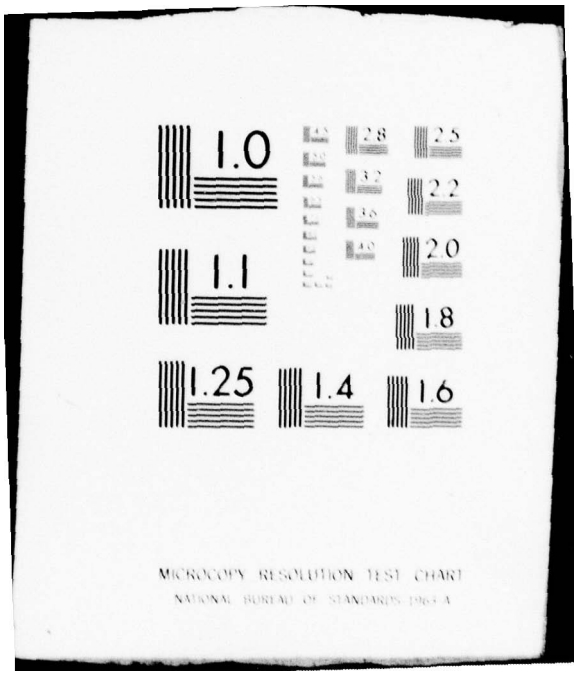
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Keystone Lake Project
February 1979

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The December 19, 1961, FWS planning report contained three well conceived recommendations pertinent to wildlife resources, viz: (1) a request for development of a plan to accommodate project zoning, (2) that all project lands acquired be clearly marked, and (3) that an approximate 3,701 ha (9,145 ac) contiguous tract located on the Cimarron arm of the reservoir be purchased in fee, fenced at project expense, and licensed to the ODWC for wildlife management purposes.

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The recommendation for a zoning plan was subsequently implemented and lands off limits to hunting have been identified and signed. The CE rejected the FWS's recommendation for the purchase of the requested tract on the Cimarron arm of the reservoir because of unfavorable cost-benefit ratio (0.1) as computed by the CE. In 1974 a total of 6,273 ha (15,500 ac) of incidentally acquired project property (including 4,970 ha (12,280 ac) of land and 1,303 ha (3,220 ac) of water), divided between the Cimarron and Arkansas River arms of the reservoir, was licensed to the ODWC for wildlife management. In all, 6,274 ha (15,504 ac) of project lands are open to public hunting.

The severe terrestrial wildlife losses anticipated by the FWS did not occur. Hunting effort currently supported by the project is greater than the FWS estimated hunting levels for resident terrestrial game species predicted for the area without-the-project. However, compensation has been achieved only as a result of intensive management involving substantial monetary outlays by the ODWC for fencing and habitat improvement programs. The post-impoundment hunting effort estimated for big game species was seven times higher than the level predicted assuming implementation of the mitigation plan. The optimistic 1961 FWS report prediction for waterfowl hunting use failed to materialize. FWS predictions for upland game hunter-day use were more accurate, although proving to be somewhat lower than ODWC estimated pre-impoundment occurrences.

Contrary to guarantees extended by the CE that power production would supply a minimum of 520 cfs below the reregulation dam, flows in the Arkansas River at Tulsa have been less than 300 cfs, an average of 20 days annually in 6 of the 13 years since impoundment. No water is released when power is not being generated, and fish kills have occurred immediately below the dam.

The reservoir clearing plan, although considered to have been too severe by the ODWC, resulted from cooperative planning efforts of all agencies involved. The recommendation that a reservoir zoning plan be adopted to insure availability of certain areas for fishing without conflicting use for general recreation was never implemented.

FWS prediction of angler-day use in both the lake and tailwater were substantially exceeded by post-impoundment estimates derived from ODWC conducted creel surveys. The combined post-impoundment ODWC lake and tailwater angler-day use estimates was almost three times greater than predicted. Total annual post-impoundment angler-day usage estimated by ODWC creel surveys was over 16 times greater than without-the-project projections made by the FWS.

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PREFACE

This document was prepared by staff of the Sport Fishing Institute for the U.S. Army Corps of Engineers (CE) under contract number DACW73-74-C-0040. The contract required the compilation and comparison of pre- and post-construction data treating fish, wildlife, or both fish and wildlife (depending upon data availability) for twenty separate CE water development projects. This report presents the findings for one of the twenty individual project evaluations.

Upon completion of the full series of twenty separate studies, a final report will be prepared which will contain an analysis of the validity of the predictive procedures used in fish and wildlife planning, and will contain recommendations for improving the planning process.

The Sport Fishing Institute could not have prepared this report without the cooperation and assistance of many knowledgeable state and federal personnel. U.S. Army Corps of Engineers staff at the Tulsa District provided most of the pre-impoundment documentation as well as supplying important parts of the post-impoundment record.

Buell Atkins, Guy Cabbiness, Harry Clement, Wendell Jamison, and Loren Mason were among the helpful Tulsa District staff. CE project personnel stationed at Keystone Lake, viz: Cliff Hays and William Budnick, supplied requested post-impoundment information. Many members of the Oklahoma Department of Wildlife Conservation contributed data and helpful comments. Among these contributors were Charles Wallace, Byron Moser, Kim

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Erickson, Dave Combs, Joe Hardridge and John Lowrey. Additional fishery-related information was supplied by Jim Mense, Greg Summers, and Thomas White, all on the staff of the Oklahoma Fisheries Research Laboratory at Norman, Oklahoma. Charles Scott, U.S. Fish and Wildlife Service in Tulsa, Oklahoma, reviewed that agencies records for Keystone Lake and provided other pertinent information. The Wildlife Management Institute's South Central Field Representative, Murray Walton, participated in the field trip and critically reviewed the manuscript.

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SPORT FISHING INSTITUTE

PROJECT PERSONNEL

Robert Martin
(Project Leader)

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Richard Stroud
(Contractor's Representative)

Mary Burroughs
(Project Secretary)

CONSULTANT'S REVIEW

Professional terrestrial wildlife consultative services were provided by the staff of the Wildlife Management Institute (WMI). Project personnel were accompanied by a WMI staff specialist during field reconnaissance and on on-site discussions. The terrestrial wildlife portion of the prepared evaluative manuscript was reviewed and evaluated by WMI. All pertinent suggestions offered by the consultant are reflected in this report.

INDIVIDUAL RESERVOIR PROJECT EVALUATION REPORTS

KEYSTONE LAKE PROJECT

INTRODUCTION

Location

The project is located within the Arkansas River Valley about 14 miles west of Tulsa, Oklahoma, in Creek, Pawnee, Payne, Osage and Tulsa counties. The dam is located at kilometer 866.9 (mile 538.8) of the Arkansas River, approximately 3.2 km (2 mi) downstream from the mouth of the Cimarron River (Figure 1). Approximately 500,000 people reside within the contiguous counties. Tulsa, Oklahoma, with a population of about 400,000, is the largest city within a 40 km (25 mi) radius of the project. Population growth in the area increased by almost 14 percent between the 1960 and 1970 census periods, and an additional growth rate of 20 percent is projected by 1980 (1). Heyburn Reservoir, 397 ha (980 ac), is the largest impoundment located within a 40 km (25 mi) radius of the project.

Authorization

Keystone Dam and Reservoir was authorized by the Flood Control Act approved 17 May 1950 as a modification of the general comprehensive plan for flood control purposes approved by the Flood Control Act of 28 June 1938, and the multiple-purpose plan for the Arkansas River and tributaries, Arkansas and Oklahoma, approved by the River and Harbor Act of 24 July 1946. The authorized purposes of Keystone Dam and Lake, as part of the comprehensive plan for development of the Arkansas River Basin, are flood con-

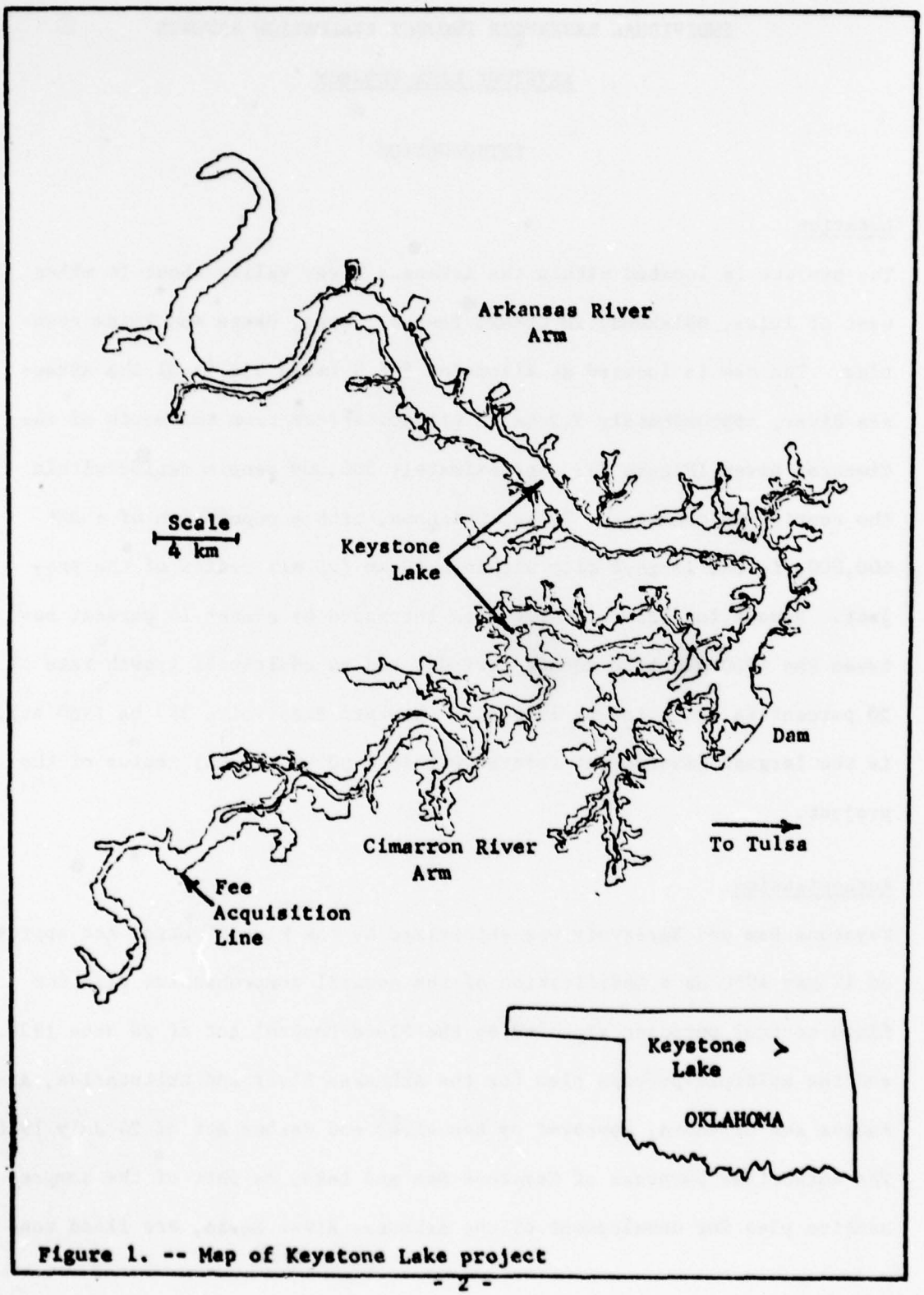


Figure 1. -- Map of Keystone Lake project

trol, water supply, hydroelectric power, and navigation.

Construction of Keystone Dam began in December 1956 and was completed for flood control operation in September 1964. Commercial operation of the powerplant began in May 1968.

The project is administered by the Tulsa District of the Southwest Division of the U.S. Army Corps of Engineers (CE).

Physical Features

The dam structure consists of an earthfill embankment, combining spillway and powerhouse, having a combined crest length of 1,402 m (4,600 ft). The average height of the embankment extends 33.5 m (110 ft) above the valley floor.

The outlet works consist of nine 1.7 by 3.05 m (5 ft 8 in by 10 ft) gated low-floor sluices passing through the concrete spillway at elevation 201 m (659.29 ft) msl. The powerhouse has two 35,000 kilowatt generators, their capacity ranging from 60,000 to 80,000 kilowatts depending on reservoir level. The midpoint of the power intake is located at elevation 204 m (669 ft) msl, approximately 19.5 m (64 ft) below the conservation pool level. The upstream watershed area is 192,954 km^2 (74,500 mi^2).

Under current operating regimes, the reservoir encompasses 10,530 surface ha (26,020 ac) at conservation pool elevation 220.4 m (723 ft) msl (Table 1). At the top of the flood control pool elevation 229.8 m (754 ft) msl (which corresponds to the predicted 5 year flood frequency level), the reservoir covers 22,338 ha (55,320 ac) and impounds $2.3 \times 10^9 m^3$ (1,879,000

Table 1 . -- Summary of physical characteristics of Keystone Lake

	Conservation pool	10 yr. minimum pool	2 yr. flood frequency pool	5 yr. flood frequency pool
Elevation				
m	220.4	218.8	225.7	229.8
ft	723	717.7	740.5	754
Surface area				
ha	10,530	8,791	16,206	22,338
ac	26,020	21,723	40,045	55,320
Storage volume				
m^3	$0.8 \times 10^9 m^3$	$0.6 \times 10^9 m^3$	$1.4 \times 10^9 m^3$	$2.3 \times 10^9 m^3$
ac. ft.	663,000	492,200	1,196,200	1,879,000
Max. depth				
m	22.5	20.6	27.6	31.7
ft	73	67.7	90.5	104
Shoreline length				
km	531			
mi	330			
Drainage area				
km^2	192,954			
mi^2	74,506			
Discharge elevation				
Sluice gate				
m	201			
ft	659			
Power intake*				
m	204			
ft	669			
Min. flow release range				
January				
m^3/sec.	113			
cfs	370			
July				
m^3/sec.	224			
cfs	735			

* Midpoint

ac ft) of water.

A sliding scale for minimum flow releases was designed to provide a minimum average daily flow ranging from 113 m^3/sec (370 cfs) in January to 224 m^3/sec (735 cfs) in July. These flows were normally expected to be provided by power releases, and occasionally supplemented by discharge from the sluice gates. Failure to incorporate this minimum release schedule is discussed in detail in this report. The maximum water discharge that can be accommodated without downstream flooding is 27,432 m^3/sec (90,000 cfs).

Project lands total 29,906 ha (73,896 ac), including 19,995 ha (49,308 ac) purchased in fee up to the five-year flood pool elevation plus 9,950 ha (24,587 ac) of additional flowage easements located between elevation 229.8 m (754 ft) and 231.3 m (759 ft) msl. Approximately 6,718 ha (16,599 ac) of the land purchased in fee is located in Creek County, 5,174 ha (12,785 ac) in Osage County, 2,078 ha (5,135 ac) in Tulsa County, 5,971 ha (14,753 ac) in Pawnee County, and 15 ha (36 ac) in Payne County. Flooding easement lands included 1,672 ha (4,121 ac) in Creek County, 2,527 ha (6,237 ac) in Pawnee County, 1,891 ha (4,663 ac) in Osage County, 955 ha (2,359 ac) in Tulsa County, and 2,905 ha (7,207 ac) in Payne County (Table 2).

Area Description

The two major arms of the lake (Arkansas and Cimarron River arms) extending from the dam form a rough "V" configuration. Project land acquisitions consist primarily of rather narrow bands of land surrounding each

Table 2 . -- Keystone Lake project -- summary of land acquired by fee and flooding easement in Creek, Pawnee, Osage, Tulsa and Payne Counties

County	Fee			Flood easement			Total		
	Area		%	Area		%	Area		%
	Ha	Ac		Ha	Ac		Ha	Ac	
Creek	6,725	16,599	33.7	1,672	4,121	16.8	8,397	20,720	28.0
Pawnee	5,967	14,753	29.9	2,527	6,237	25.4	8,494	20,990	28.4
Osage	5,168	12,785	25.9	1,891	4,663	19.0	7,059	17,448	23.6
Tulsa	2,075	5,135	10.4	955	2,359	9.6	3,030	7,494	10.2
Payne	20	36	.07	2,905	7,207	29.2	2,925	7,243	9.8
Total	19,955	49,308		9,950	24,587		29,905	73,895	

arm of the lake, collectively amounting to approximately 12,697 ha (31,373 ac) at conservation pool elevation (Table 3). Flowage easements have been acquired for an additional 9,950 ha (24,587 ac). Including an estimated 3,272 ha (8,085 ac) of aquatic habitat in the Arkansas and Cimarron Rivers and tributaries which were impounded, the total project area covers approximately 33,153 ha (81,980 ac).

Topography in the immediate project area varies from steep, broken hills bordering the Arkansas River arm to gently rolling hills along the Cimarron River arm. The valleys vary from one-half to one and one-half miles wide, having slopes of about one meter per kilometer (five feet per mile). Elevation varies from approximately 335 m (1,100 ft) msl at the western edge of the area to 220 m (723 ft) msl at the eastern edge (2).

Annual precipitation averages around 94 cm (37 in), about 60 percent occurring between March 1 and September 1. April, May, and June have the highest rainfall. The growing season is approximately 219 days. The majority of the soils are shallow and well drained [15 cm to 1.5 m (6 in to 5 ft)], underlain with sandstone bedrock.

