTRhodes
RMGrant/WJRudolph
JZell
OMaynard (2)
Records Mgmt MS2-03
EDProthro/IDFile 202 GO

June 16, 1986

Mr. R. D. Martin, Regional Administrator
U.S. Nuclear Regulatory Commission
Region IV
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76011

COPY

KMLNRC 86-111
Re: Docket No. STN 50-482
Subj: Annual Environmental Operating Report, Revision 1

Dear Mr. Martin:

Enclosed is Revision 1 to the Annual Environmental Operating Report which is being submitted pursuant to Wolf Creek Generating Station Facility Operating License NPF-42, Appendix B. This report covers the operation of Wolf Creek Generating Station for the period of March 11, 1985, to December 31, 1985.

This revision is being issued to include data that was not completely compiled when the original report was issued. Revision bars have been added in the right hand margin to indicate the changes from the original report. Also, the letter number of the original report was incorrectly labeled KMLNRC 86-077 and should have been KMLNRC 86-082.

If you have any questions please contact me or Mr. O. L. Maynard of my staff.

Yours very truly,

Original signed JOHN A. BAILEY

for/ Glenn L. Koester
Vice President - Nuclear

GLK:see

cc: PO'Connor (2)
JCummins
Document Control Desk (18)

WOLF CREEK GENERATING STATION

ANNUAL ENVIRONMENTAL OPERATING REPORT

1985

KANSAS GAS AND ELECTRIC COMPANY

KANSAS GAS AND ELECTRIC COMPANY
WOLF CREEK GENERATING STATION

1985 ANNUAL ENVIRONMENTAL OPERATING REPORT

1.0 INTRODUCTION

Kansas Gas and Electric Company (KG&E) has committed to minimizing the impact of the Wolf Creek Generating Station (WCGS) facility construction and operation on the environment. The 1985 Annual Environmental Operating Report (AEOR) is being submitted in accordance with the objectives of the Environmental Protection Plan (EPP) as required by Facility Operating License NPF-42, to demonstrate that the plant is operating in an environmentally acceptable manner.

2.0 ENVIRONMENTAL MONITORING

2.1 AQUATIC [EPP Section 2.1]

2.1.1 Impacts of Water Withdrawal on the Neosho River

WCGS has contracted with the Kansas Water Resources Board to remove 9,692,000,000 gallons per calendar year from the tailwaters of the John Redmond Reservoir. In 1985, only 571,584,651 gallons or 5.9 percent of this allotment was used. Based on monitoring studies completed by Ecological Analysts, no changes attributable to these withdrawals have been witnessed in river water quality or populations of phytoplankton, macroinvertebrates or fishes.

2.1.2 Chlorine Discharges to Wolf Creek Cooling Lake

Chlorine concentrations at the circulating water discharge structure to the cooling lake were postulated in the FES/-OLS (Section 4.2.6.1) to range between 0.68 and 1.08 mg/l total residual chlorine (TRC). These values were expected to result from three 30-minute chlorine doses per day (411 lbs. per dose) and to cause periodic, appreciable mortality among aquatic organisms. The area in which aquatic biota could be adversely affected by chlorinated effluents was conservatively estimated at 40 acres (FES/OLS Section 5.5.2.2).

Administered by the State of Kansas, the WCGS NPDES permit No. I-NE07-P002 limits circulating water TRC effluent values to a maximum of 0.2 mg/l and chlorination time to 2 hours per day. In practice, WCGS has fallen well below these allowable limits. Actual chlorine dosages have averaged about 26 lbs. per dose and daily TRC compliance has been maintained at 100%, while operating time compliance has achieved 98%. These compliance figures resulted in an average 0.1 mg/l TRC effluent value and were tabulated for the first 310 days of NPDES permit monitoring, beginning on April 24, 1985. This average TRC value equals that concentration identified in the ER/OLS (Section 5.1.3) which was expected to have no meaningful effect on the overall biological productivity of the cooling lake.

2.1.3 Cold Shock

In the event of a rapid decline in plant power level in winter, fishes attracted to the WCGS heated discharge could experience mortality due to "cold shock", a quick reduction in body temperature. In reference to licensing document evaluations, the WCGS EPP Section 2.1 (c) stated, "Cold shock effects on fish due to reactor shutdowns could cause significant mortality to aquatic species in the cooling lake". In 1985, precipitous wintertime power declines were avoided sufficiently to preclude any observable cold shock events. Re-evaluations of cold shock potential were made in light of elevated condenser delta T's experienced at both summer and wintertime water temperatures, and these summaries appear in Section 3.1 of this report.