The entire project area has been severely overgrazed in past years and no extensive areas of virgin vegetation remain. Upland vegetation is primarily a mixture of post oak-blackjack woodlands and grasslands. Common trees are post oak, blackjack oak, eastern red cedar, black hickory, and elm. Shrubs include plum, sumac, and buckbrush. Common grassland species include three-awn grass, silver beardgrass, and common ragweed. There are lesser amounts of big bluestem, little bluestem, Indiangrass, and buffalo-

Table 3 . -- Keystone Lake project -- pertinent land acquisition-lake surface area relationships. Total project area, 33,153 ha (81,980 ac), comprises an estimated 3,272 ha (8,085 ac) included in the Arkansas and Cimmaron Rivers and tributaries plus an additional 19,955 ha (49,308 ac) of land acquired in fee and 9,950 ha (24,587 ac) of flooding easements

	Conservation pool		2 yr. frequency flood pool		5 yr. frequency flood pool	
	Area	% land remaining	Area	% land remaining	Area	% land remaining
Area impounded						
Ha	10,530		16,206		22,388	
Ac	26,020		40,045		55,320	
Land remaining						
Fee						
Ha	12,697		7,021		0	
Ac	31,373	63.6	17,348	35.2	2,073	4.2
Land-water ratio	1.21		0.43		0.08	
Easement						
Ha	9,950		9,950		9,950	
Ac	24,587	100	24,587	100	24,587	100
Land-water ratio	0.94		0.61		0.44	
Total						
Ha	22,647		16,967		10,789	
Ac	55,960	76.9	41,926	51.2	26,660	32.5
Land-water ratio	2.15		1.05		0.48	

grass.

Timber has been cleared on all bottomlands and terraces except along fence rows, small tributary stream channels, and the extreme upstream reaches of the lake on the Arkansas and Cimarron River arms. Trees include cottonwood, willow, hackberry, pecan, elm, and ash. Plum, buckbrush, and wild grapes are the most abundant shrubs in the bottomlands. Grasses and weeds are dominated by bermuda grass, Johnson grass, pigweed, and common ragweed. Lesser amounts of big bluestem, little bluestem, and Indiangrass are also present. Crops grown in the area include corn, milo, soybeans, and hay.

Acquisition of Descriptive Data

Numerous sources were visited to acquire the fish and wildlife data available for the project impact area. Planning information, including formal reports and correspondence, were obtained from local offices of the two federal agencies involved with the project. U.S. Army Corps of Engineers (CE) reports were reviewed and pertinent sections obtained at the District Engineer's Offices in Tulsa, Oklahoma. Discussions with CE planning, operations, real estate, and hydrology staff contributed to the project record files from which much of the reported data were gleaned. CE personnel located at Keystone Lake also contributed to the project record. U.S. Fish and wildlife Service (FWS) reports were obtained at their Tulsa, Oklahoma, offices.

Additional data, reflecting post-impoundment conditions of project lands, fish and wildlife communities and their utilization, were obtained from of-

fices of the Oklahoma Department of Wildlife Conservation (ODWC) both at their headquarter offices in Tulsa, Oklahoma, and from local management staff. Stream gauge data were obtained from the U.S. Geological Survey (USGS) office in Oklahoma City.

WILDLIFE RESULTS AND DISCUSSION

General Discussion

The major wildlife-related planning instrument supplied to the construction agency by the conservation agencies was the December 19, 1961, report of the FWS (3). This report was released by the Albuquerque Regional Office of the FWS and was prepared in cooperation with the Oklahoma Department of Wildlife Conservation (ODWC).

The project engineering data supplied to the FWS by the CE outlined a multi-purpose project (primarily flood control and hydropower) located at mile 538.8 on the Arkansas River above Tulsa, Oklahoma. Pool elevations and acreages considered by the FWS in their 1961 report were essentially those provided by the project, i.e., a 10,644 ha (26,300 ac) normal (power) pool at elevation 220.4 m (723 ft) msl and a 22,420 ha (55,400 ac) flood pool at elevation 229.8 m (754 ft) msl.

Wildlife Resources -- Pre-impoundment Predictions

The 14-page 1961 report of the FWS included six brief paragraphs that described wildlife resource utilization estimates of the proposed Keystone building site. That discussion was as follows (verbatim):

> Keystone Dam and Reservoir will affect wildlife resources on about 55,400 acres of habitat within the project area, and to a minor extent, on about 29,400 acres in the flood plain of the Arkansas River, extending 80 miles downstream from the damsite to the confluence with the Grand River. The reservoir site lies in the post oak-blackjack oak vegetative association. Many cultivated fields are scattered along the river bottom. On the flood plain downstream from the dam, timbered areas are interspersed among extensive cultivated areas.
>
> The project area provides habitat for several important species of wildlife common along the Arkansas and Cimarron Rivers. A

mixture of cultivated land, pasture, timber and hay meadows provides good habitat in the bottom lands, but the uplands are badly eroded and overgrazed.

The white-tailed deer is the only big-game animal found on the area. Upland-game of importance includes bobwhites, fox squirrels, gray squirrels, cottontails, swamp rabbits, mourning doves, raccoons, and opossums. Waterfowl, including ducks, geese, and coots, make use of the Arkansas and Cimarron Rivers during migrations.

Wildlife resources of the project area are insufficient to meet the needs for hunters from Tulsa, Sapulpa, Muskogee, and other communities within 60 miles of the project area. Waterfowl hunting is heavy as evidenced by the fact that almost every suitable spot on the Arkansas River below Tulsa contains a blind during the waterfowl season.

Projected over the period of analysis without the project, the 55,400 acres of wildlife habitat significantly affected by the project would provide about 130 man-days of deer hunting, 6,400 man-days of upland-game hunting, and 2,800 man-days of waterfowl hunting annually.

The project area provides habitat for beavers, muskrats, minks, raccoons, skunks, opossums, badgers, foxes, and coyotes, but low pelt prices result in little trapping effort. The average annual catch is insignificant, and would be expected to remain a minor value without the project.

The terrestrial wildlife resources of the project site were expected to support an average (over period of analysis) of 6,530 hunter-days annually. Waterfowl hunting, as indicated above, was expected to average 2,800 hunter-days annually. The 22,420 ha (55,400 ac) area encompassing the planned five-year flood storage pool constituted the with-project and without-project planning area considered by the FWS. Contrary to statements contained in the 1961 report of the FWS, this large tract of land was not comprised entirely of terrestrial habitat. This area included a considerable amount of aquatic habitat within the Arkansas River and Cimarron River channels which would have greatly reduced habitat value for terrestrial

species. Both river channels are wide and frequently contain extensive dry flats and bars. These areas do provide grit for game birds and often produce good stands of annual plants valuable as wildlife food. Their value is probably below other areas due to extensive bare spots and flooding, however.

A corrected estimate of what is normally considered big game-upland game habitat, therefore, necessitate elimination of the river and stream channel areas from the 22,420 ha (55,400 ac) total project area figure. The following data contained in the FWS report of 1961 acknowledged these areas and provided data which allowed the necessary computations to be made, viz:

> Within the reservoir area, the Arkansas River channel varies from 600 to 2,500 feet in width with banks from 10 to 20 feet high. The channel in this reach is obstructed at some places by rock ledges, and in other locations the flow is divided by large heavily wooded islands.
>
> * * *
>
> The channel of the Cimarron River varies from less than 1,000 to about 1,500 feet in width.
>
> * * *
>
> Keystone Dam will decrease flood flows, regulate the normal flow of the stream, and at the top of the flood control pool, create an impoundment covering about 45 miles of the Arkansas River, 54 miles of the Cimarron River, and 22 miles of minor tributaries. Sixty-six miles of stream will be permanently inundated at conservation pool, and 77 miles at top of power pool.

Rather than relying upon the range of channel widths presented by the FWS, actual measurements of the pre-construction Arkansas and Cimarron River channels were taken from plates contained in the CE's fish and wildlife

management plan (4). These average stream channel width measurements were: 283 m (930 ft) for the Arkansas River, and 134 m (440 ft) for the Cimarron River. An estimated (unmeasured) 15 m (50 ft) average width was assumed for the 35 km (22 mi) of tributaries. Using these measurements, the pre-project area of stream bed habitat within the flood pool zone [22,420 ha (55,400 ac)] was estimated at 3,272 ha (8,085 ac). These calculations were as follows, viz:

> Stream bed area in project area (pre-project) = [930 ft x 45 mi (Arkansas River) x .1212] + [440 ft x 54 mi (Cimarron River) x .1212] + [50 ft x 22 mi (tributary streams) x .1212] = 3,272 ha (8,085 ac).

Sixty-four percent of the inundated stream mileage was within the power pool (77 out of 121 total mi); it is likely that approximately 64 percent of the area also was so located. Sixty-four percent of the total estimated river channel habitat of 3,272 ha (8,085 ac) approximates 2,104 ha (5,200 ac). Therefore, prior to project construction, the 22,420 ha (55,400 ac) anticipated flood pool included an estimated 19,148 ha (47,315 ac) of terrestrial wildlife habitat including 8,539 ha (21,100 ac) within the permanent pool basin (Table 4).

The published without-project hunting effort (1961 FWS report), converted to per unit area of terrestrial habitat (using the corrected figure), would have approximated 3.0 ha (7.4 ac) per upland game hunting trip (hunter-day) and one big-game hunting trip per 147 ha (364 ac).

These estimated unit-area hunting values are rather low, particularly for an area such as the Keystone project located near a large urban center, as described by the FWS in their 1961 report, viz:

Table 4 . -- Land and water areas within the 22,420 ha (55,400 ac) Keystone project direct impact area considered by the FWS in their 1961 fish and wildlife planning report

Conditions	Land area						Water area					
	Power pool		Flood pool		Total		Power pool		Flood pool		Total	
	Ha	Ac	Ha	Ac	Ha	Ac	Ha	Ac	Ha	Ac	Ha	Ac
Without project	8,539	21,100	10,609	26,215	19,148	47,315	2,104	5,200	1,168	2,885	3,272	8,085
With project	0	0	10,609	26,215	10,609	26,215	10,644	26,300	1,168	2,885	11,811	29,185

> The reservoir is in an area of the State which, although predominantly rural, also contains many industrial centers. Larger cities near the project include Tulsa, Stillwater, Bartesville, Muskogee, and Okmulgee. Smaller communities in the vicinity of the reservoir are Sand Springs, Sapulpa, Cleveland, Pawhuska, Oilton, Mannford, Drumright, and Pawnee. The population within a day-use range of the project is more than 540,000 persons.

As previously described, in spite of an exhaustive search for the important historical records, no support data were located that revealed the techniques employed by the pre-construction fish and wildlife planners to quantify hunting effort.

Adverse impacts to terrestrial wildlife communities were expected to occur in three distinct zones following construction of the Keystone project. These zones were the area of permanent inundation, the five-year flood frequency pool, and the downstream bottomlands protected against flooding by the project. Without additional land acquisition specifically for wildlife mitigation, recreational hunting opportunities supported by upland game animals were expected to be reduced by 67 percent, while big game hunting within the project site was expected to be totally destroyed by the Keystone project. These projections, as described by the FWS in their 1961 report to the CE, are presented below, viz:

> Initially, Keystone reservoir will permanently inundate 18,950 acres of wildlife habitat and will inundate an additional 27,850 acres once every five years. Under the ultimate plan, 26,300 acres will be permanently inundated. Loss of habitat for terrestrial wildlife in the permanently flooded area will be complete. Habitat within the flood control pool will become less suitable for wildlife because of periodic flooding.
>
> Flood protection can be expected to encourage conversion to farm crops, additional clearing of timber, and more intensive cultivation on downstream bottom lands. There, however, will be no significant effect on wildlife populations or hunting in the downstream area with the project. The bottomland habitat

will withstand these changes without damage to wildlife populations.

Keystone Reservoir will be in a strategic location to attract waterfowl. Although some aquatic food plants will become established and any slight rise in the water level will create feeding areas during the fall migration, adjacent agricultural lands will provide the most important feeding areas. The reservoir will make possible additional hunting in an area where the need is great. Additional waterfowl will use the Arkansas River downstream from the damsite, primarily as a result of the increased food supply resulting from increased production of row crops. Waterfowl hunting in the downstream area, however, will not increase because available hunting spots already are used fully.

Inundation of wildlife habitat will eliminate big-game hunting within the reservoir area. Upland-game hunting will amount to about 2,100 man-days annually, a significant loss attributable to the project. Waterfowl hunting, on the other hand, will increase to about 9,800 man-days annually.

The reservoir will eliminate 20,500 acres of terrestrial habitat for fur animals, and the shoreline will provide habitat inferior to that of the rivers. The average annual fur harvest will continue to be insignificant.

Benefits to hunting attributable to the project will average $19,000 annually.

The next to last paragraph quoted above indicates that 2,347 ha (5,800 ac) of stream and river habitat (non-terrestrial) were located within the permanently inundated zone prior to project construction. This figure was obtained by subtracting the 9,296 ha (20,500 ac) of inundated terrestrial habitat figure from the total power pool area of 10,644 ha (26,300 ac). This result lends support to the non-terrestrial habitat estimate calculated earlier.

The method used by the FWS to attribute a $19,000 value to the predicted wildlife-associated annual benefit, is not clear. After project completion, an additional 2,570 hunter-days were expected over without-project

conditions. The pre-impoundment and post-impoundment hunting effort data are presented in Table 5. The average value for this additional hunting of $7.40 per hunter-day ($19,000 ÷ 2,570) exceeds the highest allowable daily value contained in the schedule of hunting values which were in use by the planning agencies at the time (5). These monetary values are presented in Table 6.

It is possible that the term "benefit" as used by the FWS, was considered to include all of the projected post-construction hunting use without considering the pre-project use. If this were the case, the $19,000 annual value for the 11,900 hunter-day figure would have been computed by multiplying the hunting day use estimates by daily values for waterfowl hunting and upland-game hunting selected from the list of values shown in Table 6. For example, waterfowl hunting may have been assigned a daily value of $1.75 and upland-game hunting assigned a daily value of $1.00. This would have provided a monetary figure of $19,250, which may have been rounded to the $19,000 figure. Rounding monetary values to the nearest $1,000 was a common practice. Another possibility could be reflected in Table 7 where the range of possible total monetary values (lowest possible to highest possible) are illustrated. The highest possible value figures from Table 6 applied to the with and without project hunting effort figures give a pre-construction total value of $27,585 and a post-construction value of $48,825. The difference ($21,240) is close to the $19,000 figure actually used.

Losses of hunting opportunity for big-game (white-tailed deer) and upland-

Table 5 . -- Predicted hunter use of Keystone project site [22,420 ha (55,400 ac)] without-project and with-project as presented to the CE in 1961 by the FWS

Target animal group	Number of annual hunting trips (man-days) supported			
	Without Keystone project	With Keystone project	Net change	
			Number	Percent
Big-game	130	0	- 130	-100
Upland-game	6,400	2,100	-4,300	- 67
Waterfowl	2,800	9,800	+7,000	+250
Totals	9,330	11,900	+2,570	+ 28

Table 6 . -- Interim schedule of values per recreational day of hunting as recommended by the Subcommittee on Evaluation Standards (Inter-agency Committee on Water Resources), May 24, 1960

Target group	Range of values per hunting day
Small game	
Mammals	$ .50 to 1.50
Birds	$1.00 to 3.00
Waterfowl	$1.50 to 4.50
Big game	
Deer and antelope	$1.50 to 4.50
Other	$2.00 to 6.00

Table 7 . -- Possible range of monetary wildlife-associated values attributed to hunting effort for pre-construction and post-construction periods at the Keystone Lake project in Oklahoma

Animal group	Pre-construction estimates		Post-construction estimates	
	Low values	High values	Low values	High values
Deer	$ 195	$ 585	$ 0	$ 0
Upland	4,800	14,400	1,575	4,725
Waterfowl	4,200	12,600	14,700	44,100
Totals	$9,195	$27,585	$16,275	$48,825

game were expected as a consequence of construction of the Keystone project. This projected loss prompted the conservation agencies to recommend that certain remedial actions be taken by the construction agency. Simply stated, the steps considered necessary by the conservation agencies to avoid hunting losses for terrestrial game were to acquire in fee and fence 3,701 ha (9,145 ac) of additional lands outside the boundaries of the CE's planned project.

This discussion from the 1961 report of the FWS is presented in the following section, viz:

> Keystone Project will destroy or impair big-game and upland-game habitat on 55,400 acres of lands within the reservoir area with a subsequent significant loss of hunting. It is possible to mitigate these losses, in part, through the acquisition and management of suitable lands. The Oklahoma Department of Wildlife Conservation has indicated that they desire replacement habitat with a total area of approximately 16,250 acres for development and management. This proposed area is located as shown on Plate 1.
>
> Of this area, about 7,105 acres are scheduled for acquisition for primary project purposes; about 635 acres are planned for flowage easement purchase by the Corps of Engineers, and approximately 8,510 acres are located outside of the guide contour for easement acquisition.
>
> It is estimated that the cost of purchasing in fee the 635 acres on which flowage easements only would otherwise have been acquired and the 8,510 acres outside of the easement area would amount to $1,350,000. This cost includes administrative and contingency costs of land acquisition but does not include cost of acquisition of minerals. For proper management of habitat, the area should be fenced to control grazing and public use. About 30 miles of perimeter fencing will be required for the proposed management area. It is estimated that this fencing will cost about $30,000. Costs of land acquisition and fencing should be a project expense. Annual operation and maintenance costs would be borne by the Oklahoma Department of Wildlife Conservation. It should be noted that this proposal allows only for mitigation of project-caused wildlife losses and that there would be no significant enhancement benefits.

Following acquisition and fencing, the lands proposed for wildlife management should be made available to the Oklahoma Department of Wildlife Conservation under the terms of a General Plan as provided in Section 3 of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

Free public hunting and fishing in the reservoir area could be assured during project construction and operation if the boundaries of federally purchased lands were delineated and conspicuously marked immediately upon purchase.

The 1961 report of the FWS concluded by listing five specific recommendations. Three recommendations were concerned with mitigation of anticipated adverse impacts on the big-game and upland-game communities. These recommendations addressed reservoir zoning, acquisition of additional lands, and marking of project boundaries. Following receipt of the 1961 FWS report, the CE evaluated each of the three wildlife-associated recommendations, accepted one, and rejected two. A summary of the FWS recommendations and CE responses were presented in a supplement to the CE's General Design Memorandum which was released by the CE in 1963 (6). This material is presented below:

Recommendation No. 3. - That appropriate consideration be given to the development of a reservoir zoning plan in connection with overall planning for Keystone Reservoir to insure that certain areas will be available for fishing and other wildlife purposes without conflicting use for general recreation. It is further recommended that the parties involved in developing a reservoir zoning plan include the agency expected to administer the reservoir and the Oklahoma Department of Wildlife Conservation.

(1) Comments. - This recommendation is concurred in. The Corps of Engineers is charged with the responsibility for assuring full use of the reservoir by the public and it is proposed that appropriate consideration will be given to zoning of the reservoir to avoid conflicting use by the sport fishermen, hunters, and other users. Any zoning plan or study undertaken will be coordinated with all agencies having a responsibility or interest in the problem.

Recommendation No. 4. - That approximately 9,145 acres of land be purchased in fee exclusive of minerals and fenced as an integral part of the project, and that said land together with other project land, as shown on plate 1, be made available to the Oklahoma Department of Wildlife Conservation in accordance with the terms of a General Plan as provided in section 3 of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

(1) Comments. - The proposed wildlife management area is located on the Cimarron arm of the reservoir. The total acreage of the proposed wildlife management area as estimated by the Service is approximately 16,250 acres of which about 7,105 acres would be acquired for the project. The Service estimates that about 8,510 acres of additional fee lands outside the project area and about 635 acres of land in fee in lieu of easement would be required for the management area. The appraisals on lands required for the project are completed in this area and the majority of the lands for the project have been acquired. Acquisition of mineral interests on this land has also been initiated. The conversion of flowage easement areas to fee purchase and the purchase of any additional lands in fee in this area will result in dual acquisition in almost every case where land is required from an owner who was affected by the Keystone Reservoir. The Service recommends this additional land acquisition to compensate for losses in wildlife habitat. The Service report shows a loss of wildlife habitat on the 26,300 acres that will be permanently inundated, resulting in a net loss of 4,430 man-days of hunting for deer and upland game. The report does not evaluate the wildlife losses nor does it furnish complete cost data for the wildlife management area. In the absence of complete data, the Corps of Engineers has prepared an analysis of the costs in connection with the acquisition of lands and development of the proposed wildlife management area. In this analysis, all available figures from the Service report were utilized, supplemented by other data supplied by the Corps of Engineers. It is considered that the construction of fences and other developments should be a non-Federal cost and should be borne by the State agency as part of their program. The cost analysis for the proposed wildlife management area is tabulated below.

The anticipated first costs and annual operating expenses for the mitigation lands, as presented by the CE, are shown in Table 8. The estimated monetary benefits of this action, again as computed by the CE, are presented in Table 9.

Table 8 . -- Wildlife management area summary of costs and annual charges, as computed by CE

Item	Costs and charges		
	Federal	Non-Federal (Public)	Total
First cost			
Lands (exclusive of other project lands to be utilized in management area	$1,350,000	-	$1,350,000
Development	-	$30,000	30,000
Subtotal - First cost	1,350,000	30,000	1,380,000
Construction period, years	2	2	2
Interest rate, percent	2.5	3.0	-
Interest during construction	34,000	1,000	35,000
Investment	1,384,000	31,000	1,415,000
Annual charges			
Interest	34,600	900	35,500
Amortization (100-year period)	3,200	100	3,300
Operation and maintenance*	-	10,000	10,000
Major replacements	-	-	-
Total - Annual charges	37,800	11,000	48,800

* Estimated by Corps of Engineers. (Annual O&M figures not available in Fish and Wildlife Report)

Table 9 . -- Wildlife management area summary of annual benefits as computed by CE

Item	Man-days	Value*
Mitigation of net losses		
Upland game	4,300	$6,450
Deer	130	195
Subtotal	4,430	6,645
Enhancement of waterfowl	0	0
Total	4,430	6,645

* Based on unit values for hunting as currently used by the Corps of Engineers ($1.50 per man-day)

The CE summarized these anticipated costs and benefits and their conclusion with regard to recommendation No. 4 for mitigation lands as follows, viz:

> Based on annual benefits of $6,645 and annual costs of $48,800, the benefit-cost ratio for the proposed wildlife management areas is 0.1. In consideration of this study and after thorough consideration of the possible intangible benefits that might accrue, the Corps of Engineers considers the proposal for acquisition of additional lands in fee and development of the wildlife management areas would not be warranted. However, any project lands that may be requested by the Oklahoma Department of Wildlife Conservation will be considered for license to that agency for wildlife management. In this connection, consideration is being given in the master plan for reservoir development, Design Memorandum No. 12B, for zoning approximately 15,750 acres of project lands and waters for this purpose. This includes a large acreage of project lands on the Arkansas River arm as well as a substantial acreage of the Cimarron arm.

The final FWS recommendation for wildlife mitigation was evaluated by the CE as follows, viz:

> Recommendation No. 5. - That project lands acquired by the Federal Government be clearly marked following acquisition so as to delineate the area open to hunting and fishing and other public uses.
>
> (1) Comments. - It is considered impractical to survey and mark the entire project boundary. However, the marking of the approximate boundary lines at access points and at other points where known, would be worthwhile in order to delineate public lands from adjacent private lands. This recommendation will be considered after construction has been completed and all project lands have been purchased.

Wildlife Resources -- Post-impoundment Occurrences

The FWS report of December 19, 1961, originally recommended, on advice of the ODWC, the development of a 6,576 ha (16,250 ac) wildlife management area to be wholly located on the Cimarron River arm of the reservoir. This tract, to be managed by the ODWC, would include 2,875 ha (7,105 ac) sched-

uled to be purchased for primary project purposes and approximately 3,701 ha (9,145 ac) of additional land outside of the CE guide contour for fee land acquisition. However, after consideration by the CE, this recommendation was essentially shelved because of an unfavorable benefit-cost ratio of 0.1, as computed by the CE. In a counter offer, the CE proposed [supplement No. 1 to Design Memorandum No. 4 dated April 2, 1963 (6)] that approximately 6,374 ha (15,750 ac) of project lands and waters located on both the Cimarron and Arkansas River arms be zoned for wildlife management purposes for subsequent lease to the ODWC.

Although an exhaustive search of pertinent ODWC, FWS, and CE data repositories was undertaken, no further reference to the proposal was uncovered until the ODWC requested a license for project lands zoned for wildlife in a letter dated January 1, 1971 (7). In response, the CE forwarded a copy of a proposed General Plan agreement on August 23, 1972, along with a zoning map showing the proposed project wildlife management areas, to the ODWC Director and to the Regional Director of the FWS in Albuquerque, New Mexico (8). After review of the proposed General Plan agreement, the ODWC signed the agreement on October 23, 1972 (9); the FWS signed the agreement on October 27, 1972 (10).

However, a formal lease agreement between the CE and the ODWC was not executed until late January, 1974, about 9 years following impoundment in 1965, and more than 13 years after submission of the December 19, 1961, FWS letter report.

The lease provided for ODWC management of big game and upland game on 4,

970 ha (12,280 ac) of land. This ODWC leased land consisted of two separate areas bordering the upper reaches of the Cimarron River and Arkansas River arms of the lake, respectively. An additional 1,303 ha (3,220 ac) of the lake were included within the two leased tracts to facilitate waterfowl management by the ODWC.

Wildlife Habitat Resources Evaluation and Management

Approximately 12,697 ha (31,373 ac), well over half (63.6 percent) of project lands purchased in fee, are located above normal lake conservation pool elevation 220.4 m (723 ft) msl. A minimum of 6,274 ha (15,504 ac) of these lands are currently managed for wildlife and are open to public hunting, including the 4,970 ha (12,280 ac) of land managed by the ODWC under license from the CE. The remaining 1,305 ha (3,224 ac) are managed directly by the CE. Although closed to public hunting, 1,200 ha (3,000 ac) of outlying sections of property, leased by the CE to state and municiple agencies as recreational and park areas, also provide incidental (but substantial) wildlife habitat benefits. Two islands totaling 16.1 ha (40 ac) have been designated by the CE as wildlife refuges.

Wildlife lands managed by the CE have been divided into 10 widely scattered units ranging in size from 40 to 324 ha (100 to 800 ac). Wildlife management plans have been completed for each of the ten CE management areas and included in Appendix D (Fish and Wildlife Plan). However, field implementation of the plans has begun only recently. Cattle grazing is still permitted on the CE game management areas under terms of previously negotiated grazing leases. In all, some 168 outstanding grazing leases are

still in effect on a total of 5,018 ha (12,398 ac) of project lands administered by the CE (1). The average size of the individual lease is 15.3 ha (73.8 ac), ranging from 3.0 to 346 ha (7.5 to 855 ac). Over 50 percent of the individual grazing leases are less than 40.5 ha (100 ac) in size.

Operation of the project for flood control and electrical power generation (particularly) has caused the conservation pool level to fluctuate more than anticipated. Although the lake level was originally predicted to drop below elevation 219 m (717.7 ft) msl only once in 10 years, the lake level has dropped below this elevation every year but one (1968) since impoundment. The average annual duration was 76 days and ranged from a minimum of 12 days in 1971 to a maximum of 144 days in 1970. However, the two-year frequency flood pool, elevation 225.7 m (740.5 ft) msl, has been reached in only two years (78 days in 1973 and 28 days in 1974) over the 14-year period of record (1965-1978). The five-year flood pool, elevation 229.8 m (754 ft) msl, has been exceeded in only one year (two days in November, 1974).

Initially, wildlife habitat values on all project lands were severely depressed as a result of intensive and long-term livestock grazing and cropland conversion practices followed by previous land owners. As a consequence, wildlife populations were severely depleted at the time of acquisition by the CE. Huntable game populations were nil over much of the newly acquired land.

Wildlife habitat values of project lands improved only slightly during the

years immediately following acquisition by the CE. Land management practices exhibited little change over previous years of private ownership (2). In fact, conversion of cropland to pastureland increased and existing grazing leases were continued, for the most part. Project benefits to wildlife resources were limited to providing increased opportunities for public hunting as a result of public ownership, as the area was virtually closed to public access while under private ownership. Wildlife management by the CE and ODWC was minimal during this period and was restricted primarily to acceleration of wildlife law enforcement patrols by the ODWC and to implementation of an extremely modest wildlife food plot planting program by the CE. Hunter access was provided by recreational area roads, severed roads, abandoned outfield roads, and farm-to-market roads (4).

No substantial effort was made by the ODWC to improve wildlife habitat until after the lease agreement between the ODWC and the CE was finally executed on January 1, 1974.

Subsequently, in May of 1974, the ODWC developed a long-range wildlife management prospectus for the leased property (2). Principal emphasis was placed on the immediate improvement of wildlife habitat for upland and big game species.

The program was expected to provide ultimately for a minimum of 10,000 man-days of hunting per year, including 7,000 man-days for upland game species (principally quail, rabbits, squirrels), 1,000 man-days for big game species (white-tailed deer and Rio Grande turkeys), and 2,000 man-

days for migratory bird species. Major components of the ODWC management plan involved the elimination of outstanding grazing leases, boundary signing and fencing, vegetation succession control, and wildlife food and cover augmentation.

Considerable wildlife habitat improvement has been accomplished since initiation of the program in July, 1974. Individual grazing leases on all ODWC leased properties were rescinded immediately after the lease with the CE was executed.

Other accomplishments of the ODWC wildlife management program (1974-1978) are shown in Table 10. Appropriate areas of the leased property, 77.2 km (48 mi), have been fenced and signed to prevent livestock incursion and to delineate public hunting access. The boundary was previously surveyed and monumented by the CE.

Some 42,600 trees and shrubs were planted by ODWC personnel to augment food and cover for wildlife species. Shelterbelt type plantings of three to four rows of trees were utilized to break up large open fields and provide more cover and edge effect. The plantings included red cedar, mulberry, blockbrush, loblolly pine, walnut, multiflora rose, plum, autumn olive, and bald cypress.

Sharecrop cooperators were utilized to plant an average of 903 ha (2,231 ac) per year of small grains (corn, maize, wheat, millet, and sunflower) and alfalfa. Approximately 40 percent of the total crop was unharvested in both 1974-1975 and 1975-1976 and 30 percent of the crop was left in the

Table 10. -- Keystone Lake project -- Summary of wildlife management activities undertaken by ODWC on the 4,970 ha (12,280 ac) tracts leased from the CE, July 1, 1974-June 30, 1978

Year (July 1-June 30)	Fencing	Vegetation control	Planting				
			ODWC project personnel		Sharecrop cooperators		
	No. miles	No. ac. treated	Trees and shubs (no)	Herbaceous (ac)	No. ac.	No. ac. harv.	No. ac. remaining
1974-75	14.3	30	3,600	0	1,355	813	542
1975-76	6.4	0	0	0	3,023	1,814	1,209
1976-77	12.9	20	16,000	300	1,945	1,362	583
1977-78	13.2	80	23,000	12	2,177	1,524	653
Total	46.8	130	42,600	312	8,500	5,513	2,987

fields in both 1976-1977 and 1977-1978. An additional 126 ha (312 ac) of herbaceous plantings (primarily millet) were made by ODWC personnel.

Approximately 52.6 ha (130 ac) of abandoned grasslands and fields were disked by project personnel to improve food and nesting conditions.

Waterfowl management was relegated to a secondary priority during this first five-year habitat improvement phase. Sporadic attempts were made to plant millet on exposed mud flats, for the most part unsuccessful. Premature inundation by water-level fluctuation and/or dry weather following planting were responsible for failure of the plantings. However, the ODWC is planning to construct and operate several small subimpoundments [a total of 16 ha (40 ac)] in the near future to augment waterfowl food production.

Wildlife Community Studies

Resident wildlife communities have responded positively and steadily to the game management programs previously described. Although comprehensive sampling programs to document wildlife population changes have not yet been instituted at the Keystone project, limited indices of wildlife community structure and density are available from various state ODWC reports.

The populations of both big-game species, white-tailed deer and turkey, have expanded on project lands. Turkeys have been stocked at least once on project lands. Estimated big-game densities on the 4,970 ha (12,280 ac) of licensed ODWC lands were estimated in 1977 at 150 to 200 deer and approximately 160 turkeys (11). Post-season observations in 1978 indicated

presence of 218 turkeys, an increase of 58 birds over 1977 levels. The number of deer present on the total project area is estimated by ODWC personnel to include as many as 300 to 400 head (Joe Hardridge, pers. comm., 1979).

Quail were stocked, some 400 in number, on the management area during the 1976-1977 study segment and approximately 220 ringneck pheasants were released on the area during the 1977-1978 study segment. Recent ODWC reports for 1976 (11) and 1977 (12) document the rapidly expanding quail population on project lands, viz:

> Observation of quail indicate a 50 percent increase in the area population over 1975.
>
> * * * * * *
>
> Quail census work indicated an increase in the population of 60 percent over that of 1976.
>
> * * * * * *
>
> Twenty-four hunters were checked the first day of quail season. Birds taken averaged 2.25 per hunter. Wings were collected and aged revealing 84.6% of birds taken were birds of the year.

Pheasants were recorded during spring crow census and pheasant tracks were reported in the snow during the winter of 1978. No hunting for pheasants is yet permitted at the project. In fact, the narrow dimensions of publicly owned Keystone project lands are considered potential limitations to the future expansion of the pheasant population in the project area. Successful education of the owners of lands contiguous to the Keystone fee boundary to stimulate their interest in wildlife and increase their awareness of the habitat requirements of wildlife, including pheasants, would prove highly beneficial to the future of pheasants in the area (Joe Hard-

ridge, pers. comm., 1979).

No quantitative information is available relating to other upland game species on Keystone project lands except to note that quail significantly outnumber both squirrels and rabbits. Use of the project by doves is currently quite restricted. This apparently results from limited food supplies for the migratory flocks of doves.

Post-impoundment abundance of furbearers, including raccoons, minks, muskrats, and beavers (particularly), is believed to exceed their pre-impoundment abundances; however, no data are available for these resources (Joe Hardridge, pers. comm., 1978). Perhaps 10 trappers work the Keystone project, with particular effort placed on the long-haired furbearers.

Aerial counts of migratory waterfowl resting on Keystone Lake were obtained each month from October to January, beginning in 1965. This program continued intermittently over the next eight years. No observational flights were made in 1968, 1970, and 1971.

Beginning in 1973, continuing in all subsequent years, the aerial counts of waterfowl were confined to a single mid-winter flight (January). This reduction in aerial waterfowl counting on the Keystone project was a direct consequence of the low level of use being made of the project by waterfowl. Unfortunately, no similar data are available for pre-impoundment years. The count data described above (Table 11) were provided by ODWC staff (Lem Due, pers. comm., 1979). Few geese use the Keystone project, probably representing less than five percent of the total waterfowl use.