2.1.4 Impingement and Entrainment

Impacts of impingement and entrainment were projected to be significant in the WCGS EPP, with condenser mortality for entrained organisms expected to approach 100% [ER(OLS) Section 5.1.3.3]. Because of this, sampling efforts to monitor these impacts were not required by the NRC and have not been implemented by KG&E.

2.1.5 Impacts of Wolf Creek Cooling Lake Discharges to the Neosho River

WCCL discharges into the Neosho River are regulated by WCGS NPDES permit limitations. Since discharges are sporadic, water is sampled on the first day of each discharge and weekly thereafter. Effluent parameters measured included a flow rate estimate, temperature, pH, TDS, sulfate, and chloride concentrations. Wolf Creek additions to the Neosho River are regulated to maintain a zone of passage for aquatic organisms at the confluence. Consequently, the flows allowable from Wolf Creek may range from zero to unrestricted, depending upon the similarity between Wolf Creek and Neosho River water quality and temperature, with a maximum of 90°F allowable in the Neosho River downstream of the mixing zone. In 1985, no NPDES violations at the dam (Outfall 004) were recorded. Based on monitoring studies by Ecological Analysts, there have been no apparent deleterious effects to Neosho River water quality on phytoplankton, macroinvertebrate or fish populations.

2.2 TERRESTRIAL [EPP Section 2.2]

2.2.1 Control of Vegetation in the Exclusion Zone

The composition and structure of vegetation in the 453 ha (1120 acre) exclusion zone were selectively controlled to be compatible with the function and security of station facilities. Most areas in the immediate vicinity of the power block have been planted and maintained in a lawn-type condition. Landscaping and grass establishment have not been entirely completed to date, however all areas have been mowed at least once annually for security and aesthetic purposes. No restoration areas (areas not to be mowed) were established within the exclusion zone.

2.2.2 Vegetation Buffer Zone Surrounding Wolf Creek Cooling Lake

To create a buffer zone around WCCL, all agricultural production activities were curtailed in 1980 below elevation 1095' MSL, eight feet above WCCL normal operating surface water elevation (1087' MSL). Previously grazed or hayed native tallgrass areas were allowed to return to a natural state. Cultivated lands were allowed to advance through natural successional stages. Land management activites specified in an annual land management plan included controlled burning and native tallgrass seeding to enhance and/or maintain the designated buffer zone with a naturally occurring biotic community.

2.2.3 Herbicide Use for Maintenance of Wolf Creek Generating Station Structures

No herbicides were applied on WCGS - associated power transmission line corridors in 1985.

Herbicide was applied on the WCGS switchyard facilities on June 17, 1985. A soil sterilant consisting of 8 pounds of Karmex (EPA Reg. No. 352-247 and approved for use in Kansas) and 4 to 6 pounds of Oust (EPA Reg. No. 352-401 and approved for use in Kansas) per 100 gallons of water was applied at a rate of 20-50 gallons per acre. Application was completed by a contractor commercially licensed by the Kansas Department of Agriculture.

No noteworthy applications of herbicides were applied on other WCGS facilities during the period addressed by this report.

2.2.4 Waterfowl Disease Contingency Plan and Monitoring

A waterfowl disease contingency plan involving both state and federal personnel has been formulated to provide guidance for station biologists in the event of suspected or actual disease outbreaks. During routine wildlife monitoring and surveillance activities taking place over this reporting period, no avian mortality attributable to disease pathogens was identified.

2.2.5 Fog Monitoring Program [EPP Subsection 4.2.1]

Visibility monitoring was initiated in December 1983 and continued through 1985. The purpose of this study has been to evaluate the impact of waste heat dissipation from WCCL on fog occurrence along U.S. 75 near New Strawn, Kansas. A summary of fog monitoring activities is included in Attachment 1 of this report. Additional documentation is available for review at the WCGS job-site.

2.2.6 Wildlife Monitoring Program [EPP Subsection 4.2.2]

A wildlife monitoring program was initiated to monitor and assess wildlife populations or parameters most likely to be impacted by the operation of WCGS. This included a general survey program for waterfowl collision events. As outlined in the 1984/85 annual wildlife study plan, specific objectives of the wildlife monitoring program were to assess waterfowl, waterbird, and Bald Eagle usage of WCCL, to assess transmission line collision mortality of waterfowl using WCCL, to maintain a wildlife species list, and to develop an annual wildlife report. Wildlife monitoring activities are summarized in Attachment 1. Additional documentation is available for review at the WCGS job-site.