Table 11. -- Waterfowl count data available from ODWC for Keystone Lake project

Years	Monthly aerial counts			
	October	November	December	January
1965	150	1,061	450	601
1966	0	2,006	285	30
1967	581	568	0	207
1968	N.S.[1]	N.S.	N.S.	N.S.
1969	3,382	415	150	320
1970	N.S.	N.S.	N.S.	N.S.
1971	N.S.	N.S.	N.S.	N.S.
1972	600	N.S.	N.S.	4,230
1973	N.S.	N.S.	N.S.	N.S.
1974	N.S.	N.S.	N.S.	4,320
1975	N.S.	N.S.	N.S.	N.S.
1976	N.S.	N.S.	N.S.	1,332
1977	N.S.	N.S.	N.S.	680
1978	N.S.	N.S.	N.S.	N.S.
Averages[2]	943	1,013	221	1,465

1. N.S. -- No survey made

2. Average only of years for which counts made

Some nesting by wood ducks occurs along the perimeter of Keystone Lake. Yearly production, however, is slight, ranging up to 15 birds (Joe Hardridge, pers. comm., 1978). Nesting by other waterfowl species on the Keystone project is negligible.

Two non-game species of wildlife (one endangered) have stimulated special interest and concerns by their presence on Keystone project lands. Southern bald eagles have established a communal winter roost on Spring Creek. The roost site is on the Arkansas River arm of Keystone Lake approximately 6.5 km (4 mi) above the dam. Use of the Spring Creek area by eagles began in 1975 and the number of eagles attracted to the area has slowly increased in subsequent years. Data compiled by project personnel and private citizen groups indicate that 45 to 55 eagles are currently making use of this roosting area.

The CE has posted the affected roosting area to restrict human disturbance which could prove detrimental to the continued use of the area by eagles. Studies are continuing to determine the importance of the Spring Creek roost site to the welfare of the wintering bald eagles at Keystone Lake. Acquisition of additional lands by the CE to protect the site has been proposed by the Tulsa Audubon Society (13).

Great blue herons have established two large rookeries on the Cimarron River arm of Keystone Lake. The largest of these rookeries covers approximately 2 ha (5 ac) and is believed to contain up to 300 birds.

Hunting Effort and Harvest Estimates

The conservation agencies' predictions and their recommended mitigation

program for the Keystone-related impacts were described in terms of hunting use (hunter-days) of the project site. Impacts of project-related activities on wildlife habitat were poorly referenced in the pre-construction reports and no quantitative data were provided which related to wildlife communities.

The lack of quantitative wildlife data in the formal reports was exacerbated by the loss or destruction of the informal files of support data upon which the hunter-day projections may have been based. As a consequence of the limited nature of the available pre-construction information on wildlife and wildlife habitat, changes in hunting-use data constituted the solely available index with which to measure or reflect project-associated changes to wildlife communities and wildlife-dependent habitat.

Project-induced influences on terrestrial wildlife habitat and associated hunter-use at the Keystone Lake project can be separated into three separate impact areas or zones. The most significant area of impact is located between the top of the conservation pool and the top of the five-year flood frequency pool. Although subject to frequent inundation, this 12,697 ha (31,373 ac) land area provides the majority of public hunting on the Keystone project and receives the most intensive management for wildlife. The second zone consists of the surcharge water storage zone located above the five-year frequency pool [elevation 229.8 m (754 ft) msl], acquired in easement only. Such surcharge storage has occurred on only one occasion [to elevation 230.08 m (754.86 ft) msl] since project completion. This event occurred for a period of two days in November, 1974. Hunting effort

on these easement lands, which remain in private ownership and control, is currently unquantified but is believed to be considerably less intense (perhaps 75 percent less) than on the publicly-owned project lands (Bill Budnick, pers. comm., 1979). Finally, the Keystone project may have impacted wildlife communities located in the downstream section of the Arkansas River by altering the patterns and volumes of flood flow discharges. As no wildlife-associated data are available for the Arkansas River floodplain below Keystone, no impact analyses are possible for this area.

Data for hunter-use presented in this evaluation reflect only those activities on lands acquired in fee. The fee lands above conservation pool includes 12,697 ha (31,373 ac), of which 6,274 ha (15,504 ac) are open for public hunting. No systematic hunter-use survey is conducted by the ODWC. It was, therefore, not possible to report statistically reliable figures for the use made of Keystone project lands by hunters. However, crude estimates of such activity were generated by knowledgeable ODWC field personnel during, and subsequent to, the reconnaissance trip to the project undertaken specifically for this evaluation. The estimates were derived by personnel responsible for development and implementation of game management plans for the lands held in license by the ODWC. These activities are carried out by the State under Pittman-Robertson funding. Table 12 presents these ODWC estimates of hunting-use as well as the independently developed average annual hunter-visitation figure reported by the CE. Considerably different views of hunting activity are held by the ODWC and the CE for Keystone project lands and waters. The CE estimate

Table 12. -- Estimated annual hunting effort on Keystone project fee lands as reported by CE and as estimated by ODWC personnel

Game animal group	Hunter-days			
	ODWC-estimates			CE-estimates for all project fee lands[1]
	Licensed-lands	CE managed lands	Totals	
Big-game				
White-tailed deer	500	105	605	--
Turkey	250	50	300	--
Upland-game				
Squirrel	800	120	920	--
Quail	4,000	400	4,400	--
Rabbit	1,000	100	1,100	--
Dove	150	0	150	--
Furbearers				
Raccoon	120	--	120	--
Waterfowl	175	175	350	--
Totals	6,995	950	7,945	28,443[2]

1. Estimated by Ranger counts of vehicles using remote areas during hunting season and applying standard vehicle occupancy expansion factors

2. Average for 7 year period (1972-1978). Actual annual estimates for the 7 year period of record beginning in 1972 were; 11,200, 26,000, 9,700, 56,800, 36,000, 13,000 and 46,400

of average annual use, 28,443 hunter-days, is 3.6 times greater than the ODWC's estimate of 7,945 hunter-days.

The CE use figures are obtained from car counts made by CE personnel during routine patrolling of project lands when hunting seasons are open. The car counts are expanded by hunter vehicle occupancy to arrive at the reported number of hunter visits.

Examination of the more definitive species-related ODWC hunting effort data shows that quail support over one-half of the total hunting effort on Keystone project lands. Upland game species as a group provided 6,570 hunter-days or 83 percent of the hunter-days estimated by the ODWC. Big game, which includes both white-tailed deer and Rio Grande turkeys, supported an estimated 905 hunter-days. Waterfowl resources of the Keystone project currently support only 350 hunter-days. Computed on an area basis, the ODWC's use estimates reflect, perhaps conservatively, 7,595 hunter-days of terrestrial wildlife-associated hunting activity on 6,274 ha (15,504 ac), i.e., 1.2 trips per ha (0.5 trips per ac).

Limited information was available from ODWC reports (11,12,14,15) to allow documentation of relative hunting success on the Keystone Public Hunting Area. The limited data available, which were used to prepare Table 13, reflect highly variable hunter success for quail. At the same time, the harvest success data available for doves (1974-1975 and 1975-1976) were relatively consistent (2.0 and 1.5 birds per trip, respectively).

The total deer harvest on all project fee lands was estimated by ODWC per-

Table 13. -- Summary of bag check (hunter success) data available from ODWC for the Keystone Public Hunting Area

Game species	Years							
	1974-1975		1975-1976		1976-1977		1977-1978	
	No. hunters checked	Success per hunter	No. hunters checked	Success per hunter	No. hunters checked	Success per hunter	No. hunters checked	Success per hunter
Quail	--	--	12	5.8	--	--	24	2.25
Squirrel	6	4.5	--	--	--	--	--	--
Dove	5	2.0	48	1.5	--	--	--	--
Raccoon	3	0.7	--	--	--	--	--	--
Duck	13	2.4	--	--	--	--	--	--

sonnel at 15 animals in 1976-1977 and at 35 animals in 1977-1978 (Joe Hardridge, pers. comm., 1979). Of this total, 12 deer and 28 deer were harvested from the ODWC licensed lands in 1976-1977 and 1977-1978, respectively. The estimated turkey harvest from all project lands was placed between 10 and 15 birds, annually.

Wildlife Resources -- Evaluation of Planning Input

The FWS planning report of December 19, 1961, contained three well conceived recommendations pertinent to project wildlife resources. These recommendations included, (1) a request for development of a zoning plan to insure that certain areas would be available for wildlife purposes without conflicting use for general recreation, (2) that all project lands acquired be clearly marked to delineate areas open to hunting, and (3) that an approximate 3,701 ha (9,145 ac) contiguous tract located on the Cimarron arm of the reservoir be purchased in fee, fenced at project expense, and licensed to the ODWC for wildlife management purposes. Implementation of this latter recommendation was considered essential for mitigating wildlife losses on the project.

The recommendation for a zoning plan was subsequently implemented by the CE in cooperation with the ODWC and FWS.

Also, all CE administered lands off limits to hunting, such as high density recreational areas, parks, etc., have been identified and signed. Signing of areas open to public hunting is currently under way.

In retrospect, there was little relationship between the ultimate location

of wildlife management areas and/or prescribed management practices and those originally anticipated by the fish and wildlife planning agencies. A careful analysis of the 1961 FWS report indicates the authors considered only two scenarios for habitat impacts: (1) project in place without acquisition of additional mitigation lands and without state management of incidental project lands, and (2) project in-place with acquisition of additional lands [3,701 ha (9,145 ac)] specifically for wildlife mitigation purposes and with management of these lands in combination with 2,875 ha (7,105 ac) of incidental project lands by the ODWC.

Unfortunately, the most probable option, eventually implemented, was not considered (but should have been) during the planning phase. This option assumes the project in place without acquisition of additional lands specifically for wildlife mitigation, but with management of incidental project lands under license by the ODWC. Subsequently, 4,970 ha (12,280 ac) of such project lands were licensed to the ODWC. Figures 2 and 3 present graphic illustrations comparing the lands requested by the FWS and ODWC for terrestrial wildlife management by the ODWC at the Keystone project with the lands actually provided under license to the ODWC by the CE for wildlife management purposes.

Resident wildlife populations on the terrestrial habitat within the 22,420 ha (55,400 ac) Keystone project impact area supported an estimated (6,530 hunter-days prior to construction of the Keystone project. The actual amount of terrestrial habitat (vs. water) in the impact area totaled 19,148 ha (47,315 ac). Thus, the estimated pre-impoundment hunting use of

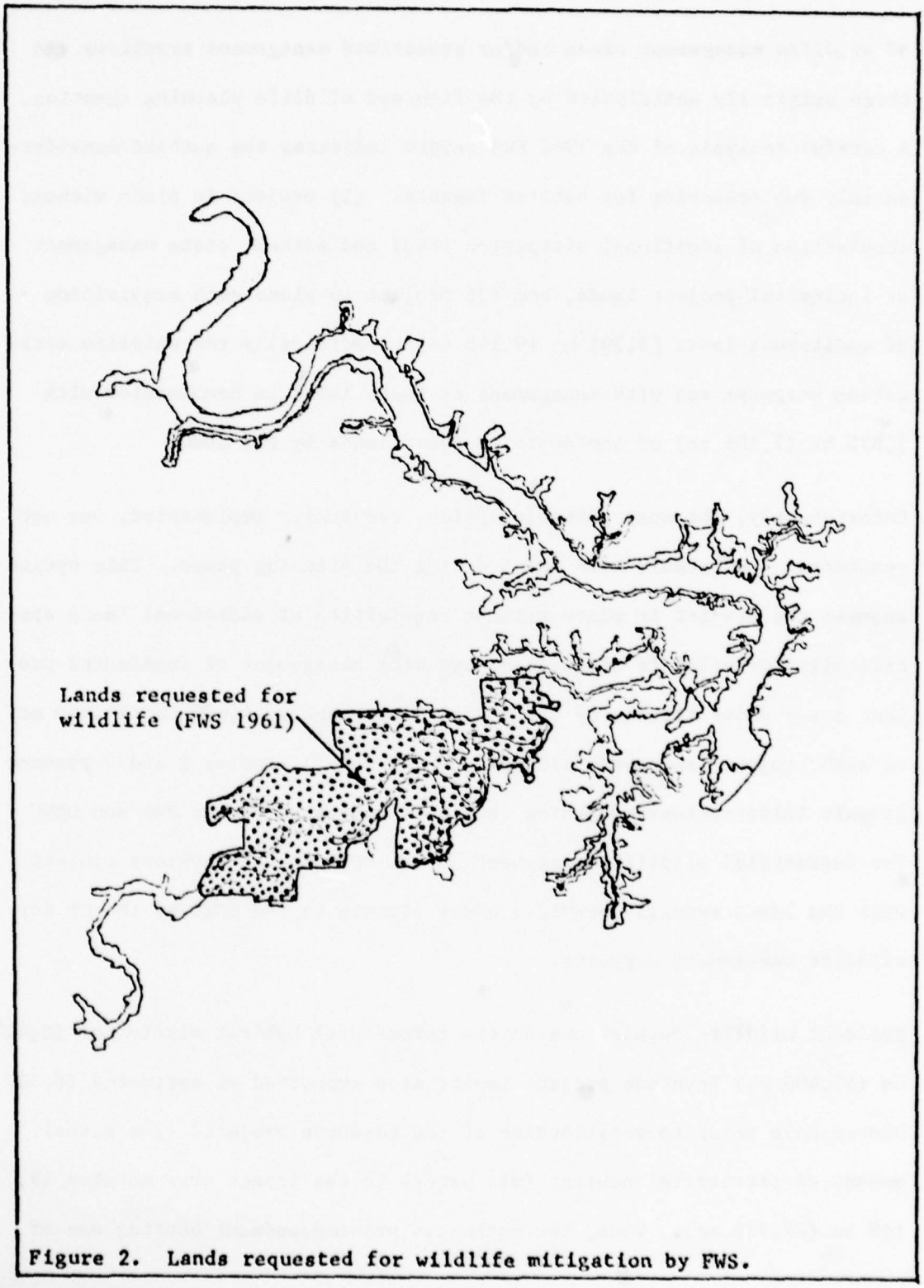


Figure 2. Lands requested for wildlife mitigation by FWS.

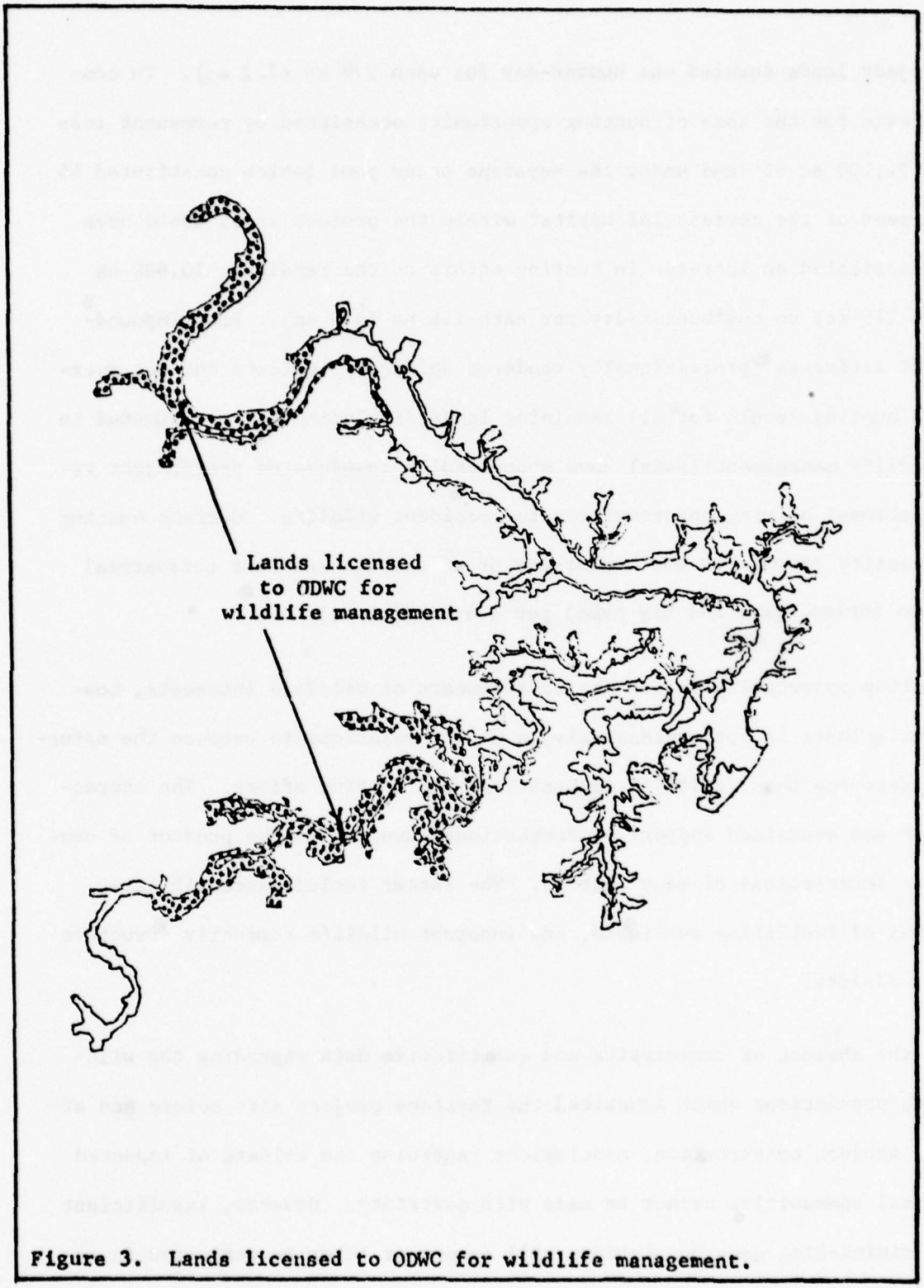


Figure 3. Lands licensed to ODWC for wildlife management.

project lands equaled one hunter-day for each 2.9 ha (7.2 ac). To compensate for the loss of hunting opportunity occasioned by permanent loss of 21,100 ac of land under the Keystone power pool (which constituted 45 percent of the terrestrial habitat within the project area) would have necessitated an increase in hunting effort on the remaining 10,600 ha (26,215 ac) to one hunter-day per each 1.6 ha (4.0 ac). Post-impoundment estimates (professionally rendered opinions) indicate current average hunting levels for all remaining lands (including but not limited to wildlife management lands) have successfully compensated pre-project recreational hunting opportunities for resident wildlife. Current hunting intensity amounts to one hunter-day of effort for resident terrestrial game (upland game and big game) per 1.4 ha (3.5 ac).

Hunting opportunity is not the sole concern of wildlife interests, however. There is not, necessarily, a direct relationship between the natural resource base (wildlife communities) and hunting effort. The attraction and sustained support of recreational hunting is the product of complex interactions of many factors. The latter include accessibility, types of facilities available, and inherent wildlife community structure and density.

In the absence of descriptive and quantitative data regarding the wildlife populations which inhabited the Keystone project site before and after project construction, conclusions regarding the welfare of impacted animal communities cannot be made with certainty. However, insufficient or diminishing game populations will sooner or later be reflected in reduced hunter use and the converse holds equally true. The indicated

greater hunter use per unit area of the remaining terrestrial habitat surrounding the Keystone Lake would support the thesis that greater numbers of desireable species are being provided on the remaining Keystone project lands than before project construction.

The prediction of severe terrestrial wildlife community losses in association with construction of Keystone Lake (unless compensated by acquisition of special mitigation lands) does not appear to be supported by post-construction information although such information is severely limited. Rather, the available data indicate that resident wildlife losses were averted at the Keystone Lake project. This circumstance resulted from an intensive and expensive program of wildlife habitat manipulation and resource management on incidental project lands by the ODWC and to a lesser degree by the CE. Thus, compensation appears successful for the terrestrial wildlife resources at the Keystone project, although mitigation efforts were restricted to incidentally purchased project lands.

Acquisition of the requested tract of mitigation lands and rehabilitation of these lands to the extent possible by fencing to avoid overgrazing, could have reduced the amount of habitat manipulation that was necessary on lands that were made available to compensate for the wildlife losses. Unfortunately, the monetary burden for the existing wildlife program has been on the ODWC and not on the pregram responsible for the original habitat loss.

Predictions of hunting activity projected in the 1961 FWS report ranged far outside estimated post-impoundment occurrences, particularly for water-

fowl and big-game hunting. As noted in Table 14, the FWS report of 1961 predicted a total loss of big-game hunting on project lands absent implementation of the recommended mitigation plan. Only 130 hunter-days per year of big-game hunting were predicted given implementation of the mitigation plan. Actual post-impoundment hunting effort estimated for big-game species (905 hunter-days per year) was seven times greater than the hunting effort predicted assuming implementation of the mitigation plan. Apparently, the resurgence of white-tailed deer on the project area (which also occurred generally throughout the nation during the 1960's) was not anticipated by the authors of the 1961 FWS report. White-tailed deer was the only big-game species considered in the 1961 FWS report, as Rio Grande turkeys were not present on the area until introduced by the ODWC in the early 1970's.

The optimistic prediction in the FWS report of 1961 for waterfowl hunter use (9,800 hunter-days) failed to materialize. This prediction, made independently of the implementation of any proposed mitigation recommendations, was 28 times the ODWC estimate of current usage (350 hunter man-days).

The significance of this excessively over-optimistic prediction of waterfowl hunting is further compounded by the fact that project use for waterfowl hunting constituted a majority of the total post-impoundment hunting activity projected for the project (approximately 82 percent of all hunter-days of use without mitigation and 60 percent with mitigation) which was used by the CE in computing the project cost-benefit ratio. A more accurate assessment of project usage for waterfowl hunting (number

Table 14. -- Hunting effort predicted for Keystone project lands, with and without acquisition and development of mitigation lands, compared to current estimates of project-associated hunting levels

Animal group	Hunter-days per year			
	Predicted in 1961 FWS report		Current use of project	
	Without mitigation plan	With mitigation plan	ODWC estimate	CE estimate
Big game	0	130	905	--
Upland game[1]	2,100	6,400	6,690	--
Waterfowl	9,800	9,800	350	--
Total	11,900	16,330	7,945	28,443

1. Minor amount of furbearer hunting (120 hunter-days) included

of hunter-days) would have substantially lowered FWS estimates of project wildlife benefits.

A possible reason for the lower than predicted number of hunter-days for waterfowl could be associated with management of reservoir water levels. The lake provided a somewhat favorable habitat for waterfowl during the first few years following impoundment. The large expanse of water made the lake attractive as a resting place for migratory birds, and a considerable amount of food was provided by native smart weeds and millet which quickly developed along the lake margins. Also, a considerable number of mast producing trees, which provided food and cover for waterfowl, were flooded.

However, the smart weed and millet were substantially reduced in later years by reservoir fluctuation and subsequent shoreline erosion. Also, the "green trees" growing in marginal areas of the lake were almost entirely eliminated by prolonged flooding which occurred during the growing season of 1973-1974. The lake level exceeded the normal conservation pool elevation by more than 5.3 m (17.5 ft) over a 63-day period from March 15 through May 18, 1973; it did not return to the conservation pool level until June 18, 1973. There is a further possibility that construction of other impoundments within the Central Flyway and within eastern Oklahoma, in particular, may have served to dilute the number of waterfowl using Keystone Lake.

Post-impoundment predictions in the FWS report were more accurate for upland game hunting use (2,100 hunter-days without mitigation, and 6,400

hunter-days with mitigation) than for big game and waterfowl, although lower than actual post-impoundment occurrences (6,690 hunter-days) estimated by the ODWC. It should be emphasized that the FWS's prediction of post-impoundment hunting for upland game, which assumed implementation of recommended mitigation features, was predicated on the supposition of fee acquisition of an additional 3,701 ha (9,145 ac) of land to be intensively managed by the ODWC. Even though the FWS recommendation for additional land purchase was not implemented, post-impoundment hunting pressure was higher than predicted.

The data contained in the FWS letter report dated December 19, 1961, lacked sufficient detail to evaluate the efficacy of the methodology and/or rationale employed in arriving at estimates of pre- and post-impoundment hunting activity in terms of hunter-days of use. The report would have benefitted greatly by inclusion of a brief statement describing the procedures utilized in deriving such estimates.

FISHERY RESULTS AND DISCUSSION

Fishery Resources -- Pre-impoundment Predictions

The fishery resources of the Arkansas and Cimarron Rivers in the area to be impacted by the Keystone Lake project were considered to be of poor quality yet able to support considerable angling use. These observations were contained in the 1961 report of the FWS (3), viz:

> The stream fisheries that will be affected by the Keystone Project, although generally low in quality, are fished heavily. Approximately 200 stream miles will be affected which include the Arkansas River downstream from the dam and portions of the Arkansas and Cimarron Rivers and their tributaries which lie within the reservoir site. The principal fishes found in the streams that will be affected are channel catfish, flathead catfish, freshwater drum, carp, buffalofishes, and river carpsuckers. Despite relatively poor quality stream habitat, intensive fishing results from the river's close proximity to Tulsa and neighboring communities.
>
> Projected over the period of analysis, the estimated average annual fishing on the 200 miles of stream habitat without the project would be 17,000 man-days. Of this total use, 12,000 man-days would occur in the stream to be inundated, and 3,000 man-days would occur in the 15-mile reach extending downstream from the damsite to Tulsa. In the remaining 65 miles from Tulsa to the mouth of the Grand River, the Arkansas River is heavily polluted and would support only about 2,000 man-days of fishing annually.
>
> Without the project, commercial fishing would be insignificant in the project area.

Post-impoundment fishery habitat conditions were expected to be improved both in the newly created lake and in the Arkansas River below the dam. The anticipated post-impoundment conditions as presented in the 1961 report were as follows:

> Keystone Dam will decrease flood flows, regulate the normal flow of the stream, and at the top of the flood control pool, create an impoundment covering about 45 miles of the Arkansas

River, 54 miles of the Cimarron River, and 22 miles of minor tributaries. Sixty-six miles of stream will be permanently inundated at conservation pool, and 77 miles at top of power pool.

With the ultimate plan, the reservoir will have 36,260 surface acres at average annual maximum pool, and 24,150 surface acres at average annual minimum pool. During 56 percent of the years of operation, floods will cause annual reservoir fluctuations in excess of 20 feet. These fluctuations will usually occur during May and June. During most of the remaining years, reservoir elevations will remain more stable with little fluctuation. This assumption does not allow for possible increases in downstream water-use requirements.

The reservoir is expected to provide good-quality habitat for largemouth bass, white bass, and channel catfish. Other important species will be white crappie, bluegill, green sunfish, goldeye, flathead catfish, freshwater drum, and possibly walleye. Carp, buffalofishes, carpsuckers, and garfishes will occur also. The reservoir will provide a benefit of about 80,000 man-days of fishing annually.

Keystone Reservoir will create a settling basin for much of the normal silt load of the Arkansas River, and waters released downstream will be much more clear than historically. Annual high flows, which historically exceeded river bank capacity once in every three years and closely approached bank capacity in the remaining years, have made the river unattractive and unsafe for fishing for periods up to three weeks during May, June, and July. Keystone Reservoir as one of a system of reservoirs in the Arkansas River drainage would be operated in such a manner that bankfull releases at the dam would rarely be exceeded, and maximum flows usually would not exceed one-half of flood-channel capacity.

The reduction of sediment and prevention of floods will improve fishing in the 15-mile reach of river lying between the dam and Tulsa, and the resulting fish habitat will attract and support about 10,000 man-days of fishing annually. The 65-mile reach below Tulsa, however, will continue to be excessively polluted during periods of low flow, which coincide with the main fishing season, and conditions will be improved only moderately providing fish habitat attracting a use of about 60 man-days per mile of stream. This reach will sustain about 4,000 man-days of fishing.

Total benefits to support fishing attributable to the project will be $82,000 annually.

During the life of the project, there will be opportunity to

harvest an estimated 190,000 pounds of commercial fishes annually from Keystone Reservoir with a value of $19,000.

In the absence of basic descriptive data, it was not possible to ascertain the procedures employed by the FWS to develop the angling effort and associated monetary values presented in the sections of the 1961 report which are quoted above. It is apparent from this and other sections of the 1961 FWS report that a reservoir-angling trip was valued at $1.00 and a river-angling trip was assessed a value 50 percent higher at $1.50. No combination of these monetary values and the angler-day values provided in the report will provide a figure of $82,000 as claimed above for the Keystone incidental fisheries benefits. The actual figure probably should have been $75,500 ($76,000 rounded). Computation of the $75,500 value, which accommodates a project-associated reservoir fishing benefit of $80,000 and a total river fishing loss valued at $4,500, is presented in Table 15.

The most probable explanation of the descrepancy between the $75,500 benefit figure in Table 15 and the $82,000 benefit figure supplied by the FWS can be associated with the improper use of the word "benefit" in the FWS's description of predicted reservoir angling usage of 80,000 trips. If instead of benefit, the authors really meant that post-impoundment lake fishing was expected to average 80,000 trips annually, then the actual "benefits" should have been 68,000 trips, i.e., (80,000 trips - 12,000 existing river angling trips) = 68,000 trips.

Monetary computations associated with the supposed FWS benefit figures pre-

Table 15. -- Recomputation of monetary values associated with incidental fishery losses and gains at the Keystone Lake project

Project segment	Without project		With project		Net change	
	Trips	Value	Trips	Value	Trips	Value
River						
Above dam	12,000	$18,000	0	0	-12,000	-$18,000
Between dam and Tulsa	3,000	4,500	10,000	$15,000	+ 7,000	+ 10,500
Below Tulsa	2,000	3,000	4,000	6,000	+ 2,000	+ 3,000
Subtotal	17,000	$25,500	14,000	$21,000	- 3,000	-$ 4,500
Impoundment	0	0	80,000	$80,000	+80,000	+$80,000
Total	17,000	$25,500	94,000	$101,000	+77,000	+$75,500

sented above would then have been: (68,000 lake trips x $1.00/trip) + (9,000 river trips x $1.50/trip) = 81,500 (rounded to $82,000). In addition, it seems clear that the FWS's original computation mistakenly ascribed a $1.00 value for the 12,000 man-days of river fishing sacrificed within the lake site instead of $1.50 per trip which should have been utilized to describe river fishing trip values. Thus, it appears that the FWS reports inadvertently assigned a $4,500 greater benefit to the post-impoundment sport fishery than warranted.

The present evaluation assumes that total reservoir angling provided incidental to lake construction was predicted to be 80,000 trips.

Considerable additional benefits were anticipated pending adoption and implementation of two management recommendations that were provided by the conservation agencies. This discussion has been duplicated in its entirety in the following section.

> The Keystone Project area lies only 15 miles from the city of Tulsa, an urban area of over 280,000 people. The five counties in which the reservoir is located have a total population of approximately 400,000 persons, almost all of whom live within one hour's driving time of the reservoir. The construction of Keystone Reservoir and the maintenance of fishing therein will meet the need for reservoir fishing in the area. As important, however, is the need for productive fish habitat on the Arkansas River, downstream from the dam.
>
> Although several water-development projects involving construction of large reservoirs and many benefits to fishing are planned, are under construction, or have been built within day-use distance of Tulsa, stream fishing often has been sacrificed as a result of reservoir construction. This diminution of stream fishing in an area where many sportsmen are traditionally river fishermen has made the restoration of the Arkansas River fish habitat an important consideration.
>
> The Arkansas River with a satisfactory water supply is capable of meeting much of the local demand for river-type fishing and,

in many respects, would offer more attractive fishing than many flood control reservoirs.

Fish production and fishing in the entire 80-mile reach of the Arkansas River downstream from Keystone Dam could be assured and improved if adequate releases were provided to control pollution and maintain a minimum of 4 parts-per-million of dissolved oxygen. A study by the U.S. Public Health Service, part of which is presented in Table 2, indicates the flows which would be necessary to meet the minimum standards of suitable water quality. If, however, these standards cannot be met, an estimated minimum instantaneous release of 300 second-feet could provide significant benefits to stream fishing in the project area largely by benefiting the 15-mile reach of the Arkansas River from Keystone Dam to Tulsa.

Since production of hydroelectric power at Keystone Dam is not included in the initial phase of construction, the storage space which is to be assigned to power production will be used for flood control and other useful purposes. A portion of this storage could be used for fish production. An allocation of storage amounting to 30,000 acre-feet would assure most of the requirements for maintenance of the downstream fish habitat during all but the most critical low-flow periods. Normally, river flows will be more than adequate to maintain the instantaneous release necessary to provide 300 second-feet of good-quality water. However, during water-short periods, releases from the fishery conservation storage would enhance the fish habitat in the Arkansas River, attracting an additional 15,000 fisherman-days annually valued at $22,000. The major portion of this use would occur in the 15-mile reach of the Arkansas River extending upstream from Tulsa to Keystone Dam. If, however, an additional increase in fishing benefits is to be realized in the river downstream from Tulsa, increased flows adequate to achieve pollution abatement as presented in Table 2, will be necessary.

When power-production features are installed and operated, problems will arise in maintaining flows for the fishery during periods of little or no generation. Solution of those problems cannot be attempted at this time since all indications are that water uses will undergo considerable change prior to the operation of the reservoir for power production.

The commercial taking of fish from the reservoir will be desirable not only as a source of food and income, but also to assist in management of the reservoir fishery. Coarse fishes often become a problem in Oklahoma reservoirs, and removal of these fishes is beneficial to the game-fish population. Appropriate seining areas free of vegetation and man-made obstruc-

tions would facilitate use of seines and other gear necessary for the efficient taking of commercial fishes. The Keystone Reservoir site contains many areas which are suitable for seining operations with little or no clearing. It is desirable, however, that the Corps of Engineers cooperate with the Oklahoma Department of Wildlife Conservation to designate such seining areas as may be found necessary.

Within the reservoir area there is considerable vegetation so located as to provide food, cover, and concentration areas for sport fish. In order that the reservoir-clearing plans reflect the latest thinking of the Oklahoma Department of Wildlife Conservation, the U.S. Public Health Service, and the Bureau of Sport Fisheries and Wildlife, a mutually acceptable clearing plan should be worked out by the Corps of Engineers in cooperation with the above agencies.

It is anticipated that Keystone Reservoir will attract many recreationists and that motor boating and water skiing will be a major activity. These water sports, unless controlled, will adversely effect the attractiveness of the reservoir for fishermen and could present a safety hazard to persons fishing from small boats. A feasible method of controlling this situation and providing greater safety to all persons who use the reservoir could be obtained by zoning of the reservoir into areas reserved for fishing and other uses. The reservation of an adequate portion of the reservoir for fishing would make it possible for the reservoir to provide an additional 60,000 man-days of sport fishing annually valued at $60,000. Designation of the zones and preparation of special regulations or enforcement measures should be developed cooperatively by those agencies responsible for administration of the reservoir and the Oklahoma Department of Wildlife Conservation.

An additional 60,000 reservoir angler-days were associated with reservoir zoning and an additional 15,000 river angler-days were expected to result from low flow augmentation (Table 16). The total project-associated angling estimate (with zoning and downstream flow stabilization) was placed at 169,000 angler-days. This total represented a 152,000 angler-day enhancement (8.9 times) over projected conditions without the project.