2.2.7 Land Management Program [EPP Subsection 4.2.3]

Land management activities on all company-owned lands except the 453 ha (1120 acre) WCGS exclusion area were designed to achieve balances between agricultural production and conservation values. An annual management plan was formulated to address needs and propose accepted techniques for land maintenance, soil conservation, and wildlife management. These included construction or repair of livestock fences and ponds, and construction or establishment of terraces, waterways, permanent vegetative cover, and shelterbelts. The 1985 Land Management report is available for review at the WCGS job-site. A summary appears in Attachment 1 of this report.

3.0 ENVIRONMENTAL PROTECTION PLAN REPORTING REQUIREMENTS

3.1 Plant Design or Operating Changes [EPP Section 3.1]

Proposed plant design and operating changes which have the potential to affect the environment must receive an environmental evaluation prior to implementation. A summary of each Plant Modification Request (PMR) or operating change which received an environmental evaluation prior to implementation in 1985 is presented.

Evaluation 85-01 - WCGS Operation at Elevated Condenser Delta T's

Periodic loss of one of the three circulating water intake pumps for maintenance has resulted in increased heating of the reduced cooling water volume. The maximum 3 pump condenser delta T postulated in the FES(OLS) Section 4.2.6.3 was 31.5°F and delta T's at 2 pump, 100% power operation are now projected to approach 42°F. Because licensing documents predicted "significant" discharge cove cold shock mortality in the event of a midwinter plant trip and 100% entrainment mortality during routine operation, an increase in delta T should not fundamentally alter the magnitudes of these impacts. Additionally, this will not likely impinge on NPDES limitations for the temperatures of discharges into the Neosho River. Therefore, operation at elevated condenser delta T's was approved.

Evaluation 85-02 - Late Spring, Summer, and Early Fall Operation at Elevated Condenser Delta T's

The potential for cold shock in the WCGS discharge cove has been evaluated as problematic during the coldest months [FES(CP) Section 5.5.2.3]. Hence, this evaluation approved prolonged operation at elevated delta T's ($>31.5^{\circ}$F) from late spring through early fall when WCCL fishes avoid the immediate discharge area due to higher-than-preferred temperatures.

There were no changes in station design or operation nor were there tests or experiments which involved a potentially significant unreviewed environmental question in 1985.

3.2 Non-Routine Environmental Reports [EPP Subsection 5.4.2]

3.2.1 Submitted Non-Routine Reports

No non-routine environmental reports involving significant impact were submitted to the NRC from March through December 1985. The single unusual or important environmental event evaluation completed during this period is summarized in the following section.

3.2.2 Unusual or Important Environmental Event Evaluations

May 20, 1985 Fish Kill in Construction Pond 3A

On May 17, hydrazine and ammonia was inadvertently released from the condenser to the Wolf Creek Cooling Lake through NPDES Outfall 002. The hydrazine combined with the free oxygen in the water resulted in a number of fish dying from oxygen starvation in the immediate vicinity of the outfall. The loss of these fish had little to no impact on the cooling lake and resulted in no offsite impact. Therefore it was determined that this event was not reportable pursuant to EPP Sections 4.1 and 5.4.2.

3.3 Environmental Noncompliances [EPP Subsection 5.4.1]

At WCGS in 1985, all environmental noncompliances were recorded along with the events surrounding them. The noncompliances of interest were of two types, either deviations from NPDES permit limitations or short-term fog visiometer malfunctions. These noncompliances were evaluated and determined not to be reportable pursuant to EPP Section 5.4.1. All 1985 environmental noncompliances are available for review at the WCGS job-site.

ATTACHMENT 1

SUMMARY OF
ENVIRONMENTAL INVESTIGATIONS
AT WOLF CREEK GENERATING STATION, 1985

Kansas Gas and Electric Company

Environmental Management

Burlington, Kansas

1. 1985 LAND MANAGEMENT REPORT

In keeping with annual land management plan guidelines, an annual progress report was formulated. Land maintenance items outside the exclusion zone involved stock pond and fence construction or repair. Improvement activities included native grass seeding and shelterbelt establishment. Grazing, haying, and cultivation lease control were primary mechanisms used for managing company land resources for both agricultural benefits and enhancement of wildlife, soil, and native plant resources.