As presented in previous discussion, no records have been maintained by the FWS to document the methodology employed by the authors of the pre-

Table 16. -- Predicted number of angler-days for the area impacted by Keystone Lake under without and with project conditions

Project conditions	Predicted number of angler-days					
	Lake (site)		Arkansas River between Keystone dam and Tulsa, OK		Arkansas River below Tulsa, OK	
	Total	Projected increase	Total	Projected increase	Total	Projected increase
Without project	12,000	--	3,000	--	2,000	--
Post-impoundment						
Without lake zoning and 300 cfs minimum release	80,000	+68,000	10,000	+ 7,000	4,000	+2,000
With lake zoning and 300 cfs minimum release	140,000	+60,000	25,000[1/]	+15,000[1/] (combined)	4,000[1/]	[1/]

1/ Additional 15,000 man-days fishing in Arkansas River if 300 cfs minimum flow provided. This projected usage figure was not differentiated by above Tulsa and below Tulsa sections

construction planning report. References to population in the Tulsa urban area acknowledge consideration of this factor but the precise applications are unknown.

Three fishery-specific recommendations were submitted by the conservation agencies which, it was believed, would maximize those beneficial project uses associated with recreational fishing. Each of these recommendations was accepted by the construction agency, as reflected in the following treatment appearing in the CE's General Design Memorandum (6), viz:

> Recommendation No. 1. - That a minimum instantaneous flow of 300 second-feet of good quality water capable of supporting desirable fish habitat be released at Keystone Dam until such time as power and navigational releases are available, at which time adjustments should be made to protect the fish habitat.
>
> Comments. - Releases for hydropower production and water quality control are expected to equal or exceed the requirements as shown by the Service. Releases below the reregulation structure from Keystone Reservoir will not drop below the minimum requirements for water quality control set by the Public Health Service for 1989 conditions. In meeting these requirements, 7,500 acre-feet of storage would be provided above the reregulation structure which would maintain a minimum sustained flow varying from 1,110 c.f.s. in August to 520 c.f.s. in January. Therefore, it is considered that the flow requirements for the downstream fishery below Keystone Dam will be met with the expected plan of operation.
>
> Recommendation No. 2. - That a mutually acceptable reservoir clearing plan be developed cooperatively by the Corps of Engineers, the U.S. Public Health Service, the Oklahoma Department of Wildlife Conservation, and the Bureau of Sport Fisheries and Wildlife.
>
> Comments. - Reservoir clearing plans have been prepared and approved. The contract for clearing was advertised for bid on 6 November 1962. These plans were coordinated with the Oklahoma Department of Health and Oklahoma Department of Wildlife Conservation during preparation. Provisions have been made for seining areas and small uncleared areas for fish concentration sites.
>
> Recommendation No. 3. - That appropriate consideration be given

to the development of a reservoir zoning plan in connection with overall planning for Keystone Reservoir to insure that certain areas will be available for fishing and other wildlife purposes without conflicting use for general recreation. It is further recommended that the parties involved in developing a reservoir zoning plan include the agency expected to administer the reservoir and the Oklahoma Department of Wildlife Conservation.

Comments. - This recommendation is concurred in. The Corps of Engineers is charged with the responsibility for assuring full use of the reservoir by the public and it is proposed that appropriate consideration will be given to zoning of the reservoir to avoid conflicting use by the sport fishermen, hunters, and other users. Any zoning plan or study undertaken will be coordinated with all agencies having a responsibility or interest in the problem.

Discrepancies existed regarding the actual angling use of the Arkansas and Cimarron Rivers within the project impact area in the absence of the project. As noted in a preceeding section, demonstrated in Table 16, the FWS report of 1961 listed without-project angling use (over life of project) of these rivers within the project site above Tulsa, Oklahoma, at 15,000 angler-days per year. The CE, in a supplement to their General Design Memorandum for the Keystone project (6), expressed findings of use of the rivers of a significantly different level, viz:

Report by other agencies. - A pre-impoundment fishery survey of the Arkansas and Cimarron Rivers within the Keystone Reservoir area was conducted during the summer of 1960 by the Oklahoma Fishery Research Laboratory with the Oklahoma Department of Wildlife Conservation and the Tulsa District Corps of Engineers cooperating. This study was published in Report No. 81, Oklahoma Fishery Research Laboratory, entitled "A Study of Fishes of the Arkansas and Cimarron Rivers in the Area of the Proposed Keystone Reservoir" dated July 1961. A copy of this report is enclosed herewith as exhibit B. This survey consisted of fish distribution studies, age and growth studies, and estimation of populations and standing crops of fishes. The rough fish species were predominate in all collections, the river carpsucker being the most numerous. The fish population estimate made on Mud Creek, a tributary of the Arkansas River shows the river

carpsucker makes up 70 percent by numbers and 53 percent by weight of the total estimated standing crop of fishes. This study further shows that the total sport fish species collected made up only 8 percent by number and 7 percent by weight of the total estimated standing crop. It also states that water conditions of the Keystone Reservoir would probably be comparable to Lake Texoma and the fish population of Keystone similar to that of Canton Reservoir. It states that white crappie and channel catfish should become important components of the sport fish population. A limited creel census conducted during the survey indicates a very limited use of the rivers for sport fishing and a very poor return in catch per unit of effort. The Oklahoma Fishery Research Laboratory has further expanded the creel census data collected to include an estimate for total angler usage in the reservoir area under pre-impoundment conditions. Supplemental information furnished by that laboratory shows an estimated 800 fisherman-days per year in that portion of the Arkansas River from Cleveland to Tulsa and of the Cimarron River from Cushing to its confluence with the Arkansas River. This compares with an estimated usage of 15,000 man-days per year for the same area as shown in the report of the Fish and Wildlife Service.

An effort by the authors of the present report to track down the "Supplemental information furnished by that laboratory" with staff of the Oklahoma Fishery Research Laboratory (OFRL) proved futile. The pertinent section of the OFRL's 1961 report (16) is presented below.

> To determine the number of people fishing in the waters of the two rivers in the proposed reservoir area and the time spent fishing, a creel census was conducted.
>
> An area of approximately 75 miles was covered, from Tulsa to Cleveland, Oklahoma, on the Arkansas River, and to Drumright, Oklahoma, on the Cimarron River. The interviews were started at daybreak and continued until 10:00 A. M. in the morning and from 4:00 P. M. until it became dark in the evening. In the month of July the census was conducted for seven days, in August, 14 days, and in September 3 days. The return or catch per unit of effort was very poor. An average of one fish was taken for 4.25 hours spent fishing in July, 5.7 hours in August, and 13 hours in September (Table 6). There were only five species caught by the fishermen interviewed. These were channel catfish, flathead catfish, carp, freshwater drum, and longnose gar. Of these, the fish taken most frequently was the channel catfish.

The OFRL's Table 6 quoted above has been reproduced in this report as Table 17.

These OFRL data are limited to 90 fishermen contacted on parts of 24 census days along a 121 km (75 mi) section of the two rivers. Angling effort not covered in the reported figures would have included: (1) All fishing during the year occurring on days other than the 24 survey days, (2) All angling between 10:00 A. M. and 4:00 P. M. on surveyed days, (3) All fishermen along the 121 km (75 mi) of riverine system not contacted during survey days. It is the opinion of the present authors that the limited 1960 OFRL survey could not have resulted in the contact of 11 percent (90 ÷ 800) of all angler-trips on these river sections in 1960.

This CE expressed confusion may reflect, in part, misunderstanding on their part that the FWS projected figure was an average over the total period of project analysis (probably 50 years).

Fishery Resources -- Post-impoundment Occurrences

The Keystone project was completed for flood control operation in September, 1964. Commercial operation of the power plant began in May, 1968. At conservation pool elevation 220.4 m (723 ft) msl, the lake covers 10,530 ha (26,020 ac) and has a shoreline of 531 km (330 mi).

A wide range of fishery management practices and investigations have been carried out on the Keystone Lake and tailrace. The CE has installed a brush pile fish attractor and the ODWC have placed tire reefs in the lake to enhance the sport fishery. The lake basin was heavily timbered during construction and these artificial devices serve to concentrate fish in a

Table 17. -- Creel census of the Arkansas and Cimarron Rivers in the area to be inundated by Keystone Reservoir. Extracted from Oklahoma Fishery Research Laboratory report of 1961 (16)

Month	No. of days of census	Number of fishermen	Hours fishing	Total catch	Catch per unit of effort
July	7	6	8.5	2	4.25 hour/fish
August	14	74	213	37	5.75 hour/fish
September	3	10	13	1	13.00 hour/fish

manner similar to flooded standing timber. A fish rearing pond was constructed on Keystone project lands at a cost of $2,000. This pond was cooperatively constructed by local fishing club members, the CE and the ODWC.

Reservoir zoning has not been used to specifically enhance the recreational fishery. Only two zones are recognized by the construction agency. A limited area has been zoned to restrict all water uses as a matter of safety. The remaining lake area is open to all normal lake uses including boating, skiing and fishing.

Other management-related activities have been carried out at Keystone which will be discussed individually and in greater detail in the following sections. These include water fluctuation studies in both lake and tailrace, fish population analyses (including stocking) and creel survey studies.

According to the CE's environmental statement on Keystone Lake (1), minimum average daily releases from the project are not scheduled to be less than 370 cfs, viz:

> In order to maintain downstream water quality, minimum average daily releases have been established. These vary from 370 c.f.s. in January to 735 c.f.s. in July. These flows are normally provided by power releases, but are also discharged through the sluice gate during periods when power is not being generated. No releases are made when the lake is below elevation 706 feet MSL.

Actual project operations have deviated substantially from the operational guidelines presented above. Since 1973, no water has been released from Keystone dam on 15.7 percent of the days (Table 18). This amounts to 57

Table 18. -- Number of days when no water was discharged from Keystone dam, according to CE's monthly reservoir regulation charts

Year	Month												
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1973	0	0	0	0	1	1	6	3	11	0	0	0	22
1974	2	4	2	0	0	0	0	2	0	7	0	0	17
1975	0	0	0	0	0	0	2	4	8	10	11	10	45
1976	7	9	10	5	2	3	0	7	15	12	11	10	91
1977	11	14	19	15	N.D.	N.D.	N.D.	N.D.	N.D.	7	7	9	82*
1978	4	5	3	4	0	0	6	4	10	18	10	--	64**
Average	4.0	5.3	5.7	4.0	0.6	0.8	2.8	4.0	8.8	9.0	6.5	5.8	57.3

* Minimum, excluding May-September

** Minimum, excluding December

N.D. -- No data, unable to read minimum release data due to Y-scale used on these monthly charts

days annually on the average; moreover, in 1976, there were 91 days when no water was released from Keystone dam. During the same period the lake receded only to elevation 217.3 m (712.99 ft), well above the stated cut-off level of 215.2 m (706 ft) msl (Table 19).

The reregulation structure was expected to provide 9.25 x $10^6 m^3$ (7,500 ac ft) of storage, expected by the CE to maintain minimum sustained flows varying from "1,110 cfs in August to 520 cfs in January" (6). Such has not been the case, however. Water-discharge records from the U.S. Geological Survey gauge 07164500, located on the Arkansas River at Tulsa, Oklahoma (17), clearly show many days when the average flows was below 300 cfs since project construction. Daily average discharges for power production and other purposes approached or exceeded 300 cfs almost continuously until September 1971. On three days of that month, the average daily flow approached zero. This condition did not recur until May of 1973 when, judging from the CE's monthly reservoir regulation records, the 300 cfs minimum average daily discharge regime was abandoned (Figure 4).

A significant fish kill (not the first event of this nature) occurred in the stilling basin below Keystone dam during August of 1972. In September a CE biologist recommended that a water quality testing program (dissolved oxygen, pH, and temperature) be initiated in the stilling basin during summer months in combination with installation of an aeration system in the stilling basin or the partial opening of sluice gates to provide low-flow augmentation during this critical summer period (18). In July, 1975 (22 months later), the water quality monitoring program was finally authorized

Table 19. Monthly minimum elevation (in feet) of Keystone pool between January 1973 and November 1978

Year	Month											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1973	721.56	722.30	722.10	749.43	726.19	722.41	720.96	717.58	717.29*	728.40	723.01	728.98
1974	723.51	723.53	723.68	723.64	726.51	728.58	717.26	716.96*	722.90	722.10	730.50	727.97
1975	721.96	725.25	723.55	722.99	722.87	726.37	722.70	721.62	718.09	717.77	716.58*	716.89
1976	718.43	718.94	719.72	718.82	721.86	720.08	719.89	717.40	715.61	715.33	714.75	714.20*
1977	712.99*	713.77	715.69	718.04	720.12	723.88	725.01	724.49	723.29	721.50	720.85	720.85
1978	718.69	718.03	722.82	722.61	723.44	724.61	722.82	719.34	717.02*	717.23	717.18	--

* Annual minimum elevation

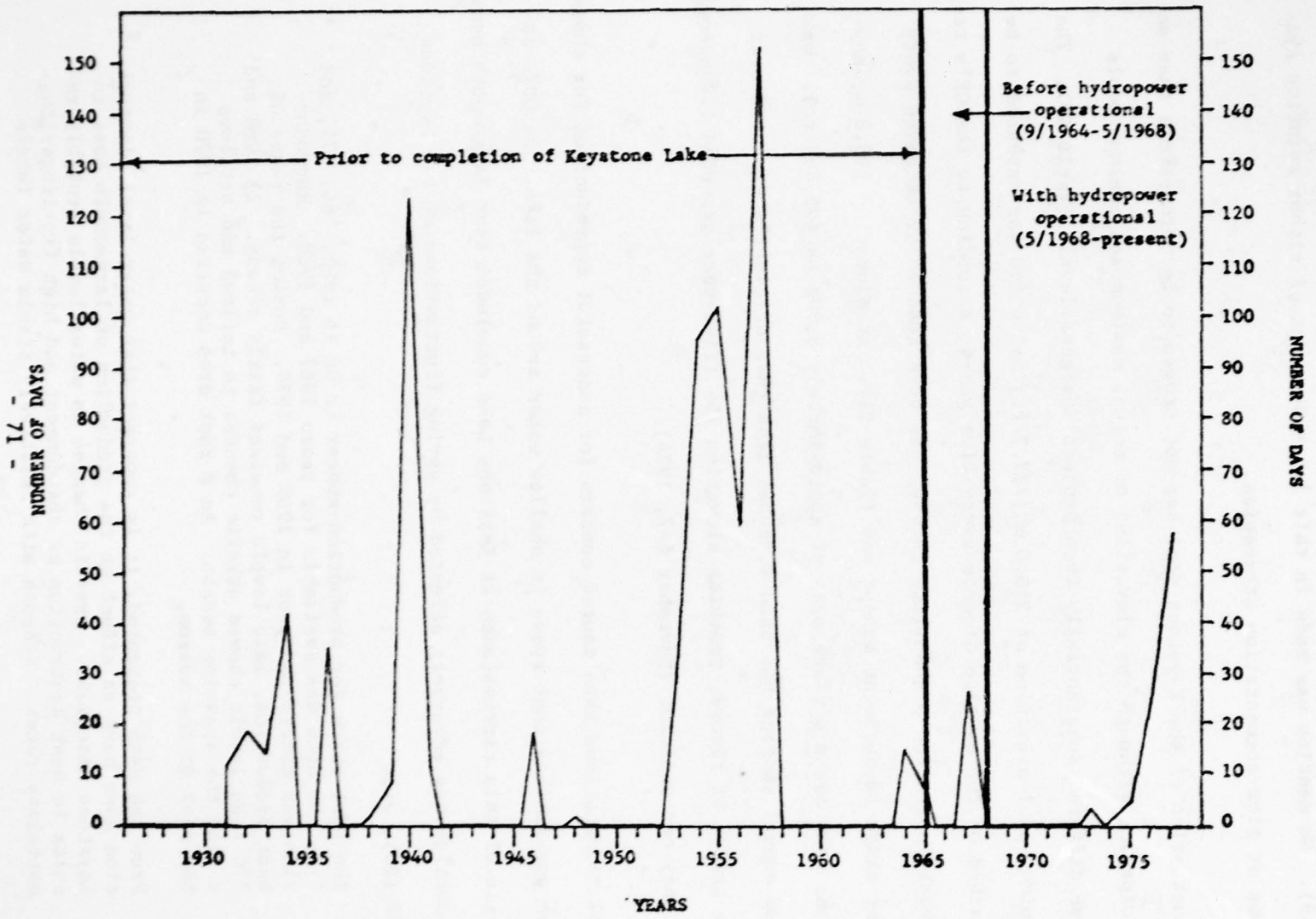


Figure 4 . -- Number of days each year (1926-1977) when Arkansas River flow at Tulsa, Oklahoma, averaged less than 300 cfs.

(19). No mention was made in this later document of either aeration systems or flow-augmentation strategies.

Fluctuation of the Keystone pool has not proven to be more severe than anticipated, although the elevations of actual maximum and minimum pools have differed substantially from project designed levels (Table 20). The minimum pool elevation of 218.8 m (717.7 ft) msl which was expected to be reached on the average of once every five years, according to the CE's reservoir operation probability curves, has been reached or exceeded every year since impoundment except one (Table 21). At elevation 218.8 m, Keystone Lake has a surface area of approximately 8,903 ha (22,000 ac). Maximum annual storage has been somewhat less than originally expected over the period of record, reaching elevation 754 (five-year expected frequency) on only one occasion (November 6-7, 1974).

Pool fluctuations have caused concern for successful reproduction for those fish populations that spawn in shallow water around the lake. An ODWC analysis of this circumstance at Keystone Lake concluded that largemouth bass production was adversely affected by spring fluctuations of the Keystone pool (20), viz:

> The best years for production appear to be in 1965, '66, '71, and '72. No data was available for years 1967 and 1968. Reproduction was considered poor in 1969 and 1970. During the years of best production, lake levels remained fairly steady. In 1969 and '70 lake levels showed erratic changes in inflows and outflows during the spawning season. An 8 foot drop occurred in 1970 in the peak of the season.
>
> From the data presented, it is apparent that water level fluctuation does have an effect on the production of largemouth bass in Keystone Reservoir. Drastic changes in water levels probably results in nest destruction or abandonment and high fry-fingerling mortality rates. Seasons with relatively stable water levels

Table 20. -- Maximum and minimum storage elevations and fluctuation of Keystone pool for period 1965-1968

Year	Maximum elevation		Minimum elevation		Fluctuation	
	M	(Ft)	M	(Ft)	M	(Ft)
1965	222.0	(728.3)	215.1	(705.8)	6.9	(22.5)
1966	221.3	(726.1)	218.0	(715.2)	3.3	(10.9)
1967	222.1	(728.6)	218.0	(715.2)	4.1	(13.4)
1968	221.7	(727.5)	219.8	(721.2)	1.9	(6.3)
1969	222.1	(728.6)	218.4	(716.5)	3.7	(12.1)
1970	223.5	(733.3)	218.4	(716.4)	5.2	(16.9)
1971	221.4	(726.3)	218.1	(715.7)	3.2	(10.6)
1972	220.4	(723.2)	218.1	(715.6)	2.3	(7.6)
1973	229.1	(751.8)	218.6	(717.3)	10.5	(34.5)
1974	230.1	(754.9)	218.5	(717.0)	11.6	(37.9)
1975	224.5	(736.7)	218.4	(716.6)	6.1	(20.1)
1976	221.5	(726.7)	217.7	(714.2)	3.8	(12.5)
1977	223.5	(733.2)	217.3	(713.0)	6.2	(20.2)
1978	222.2	(729.1)	218.5	(717.0)	3.7	(12.1)
Avg.	223.3	(732.5)	218.1	(715.5)	5.2	(17.0)

Table 21. -- Number of days each year when Keystone pool has dropped below elevation 218.8 m (717.7 ft) msl (1966-1978)

Month	Month												
	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
January	--	31	--	--	31	--	--	--	--	--	--	31	--
February	--	28	--	--	28	--	--	--	--	--	--	28	--
March	--	31	--	--	30	--	--	--	--	--	--	31	--
Arpil	--	30	--	--	--	--	17	--	--	--	--	--	--
May	--	6	--	--	--	--	--	--	--	--	--	--	--
June	--	11	--	--	--	--	8	--	--	--	--	--	--
July	--	--	--	--	2	--	2	--	3	--	--	--	--
August	--	--	--	11	29	8	30	2	9	--	6	--	--
September	--	--	--	2	24	4	30	7	--	--	30	--	19
October	3	--	--	--	--	--	31	--	--	3	19	--	31
November	30	--	--	--	--	--	--	--	--	6	30	--	5
December	31	--	--	30	--	--	--	--	--	24	31	--	--
Total	64	137	--	43	144	12	118	9	12	33	116	90	55

showed best production.

The degree to which water level fluctuation effects production is not exactly known but it must be somewhat considerable. However, other limiting factors involved may be: limited spawning habitat, wind action, and water quality.

These conclusions were based upon shoreline seining operations specifically conducted for the purpose of measuring spawning success. Unfortunately, the records only reflect the number of young bass captured and not the shoreline distance sampled for the first two years of these studies. These data gaps unhappily coincided with the years of apparently greatest bass reproduction. The ODWC's largemouth bass reproduction data were used to prepare Table 22.

Natural reproduction of largemouth bass at Keystone Lake was supplemented on occasion with hatchery fish, particularly when the lake was initially impounded. Two additional predator game fish have been introduced at Keystone, viz: striped bass and walleye. Striped bass have adapted and flourished in the lake. Striped bass successfully spawn in the Arkansas River above the lake and have not been stocked since 1969. The walleye introductions did not successfully establish at Keystone. Table 23 summarizes the available stocking data for the Keystone project.

The fish community of Keystone Lake includes species which were endemic to the Arkansas and Cimarron Rivers as well as the species purposefully stocked by the ODWC. A diverse and dynamic fishery has been established at Keystone and many evaluations of this community have been made by ODWC personnel.

Table 22. -- Number of young-of-year largemouth bass collected from Keystone Lake during routine shoreline seining studies (1965-1972)

Year	Total shoreline sampled		Total young-of-year captured	Young-of-year collected per	
	M	(Ft)		Km	(1,000 ft)
1965	--		294	--	--
1966	--		242*	--	--
1967	No data		--	--	--
1968	No data		--	--	--
1969	61,115	(200,510)	5	0.08	(0.02)
1970	35,169	(115,385)	10	0.28	(0.09)
1971	8,690	(28,510)	7	0.81	(0.24)
1972	7,442	(24,415)	15	2.02	(0.61)

* Combined collection from shoreline seining and cove rotenone samples

Table 23. -- Predator stocking records for Keystone Lake

Species	Years stocked	Number stocked	Size stocked
Largemouth bass	1960*	1,436	Fingerlings
	1963*	4,000	Fingerlings
	1966	2,000,000	Fry
	1973	5,000	Fingerlings
	1975	30,000	Fingerlings
	1978**	50,740	Fingerlings
Striped bass	1955	1,750,000	Pro-larvae
	1965	2,000,000	Fry
	1965-1967	18,739	Adults & subadults
	1967-1969	729,201	Fingerlings
Walleye	1965	400,000	Fry
	1966	1,200,000	Fry
	1967	1,200,000	Fry

* Stocked in existing lakes later inundated by impounding Keystone Lake

** Stocked in artificial nursery pond and later released to lake

Post-impoundment fish population samples from Keystone Lake were obtained by ODWC fishery biologists (21), using conventional cove rotenone sampling techniques, in 1971, 1972, 1973, 1976, 1977 and 1978 (Table 24). Each annual sample reflected composite values representing the weight (kg/ha) of fish collected from two coves with average surface areas ranging from 1.1 to 1.4 ha (2.81 to 3.54 ac).

Standing crop estimates derived from cove rotenone samples averaged 1,499 kg/ha (1,337 lbs/ac) over the six-year sampling period. The total weight of fish collected ranged from a low of 647 kg/ha (577 lbs/ac) in 1973 to a high of 2,626 kg/ha (2,342 lbs/ac) in 1978 -- a 4-fold increase over the 1973 samples. Gizzard shad, which comprised an average of 73.7 percent of the total weight of fish sampled, exhibited the greatest annual variability in weight. For example, 2,180 kg/ha (1,945 lbs/ac) of gizzard shad were collected in 1978, which was over 7.5 times the 291 kg/ha (260 lbs/ac) of gizzard shad collected in the 1972 samples.

The annual variability of the cove rotenone samples was substantially reduced if gizzard shad were omitted from the samples. Excluding gizzard shad, the annual cove rotenone fish samples averaged 395 kg/ha (352 lbs/ac). The highest annual value, 483 kg/ha (431 lbs/ac) in 1977, was only 1.8 times higher than the lowest value, 272 kg/ha (242 lbs/ac), obtained in 1973. The sunfishes (primarily bluegill), largemouth bass, channel catfish, drum, smallmouth buffalos, and river carpsuckers exhibited the least annual variability in standing crop. Striped bass, white bass, gizzard shad (all pelagic species); crappies, and flathead catfish exhibited the

Table 24. -- Keystone Lake -- Standing fish crop (kg/ha) estimated from cove rotenone samples collected by the ODWC, 1971-1973 and 1976-1978

	June	July	Aug.	Aug.	Aug.	Aug.	Average	% composition	
	1971	1972	1973	1976	1977	1978	(Kg/ha)	Total	Less g. shad
Black bass[1]	12.6	3.2	7.3	11.9	11.1	11.1	9.5	0.6	2.4
Striped bass	0.7	0.1	0.1	0.2	0.1	1.5	0.5	tr	0.1
White bass	9.4	15.0	2.4	10.8	5.2	19.6	10.4	0.7	2.6
Crappie[2]	4.5	4.9	13.1	11.1	9.0	1.1	7.3	0.5	1.9
Sunfish[3]	43.3	59.3	48.1	68.5	51.7	64.9	56.0	3.7	14.2
Channel catfish	24.1	18.9	18.6	26.9	12.8	21.8	20.5	1.4	5.2
Flathead catfish	16.5	0.3	14.2	4.9	5.3	5.3	7.8	0.5	2.0
Gar[4]	0.4	--	0.9	1.6	0.2	2.3	0.9	tr	0.2
Carp	61.3	57.5	58.2	68.4	129.0	104.6	79.8	5.3	20.2
Drum	28.5	36.6	24.4	45.9	59.8	88.0	47.2	3.2	12.0
Buffalo[5]	110.8	109.7	36.8	74.4	74.5	52.2	76.4	5.1	19.4
River carpsucker	69.8	48.6	47.1	102.6	122.9	72.6	77.3	5.2	19.6
Gizzard shad	1,317.1	290.7	685.7	1,218.7	935.1	2,179.8	1,104.5	73.7	--
Others[6]	0.7	1.8	0.8	1.4	1.8	1.0	1.3	tr	0.2
Total (kg/ha)	1,700.0	647.0	958.0	1,647.0	1,419.0	2,626.0	1,499.0		
(lbs/ac)	1,517.0	577.0	855.0	1,469.0	1,266.0	2,342.0	1,337.0		
Total, less g. shad									
(kg/ha)	383.0	356.0	272.0	429.0	483.0	451.0	395.0		
(lbs/ac)	342.0	317.0	242.0	383.0	431.0	402.0	352.0		

1/ Primarily largemouth bass, with trace amounts of smallmouth bass and spotted bass
2/ Primarily white crappie; less than 4% black crappie
3/ Primarily bluegill; less than 5% green sunfish, warmouth, longear sunfish and orange spotted sunfish
4/ Includes longnose, shortnose and spotted gar
5/ Primarily smallmouth buffalo, with less than 1% bigmouth buffalo
6/ Includes brook silversides, Mississippi silversides and miscellaneous darters and minnows

greatest annual variability in the cove rotenone samples (Table 25). Undoubtedly, the extremely small area sampled [only two coves with a total area of less than 1.5 ha (4 ac) from a 10,643 ha (26,300 ac) lake] contributed to the high variability in standing crop values, particularly for pelagic and deep-water species.

Post-impoundment creel surveys of the Keystone Lake fishery were conducted by the ODWC from July 1, 1972 to June 30, 1974; July 1, 1974 to June 30, 1975; and June 1, 1978 to November 30, 1978. Creel data from the tailwater were obtained only in the July 1, 1974 to June 30, 1975 survey.

Estimates of angling pressure were derived from aerial counts. All angler counts were assumed to be instantaneous, regardless of the actual time it took for the count. The aerial counts were used to estimate the mean number of fishermen on the reservoir at any instant during survey period. The product of this mean value and the total hours of daylight available for fishing provided the estimated total man-hours of fishing (angler-hours). Catch rate and harvest data were collected by creel clerks by direct interviews of anglers. Catch rates were compiled directly from the interview data by dividing the total catch for any given period by the total hours of fishing as determined from the interviews. Fish harvest was expressed as the product of catch rate and total hours fished.

Average annual creel statistics, derived from the two-year creel survey conducted from July 1, 1972 to June 30, 1974 (22), are presented in Table 26. It was estimated that Keystone Lake supported angling use averaging 67.1 hrs/ha (27.1 hrs/ac) over the two-year census period. An estimated

Table 25. -- Keystone Lake -- Average weight and range (kg/ha) of fish collected in 1971, 1972, 1973, 1976, 1977 and 1978 cove rotenone samples obtained by the ODWC

Species	Average	Range
Largemouth bass	9.5	3.2 - 12.6
Sunfish	56.0	43.9 - 64.0
Striped bass	0.5	0.1 - 1.5
White bass	10.4	2.4 - 20.0
Crappie	7.3	1.5 - 13.0
Channel catfish	20.5	13.0 - 24.0
Flathead catfish	7.8	0.3 - 17.0
Drum	47.2	29.0 - 88.0
Buffalo	76.4	37.0 - 111.0
Carpsucker	77.3	47.0 - 123.0
Gizzard shad	1,104.5	291.0 - 2,180.0

Table 26. -- Keystone Lake -- Summary of annual average creel statistics obtained over a two-year period, July 1, 1972-June 30, 1974. Expanded data based on an average of 17 aerial angler counts and 9,018 angler interviews per year

	Annual average (1972-74)	Number and weight of fish creeled (annual average, by species)			
		Species	Number	Lbs	Kg
Angling pressure					
No. hrs.	713,782	Striped bass	30,542	42,947	
No. trips*	178,446	White bass	94,370	36,386	
No. hrs/ha	67.1	Largemouth bass	10,686	7,754	
No. hrs/ac	27.1	Crappie	316,023	88,876	
No. trips/ha	16.8	Bluegill	14,215	2,386	
No. trips/ac	6.8	Channel catfish	71,728	71,578	
		Flathead catfish	9,623	17,895	
Harvest		Blue catfish	2,959	5,368	
No. fish	573,880	Carp	15,028	14,316	
No. kg.	296,251	Drum	4,931	3,579	
No. lbs.	653,111	Other	3,769	5,167	
No. fish/ha	53.9		573,800	296,251	
No. fish/ac	21.8				
No. kg/ha	27.8				
No. lbs/ac	24.8				
Catch rate					
No. fish/hr.	0.80				
No. kg/hr.	0.42				
No. lbs/hr.	0.92				
% successful	74.1				

* Represents an arbitrary assessment based on a statewide average for reservoir anglers of 4 hours per angling trip as determined by the ODWC

annual average of 54 fish/ha (22 fish/ac) totalling 27.8 kg/ha (24.8 lbs/ac) were creeled at a catch rate of 0.8 fish/hr and/or 0.42 kg/hr (0.92 lbs/hr).

The ODWC creel survey of the reservoir was continued the following year (23), July 1, 1974 to June 30, 1975, and expanded to include the tailwater fishery (Table 27). An estimated total of 906,147 angling hours, including 606,836 hours on Keystone Lake and 299,311 hours in the tailwater immediately below the dam, were registered on the project during the year. Fishing use (including the tailwater fishery) amounted to an estimated 85 angler-hours/ha (34 hr/ac).

An estimated total of 376,850 fishes [35/ha (14/ac)] were harvested; they aggregated an estimated 138,353 kg (305,013 lbs) or 13 kg/ha (11.6 lbs/ac). The combined reservoir-tailwater harvest (Table 28) was dominated by striped bass [47,980 kg (105,776 lbs)] and white bass [29,323 kg (64,646 lbs)]. Crappie, primarily white crappie, constituted the third most abundant component of the creel on a weight basis. A total of 22,891 kg (50,465 lbs) of crappie were harvested, including 6,056 kg (13,351 lbs) from the lake and 16,835 kg (37,114 lbs) from the tailwater.