2. 1985 EA, ENGINEERING, SCIENCE, AND TECHNOLOGY ENVIRONMENTAL MONITORING REPORT

Environmental monitoring performed by EA, Engineering, Science, and Technology Inc., in 1985 included those tasks done in 1984 plus bottom-to-surface dissolved oxygen profiles on WCCL and Neosho River benthic and fish community sampling. Seasonal mean concentrations of water quality parameters during 1985 were within previously established ranges for the Neosho River. Unusually high precipitation resulted in consistently elevated flows, resulting in chlorophyll concentrations and carbon fixation rates near the previously recorded minima. Similarly, highly variable river fishery and macroinvertebrate data show no long-term patterns, differences between upstream and downstream locations, or alterations attributable to plant construction and/or operation. Cooling lake water quality has been uniform among locations with dissolved and suspended constituents having shown declining trends since lake filling, indicating an improvement in overall water quality and no adverse impacts from plant operations. The WCCL macroinvertebrate population is fairly typical of midwestern reservoirs, with locational dissimilarities reflecting primarily depth and substrate differences. Operation of WCGS has caused no apparent changes in the cooling lake benthos community in 1985. Lastly, groundwater monitoring in the WCGS vicinity since 1973 indicated the well water to be very hard and to contain high levels of dissolved constituents. These observations have not altered since the filling of WCCL or since WCGS has been constructed and begun operation.

3. 1984 ECOLOGICAL ANALYSTS ENVIRONMENTAL MONITORING REPORT

Environmental monitoring completed by Ecological Analysts in 1984 included studies on the Neosho River, WCCL, and adjacent lands. Items accomplished by this study were:

1. documentation of concentrations of general water quality parameters, aquatic nutrients, organically-derived materials and certain trace metals in the Neosho River and cooling lake

2. determination of general groundwater quality in the vicinity of the facility

3. characterization of the cooling lake benthic community

4. determination of phytoplankton productivity of the Neosho River and cooling lake

5. determination of zooplankton biomass in the cooling lake

In addition to the above specific objectives, the studies documented naturally occurring variations in the aquatic communities of the Neosho River and cooling lake. Study results have shown that chemical and biological changes in WCCL have followed the trends expected for a newly impounded reservoir. Water quality and biological parameters in the Neosho River show patterns dependent primarily on John Redmond Reservoir releases.

4. FISHERY MONITORING ACTIVITIES

1984

Fishery monitoring surveys were conducted on WCCL near WCGS, from April 1984 through October 1984. Collection methods employed included seining, electrofishing, otter trawling, gill and fyke netting. These resulted in the collection of 8,221 fish representing 10 families and 27 species. Data collected and data from the 1983 Fishery Report were used to describe the fishery which was subsequently evaluated based on the goal of increased plant reliability through reduced gizzard shad impingement. Plant construction during this period resulted in no observed impacts to the fishery. As in 1983, black bullheads ranked first in numbers caught, with gizzard shad and bluegills/*Lepomis* spp. following and black crappie and largemouth bass at fifth and sixth, respectively. Black bullheads also dominated biomass measurements, making up 16.3% of the total. These were followed by largemouth bass (13.6%), walleye (10.0%), common carp (9.5%), wiper (9.2%) and gizzard shad (5.7%). Relative biomass values reflected an unusually high ratio of predator fish to roughfish when compared with other midwestern reservoirs. This ratio was attributed primarily to pre-impoundment renovation and stocking efforts and high predator diversity. Average growth rates and condition (W_r or KTL) of predators (largemouth bass, wipers, and black crappie) were at or above Kansas and regional averages while walleyes were the only species examined which showed below average condition. Proportional and Relative Stock Densities (PSD and RSD) were calculated for the most important WCCL species and found to be increasing as initial year classes grow into the larger size categories. Changing predator/prey interactions were considered along with the effect of submersed macrophyte (*Potamogeton*) growth in predicting a decline in initial, rapid predator growth rates with a continuation of the observed predator dominance over gizzard shad.

Fishery monitoring surveys were conducted on WCCL from March through December 1985. As in the past, collection methods used included seining, electrofishing, otter trawling, gill and fyke netting. The total catch consisted of 12,128 fish representing 32 species. Relative abundances in 1985 from a standardized sampling effort showed a drop from 20.0% in 1984 to 5.8% for black bullheads while bluegill/*Lepomis* spp. jumped from 29.0 to 38.7%. Largemouth bass increased 9.9% to 13.9% and gizzard shad declined from 18.6 to 5.2%. These same trends, however, were not reflected in relative biomasses from standardized catches. Wipers, showing little change in relative abundance between years, more than doubled in percent biomass (9.2 versus 20.8%), indicating growth of the 1981 year class. Gizzard shad biomass fell from 5.7 to 2.2%. The marked increases in WCCL centrarchid abundances were not reflected in their biomasses, with largemouth bass increasing only 3.1 and bluegill/*Lepomis* spp. rising even less. This was due to the preponderance of the catch being small, newly hatched fish caught seining and trawling. Increases in these fishes were predicted as *Potamogeton* growth expanded due to their dependence on cover for protection and for the food associated with it. As in the past, relative biomass data indicated an unusually high predator/prey ratio. Growth rates of the 1981 wiper and largemouth bass year classes declined during 1985. Gizzard shad condition (Wr) increased to approximately 95 and average largemouth bass Wr remained in the 95-105 range, with 100 being the North American average. Wiper condition (K_{TL}) declined from 1.30 in 1984 to 1.16 in 1985. Marked declines in wiper growth and condition were likely attributed to the reduced number and biomass of gizzard shad, their primary forage.

Plant operational effects on WCCL fishes observed in 1985 varied with plant mode of operation and with seasonal temperature changes. Operation of the circulating water system in spring prior to thermal inputs attracted to the discharge high densities of all three WCCL *Morone* species because they require flowing water when spawning. Later, largemouth and smallmouth bass, channel catfish, and gizzard shad were also attracted. Throughout summer as ambient lake temperatures rose, plant power level also increased, thus elevating discharge temperatures to above 90°F and out of the preferred range for WCCL fishes, creating an area of avoidance. During that time, any prolonged drop in plant power level which reduced discharge temperatures below approximately 90°F precipitated a return of fishes to the discharge area. In November and December, as ambient temperatures fell, discharge temperatures were once again attractive, and high fish densities returned. Studies were initiated to monitor the delta T caused by condenser passage as it affected discharge temperature and temperatures throughout the discharge cove.

In summary, through 1985 the WCCL predator population continued to develop and function unusually well to control gizzard shad and keep impingement rates low. While WCGS operations caused the changes in the discharge cove fish distribution which were predicted in the ER(CP) and the FES(CP), data indicate no decernable negative impacts to date on WCCL fishes either locally in the discharge cove, or in the lake as a whole.

5. FOG MONITORING ACTIVITIES

Visibility monitoring was initiated in December 1983 to evaluate the impact of waste heat dissipation from WCCL on fog occurrence along U.S. Route 75 in New Strawn, Kansas. The site chosen for monitoring was considered conservative due the relatively high frequency of cooling lake-induced fog predicted to occur at this location, as well as the theoretical impact of increased fogging on traffic safety along Route 75.

1984

Preliminary results based on data collected in 1984 during the preoperational period indicated that the frequency of natural fog at Wolf Creek was in general agreement with climatological averages of fog occurrence in the region. Fog episodes were more numerous, lasted longer, and were more intense during cooler months of the year. On a daily basis, early morning was the most favorable period for fog development. Most fog episodes were of relatively short duration, lasting an average of about 4 hours.

Visibility data will be collected through the first year of plant operations in order to quantify changes, if any, in the frequency, intensity, and duration of fog at the monitoring site. These data will be analyzed by comparison with data from the meteorological tower at Wolf Creek to determine the extent of cooling lake effects on local fogging.

1985

Visibility was monitored at New Strawn, Kansas during 8-months in 1985. Approximately 220 hours of fog were detected at the monitoring site, compared to the 1984 total of 122 hours. Since visibility was monitored for a comparable number of hours during both years, this change represents a substantial increase in the frequency of fog occurence from the previous year. The change can be partially attributed to the fact that visibility was monitored more intensively during the winter months in 1985 compared to the previous year. In fact, about 100 hours of fog were recorded during January and February of 1985, a period for which visibility data was not available during 1984.

It should also be noted that the majority of fog episodes were recorded in the months of January through May. This represents the pre-operational period for Wolf Creek Generating Station, which received it's full power operating license from the Nuclear Regulatory Commission on June 4, 1985. Since visibility was monitored during only three months of the operational period in 1985, there is insufficient data at this point to draw conclusions concerning the effects of Wolf Creek Cooling Lake operations on the frequency of fog along Route 75 in New Strawn.

In addition to the increase in total fog-hours during 1985, corresponding increases in heavy and dense fog were also seen at the monitoring site. Heavy fog (hourly average visibility less than 1 mile) was recorded on 25 days during 1985. Compared to 12 days in 1984. The incidence of dense fog (visibility less than 1/4 mile during any part of an hour) was also approximately twice the 1984 total. In general, the intensity of fog episodes was greatest during the first quarter of the year.

6. WILDLIFE MONITORING ACTIVITIES

September 1984 through April 1985

Wildlife monitoring studies were conducted in the vicininty of WCGS from September 1984 through April 1985. Use of WCCL by wildlife was determined especially for waterfowl, waterbirds, and Bald Eagles. Bird mortality due to collisions with transmission lines traversing WCCL was assessed. With special attention to threatened and endangered species, records of all mammals, birds, and herptiles observed were maintained for comparisons to past construction and preoperational studies conducted since 1973.

A total of 145 avian species were observed during the 1984-1985 monitoring program. The most abundant species were the mallard and american coot, which comprised 34.2 and 19.2 percent respectively. Comparative use of the cooling lake and John Redmond Reservoir by waterfowl and waterbirds was determined. Of the commonly observed species, only the american coot used WCCL to a greater extent than John Redmond Reservoir. Comparative use between five cooling lake areas was determined with pondweed (Potamogeton) concentrations within WCCL generally being used to a greater degree.

Transmission line collision surveys revealed 30 mortalities representing 10 species. No mortalities of threatened or endangered species were observed. Twenty-five percent of those individuals identified were not waterbird species and were considered incidental mortalities not influenced by WCCL attraction. No significant avian mortality due to transmission line impaction was observed.

Twenty-three mammal and 16 herptile species were observed in the vicinity of WCGS during the 1984-1985 monitoring. One mammal and two reptiles were not previously documented. No threatened or endangered species were observed.

The Bald Eagle, prairie falcon and interior least tern represented the threatened or endangered bird species observed in the vicinity of WCGS. Bald Eagles were common winter residents and fed on fish and weakened waterfowl. Eagles in the vicinity of WCGS used the cooling lake solely as a feeding and loafing site, however not to the extent observed on John Redmond Reservoir. No Bald Eagles were observed roosting on WCCL. The prairie falcon and interior least tern are two species which migrate through the area and are expected to be observed occasionally in the future.

May 1985 through December 1985

This synopsis provides a summary of data collected from May through December 1985 as part of the 1985-1986 operational wildlife monitoring program. Use of WCCL by waterfowl, waterbirds, and Bald Eagles was assessed from September through December 1985. Records of all mammals, birds, and herptiles observed were maintained for comparisons to past construction and preoperational studies conducted since 1973. Special attention was given to both state and federally listed threatened and endangered wildlife species during all observations.

A total of 131 avian species were observed during the 1985 monitoring. The most abundant species were the Amerian coot, Franklin's gull, and mallard. These species have commonly been observed during all preoperational studies. Other species totals that increased from the same time period during 1984 include the common merganser (77 percent), American wigeon (18 percent) and Canada goose (2 percent). Apparent factors that have influenced usage of WCCL during 1985 continue to include relatively clear water, secluded wind protected areas, and concentrations of aquatic weed growth. The lake and land management activities surrounding it have continued to provide foraging, loafing, and nesting habitats.

Transmission line collision surveys in 1985 revealed 19 mortalities representing 11 different species. These surveys were conducted from September through December 1985. No mortalities of threatened and endangered species were observed. Twenty-one percent of the specimens found were not water-related birds and were considered incidental mortalities not influenced by WCCL attraction. This percentage compares closely with those observed during preoperational studies. Collision rates were 25 percent lower than those observed during the same time period in 1984. No significant avian mortality due to transmission line impaction was observed.

Twenty-five mammal and 12 herptile species were observed in the vicinity of WCGS during 1985 monitoring. No new species were identified. No threatened or endangered mammal or herptile species were observed.

There were three threatened or endangered avian species observed in the vicinity of WCGS. These included the Bald Eagle, prairie falcon, and interior least tern. As during preoperational observations, Bald Eagles were common winter residents. Eagles in the vicinity of WCGS used the cooling lake solely as a feeding and loafing site, however not to the extent observed on John Redmond Reservoir. No changes in Bald Eagle usage of WCCL due to station operation were identified. The prairie falcon and interior least tern are two species which migrate through the area and are expected to be observed occasionally in the future.