Substantial difference between various parameters of the July 1, 1972 to June 30, 1974 and the July 1, 1974 to June 30, 1975 creel surveys of the lake were observed (Table 29). Angling pressure estimates developed in the July 1, 1972 to June 30, 1974 creel survey were based on an annual average of 17 aerial counts (approximately 1.5 counts per month). The number of aerial angler counts was almost doubled (32 counts, or approximately 2.5

Table 27. -- Summary of creel statistics collected from Keystone Reservoir and tailwater, July 1, 1974-June 30, 1975 (80% confidence intervals in parenthesis)

	Reservoir		Tailwater		Total project
Anglers interviewed					
No. anglers	659		171		830
No. hrs. fished	1,597		276		1,473
% successful	29.7		23.4		28.6
No. fish/hr	0.33	(±0.03)	(±0.59)	(±0.09)	0.42
Kgs/hr	0.15	(±0.02)	(±0.16)	(±0.03)	0.15
Lbs/hr	0.33		0.35		0.34
Expanded estimates					
Angling pressure					
No. trips*	151,709		74,828		226,537
Hrs. fished	606,836	(±197,329)	299,311	(±44,320)	906,147
Hrs/ha	57.0	(±18.54)	--		85.1
Hrs/ac	23.1		--		34.4
Harvest					
No. fish	200,256		176,594		376,850
No. fish/ha	18.8		--		35.4
No. fish/ac	7.5		--		14.3
Kg	90,835		47,518		138,353
Lbs	200,255		104,758		305,013
Kg/ha	8.5		--		13.0
Lbs/ac	7.6		--		11.6

* Number of trips computed with the assumption of a 4 hour average trip length (statewide average trip length on Oklahoma reservoirs)

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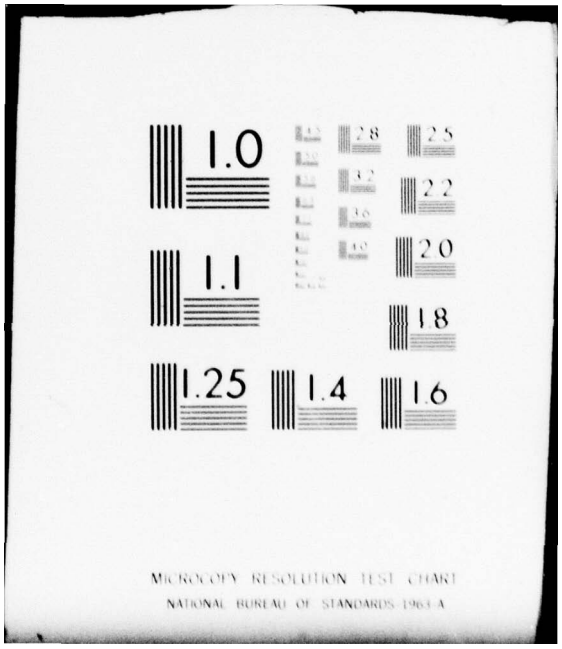

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Table 28. -- Number and weight of fish recorded in ODWC creel survey of Keystone Reservoir and tailwater, July 1, 1974-June 30, 1975 (± 80 percent confidence intervals in parentheses)

Species	Number			Kg			Lbs		
	Reservoir	Tailwater	Total	Reservoir	Tailwater	Total	Reservoir	Tailwater	Total
Striped bass	24,880 (3,890)	13,170 (4,221)	30,050	34,132 (6,352)	13,848 (5,222)	47,980	75,247	30,529	105,776
White bass	72,214 (14,003)	48,788 (11,512)	121,002	19,819 (1,235)	9,504 (2,263)	29,323	43,693	20,953	64,646
Largemouth bass	14,564 1/ (3,890)		14,564	6,634 (1,799)		6,634	14,625		14,625
Crappie	37,624 2/ (5,446)	85,603 (24,942)	123,227	6,056 (1,059)	16,835 (5,222)	22,891	13,351	37,114	50,465
Bluegill	12,137 3/ (4,668)	4,490 (3,837)	16,627	826 (353)	136 (129)	962	1,821	300	2,121
Channel catfish	23,060 (4,668)	17,360 (4,605)	40,420	11,286 (4,235)	4,073 (1,218)	15,359	24,881	8,979	33,860
Flathead catfish	1,821 (778)		1,821	4,679 (4,235)		4,679	10,315		10,315
Blue catfish	607 (778)		607	551 (353)		551	1,215		1,215
Carp	9,709 (3,112)	2,095 (1,535)	11,804	4,404 (1,412)	543 (522)	4,947	9,709	1,197	10,906
Drum	607 (778)	3,592 (1,535)	4,199	55 (35)	679 (348)	734	121	1,497	1,618
Other	607 4/ (778)	1,197 (767)	1,804	1,101 (1,059)	2,172 (1,741)	3,273	2,427	4,789	7,216

1/ Primarily largemouth bass; less than 0.5% spotted and smallmouth bass
2/ Primarily white crappie; less than 4% black crappie
3/ Primarily bluegill; less than 0.2% green sunfish and warmouth
4/ Includes paddlefish, sauger walleye, bullhead and gar

Table 29. -- Comparison of creel statistics collected at Keystone Reservoir during the period July 1, 1972-June 30, 1974 (annual average) and from July 1, 1974-June 30, 1975

	1972-74 (ann. avg.)	1974-75	Difference	
			No. Units	%
Angler counts and interviews				
No. angler counts (aerial)	17	32	+15	+88
No. anglers interviewed	9,018	659	-8,359	-93
No. fish/hour	0.8	0.33	-0.47	-59
Kg/hour	0.42	0.15	-0.27	-64
Lbs/hour	0.92	0.33	-0.59	-64
% successful	74.1	29.7	-44.4	-60
Pressure (expanded)				
No. hrs/ha	67.1	57.0	-10.1	-15
No. hrs/ac	27.1	23.1	-4.0	-15
No. trips/ha	16.8	14.3	-2.5	-15
No. trips/ac	6.8	5.8	-1.0	-15
Harvest (expanded)				
No. fish/ha	53.9	18.8	-35.1	-65
No. fish/ac	21.8	7.6	-14.2	-65
Kg/ha	27.8	8.5	-19.3	-69
Lbs/ac	24.8	7.6	-17.2	-69

counts per month) during the July 1, 1974 to June 30, 1975 survey. The observed increase in the number of angler counts may have increased the accuracy of the angling pressure estimates for the July 1, 1974 to June 30, 1975 creel over the July 1, 1972 to June 30, 1974 survey. However, the difference in estimated angling pressure for the two creel surveys was slight, 67 hrs/ha (27 hrs/ac) and/or 16.8 trips/ha (6.8 trips/ac) for the July 1, 1972 to June 30, 1974 survey. By comparison, 57 hrs/ha (23 hrs/ac) and/or 14.3 trips/ha (5.8 trips/ac) were estimated for the July 1, 1974 to June 30, 1975 survey. Overall, the annual angling pressure over the three-year period from July 1, 1974 through June 30, 1975 averaged 63.7 hrs/ha (25.8 hrs/ac) and/or 16 trips/ha (6.5 trips/ac).

The precipitous decline (93 percent) of the number of angler interviews conducted during the July 1, 1974 to June 30, 1975 survey (659 angler interviews), compared with the previous survey (9,018 angler interviews), may have adversely affected the accuracy of the July 1, 1974 to June 30, 1975 survey estimates of catch rate, angler success, average size of fish creeled, and species composition of the creel. As noted in Table 30, the catch rates (both numbers and weights of fish creeled) in the July 1, 1972 to June 30, 1974 creel survey were substantially higher for all species, with the exception of largemouth bass. The catch rate for crappies (0.44/hr) in the July 1, 1972 to June 30, 1974 creel survey, for example, was seven times higher than the estimate of 0.062 crappies/hr generated by the July 1, 1974 to June 30, 1975 creel statistics.

Substantial differences were also evident in the percentage composition of

Table 30. -- Keystone Lake -- Comparison of catch-per-unit effort for striped bass, white bass, largemouth bass, crappie and channel catfish from creel surveys conducted by ODWC from July 1, 1972-June 30, 1974 (annual average); July 1, 1974-June 30, 1975; and June 1, 1978-November 30, 1978

	Striped bass			White bass			Largemouth bass			Crappie			Channel catfish		
	1972-74	1974-75	1978	1972-74	1974-75	1978	1972-74	1974-75	1978	1972-74	1974-75	1978	1972-74	1974-75	1978
Catch rate															
No/hr	0.043	0.041	0.023	0.13	0.12	0.15	0.015	0.024	0.018	0.44	0.062	0.16	0.1	0.038	0.018
Kg/hr	0.060	0.056	0.026	0.051	0.033	0.02	0.011	0.011	0.006	0.12	0.010	0.013	0.1	0.019	0.002
Lbs/hr	0.13	0.124	0.058	0.11	0.040	0.044	0.024	0.024	0.014	0.27	0.022	0.029	0.22	0.041	0.005
Avg. Wt. (kg)	1.4	1.4	1.1	0.39	0.28	0.13	0.73	0.46	0.35	0.27	0.16	0.08	1.0	0.50	0.26

species creeled during the two survey periods (Table 31). Crappies made up over 55 percent of the total number of fish creeled during the July 1, 1972 to June 30, 1974 survey, contrasted to only 19 percent of the fish creeled during the July 1, 1974 to June 30, 1975 survey. Reflecting the reduced abundance of crappies, in part, the relative abundance of striped bass, white bass, largemouth bass, bluegills, and carp increased appreciably in the July 1, 1974 to June 30, 1975 survey. Little change occurred in the relative abundance of the remaining species.

Primarily as a result of higher prevailing catch rates, the estimated total fish harvest was over three times higher during the period July 1, 1972 to June 30, 1974, i.e., 27.8 kg/ha (24.8 lbs/ac), than the 8.5 kg/ha (7.6 lbs/ac) estimated during the July 1, 1974 to June 30, 1975 survey.

The estimated harvest of each individual species, by weight, was greater during the July 1, 1972 to June 30, 1974 survey (Table 32). Also, the estimated number of fish of each species harvested, with the exception of largemouth bass, was greater in the July 1, 1972 to June 30, 1974 survey. The estimated annual harvest over the three-year census period, July 1, 1972 to June 30, 1975 averaged 21.4 kg/ha (19.1 lbs/ac).

The standing crop (kg/ha) of sport fish species exhibited by cove-rotenone samples did not appear to be closely correlated with their occurrence in the creel. The average annual weight of striped bass harvested [3.7 kg/ha (3.3 lbs/ac)] was over 13 times greater than their standing crop, estimated from cove rotenone samples (0.5 kg/ha). It would appear reasonable to assume that the cove-rotenone sampling techniques employed in this invest-

Table 31. -- Average annual percentage composition (by number and weight) of species creeled in Keystone Reservoir; July 1, 1972 - June 30, 1974; July 1, 1974 - June 30, 1975 and June 1, 1978 - November 30, 1978

Species	Number			Weight[1]	
	July 1, 1972-June 30, 1974	July 1, 1974-June 30, 1975	June 1, 1978-Nov. 30, 1978	July 1, 1972-June 30, 1974	July 1, 1974-June 30, 1975
Striped bass	5.3	12.6	5.9	14.5	38.1
White bass	16.4	36.5	39.8	12.3	22.1
Largemouth bass[2]	1.9	7.4	4.7	2.6	7.4
Crappie[3]	55.1	19.0	42.4	30.0	6.8
Bluegill[4]	2.5	6.1	0.6	0.9	0.9
Channel catfish	12.5	11.7	4.7	24.1	12.6
Flathead catfish	1.7	0.9	0.3	6.0	5.2
Blue catfish	0.5	0.3	0.3	1.8	0.6
Carp	2.6	4.9	0.9	4.8	4.9
Drum	0.9	0.3	0.4	1.2	0.1
Other	0.6[5]	0.3[6]	--	1.8	1.2

1/ Total weight of fish not available from 1978 creel

2/ Primarily largemouth bass, less than 0.5 percent spotted and smallmouth bass

3/ Primarily white crappie, less than 4 percent black crappie

4/ Primarily bluegill, less than 0.2 percent green sunfish, warmouth, and rockbass

5/ Includes sauger, walleye, bullhead and gar

6/ Paddle fish

Table 32. -- Number and weight per unit surface area -- [ha (ac)] -- of fish creeled from Keystone Reservoir, July 1, 1972-June 30, 1975

	Number -- [no/ha (no/ac)]			Weight -- [kg/ha (lbs/ac)]		
	July 1, 1972-June 30, 1974	July 1, 1974-June 30, 1975	Annual Average	July 1, 1972-June 30, 1974	July 1, 1974-June 30, 1975	Annual Average
	(Avg. ann.)					
Striped bass	2.7	2.3	2.6	4.0	3.2	3.7
	(1.1)	(0.93)	(1.1)	(3.6)	(2.9)	(3.3)
White bass	8.9	6.8	8.2	3.4	1.9	2.9
	(3.6)	(2.8)	(3.3)	(3.05)	(1.7)	(2.6)
Largemouth bass	1.0	1.4	1.1	0.73	0.62	0.7
	(0.41)	(0.57)	(0.45)	(0.65)	(0.55)	(0.6)
Crappie	28.7	3.5	20.3	8.4	0.57	5.8
	(12.0)	(1.4)	(8.5)	(7.45)	(0.51)	(5.2)
Bluegill	1.3	1.1	1.2	0.22	0.08	0.2
	(0.54)	(0.45)	(0.49)	(0.20)	(0.07)	(0.18)
Channel catfish	6.7	2.2	5.2	6.7	1.1	4.8
	(2.7)	(0.89)	(2.1)	(6.0)	(0.98)	(4.3)
Flathead catfish	0.90	0.17	0.7	1.7	0.44	1.3
	(0.37)	(0.07)	(0.3)	(1.5)	(0.39)	(1.2)
Blue catfish	0.28	0.054	0.2	0.5	0.05	0.4
	(0.11)	(0.022)	(0.8)	(0.45)	(0.04)	(0.36)
Carp	1.4	0.91	1.2	1.3	0.41	1.0
	(0.57)	(0.37)	(0.5)	(1.2)	(0.37)	(0.89)
Drum	0.46	0.056	0.3	0.33	0.005	0.2
	(0.19)	(0.023)	(0.1)	(0.30)	(0.004)	(0.18)
Other	0.35	0.056	0.3	0,48	0.1	0.2
	(0.14)	(0.023)	(0.12)	(0.43)	(0.09)	(0.18)

igation provided grossly underestimated values of striped bass abundance. The standing crop of largemouth bass, onthhe other hand, 9.5 kg/ha, was over 13 times larger than the estimated annual harvest of 0.7 kg/ha.

The outstanding striped bass fishery provided by the project, both in Keystone Lake and the tailwater, was particularly noteworthy. An estimated average of 36,920 kg (81,400 lbs) were harvested annually from the lake over a three-year period (July 1, 1972 to June 30, 1974) at an average size exceeding 1 kg (2.2 lbs). This represents a harvest averaging 3.7 kg/ha (3.3 lbs/ac) at an average catch rate of 0.06 kg/hr (0.13 lbs/hr). The tailwater harvest (July 1, 1974 to June 30, 1975) amounted to an additional 13,170 kg (24,880 lbs). Striped bass accounted for 17 percent of the total weight of all fish harvested from the reservoir and comprised 72 percent of the weight of fish creeled in the tailwater.

This naturally reproducing population developed over the years as a result of a well conceived and executed stocking program conducted by the ODWC. Few, if any, bodies of freshwater in the United States provide better angling opportunity for striped bass than the Keystone project.

Fishery Resources -- Evaluation of Planning Input

The December 19, 1961, FWS report predicted that the Keystone Lake project would affect approximately 322 km (200 mi) of existing stream fisheries. This riverine habitat included approximately 193 km (120 mi) of the mainstream section of the Arkansas and Cimarron rivers and their tributaries subsequently impounded and 129 km (80 mi) segment of the Arkansas River downstream from the Keystone dam.

A reduction of the silt load carried by the Arkansas River below Keystone dam, combined with reduction in flood flows, were expected to improve fishing in the river between the dam and Tulsa, a distance of 24.1 km (15 mi). The 105 km (65 mi) section of the Arkansas River between Tulsa and its confluence with the Grand River was not expected to be appreciably improved because of the poor water quality below Tulsa during periods of low flow. In order to provide adequate water quality to sustain attractive fishing in the Arkansas River between the dam and Tulsa, the FWS recommended a minimum instantaneous release of 300 cfs from Keystone dam. This recommended action was sought only for the period preceeding initiation of power generation. It was assumed that power generation and navigation releases would provide, at least in part, protection of the downstream fishery and the FWS expected adequate adjustments of the specific release requirements for flow augmentation following initiation of power production.

An opportunity to enhance fishing on the remaining riverine habitat in order to compensate the permanent loss of a significant portion of this type of fishery resource by guaranteeing adequate minimum instantaneous flows, has been ignored. Contrary to guarantees extended by the construction agency that power production would supply a minimum of 520 cfs below the reregulation dam, flows in the Arkansas River as measured at Tulsa have been less than 300 cfs, an average of 20 days annually in 6 of the 13 years since impoundment. Water quality problems continue to adversely impact the assemblege of game fish that congregate below Keystone dam during the summer months. No water is released when power is not being generated,

and as a consequence, fish kills have occurred immediately below the dam.

Planning for fishery-related matters failed to address water level manipulation within the reservoir except to note an anticipated maximum fluctuation of 21.8 m (42 ft) and an annual average fluctuation of 4.7 m (15.3 ft). Over the period of record (1965-1978), the actual maximum water level fluctuation for the Keystone pool has been 11.5 m (37.8 ft) and has averaged 5.2 m (17.0 ft), annually. No specific requests were made by the pre-construction planner with regard to the possibility of minimizing water level fluctuations during the spring spawning season.

The FWS's recommendation to protect certain tracts of forested lands within the lake site to serve as attractive fishing sites when flooded by the waters of Keystone Lake was certainly reasonable and warrented. However, judging by the recent activities on behalf of both the CE and ODWC to construct artificial fish attractors, an insufficient number of such timbered locations were protected originally. The adopted plan, currently considered inadequate by the ODWC, resulted from cooperative planning efforts of all agencies involved, and was not the result of a failure to coordinate or failure to implement recommended actions.

With the project in place (and assuming no downstream low flow augmentation), the FWS planners predicted that the downstream fishery would provide an average of 14,000 angler-days annually over the life of the project. Approximately 10,000 angler-days were expected to occur within the 15 mile section of the Arkansas River between the dam and Tulsa, Oklahoma. Four thousand angler-days were estimated for the 65 mile river segment down-

stream from Tulsa. The lake fishery (assuming no implementation of the lake zoning recommendation) was expected to provide an additional 80,000 angler-days which would increase the total average annual number of project associated angler-days to 94,000 (Table 33).

The FWS further predicted that total project associated angling would be increased to 169,000 angler-days per year (an overall increase of 80 percent) with implementation of recommendations for a 300 cfs minimum instantaneous flow release from the lake and adoption of a reservoir zoning plan designed to minimize conflicts between anglers and general recreationists. The implementation of the 300 cfs instantaneous minimum release below the dam was expected to increase angling in the Arkansas River by some 107 percent (from 14,000 to 29,000 angler-days/yr). Angler-day usage within the lake was expected to increase 80 percent (from 80,000 to 140,000 angler-days) with adoption of an adequate lake zoning plan. Neither recommendation for the 300 cfs minimum instantaneous flow release nor lake zoning was subsequently implemented.

However, subsequent post-impoundment project angler-day usage, as documented by ODWC conducted creel surveys, substantially exceeded FWS planning report predictions for both the lake and tailwater. The total post-impoundment ODWC lake and tailwater angler-day use estimates (approximately 280,000 angler-days) was almost three times greater than the 94,000 angler-days predicted by the FWS report. The ODWC tailwater creel survey conducted from July 1, 1974 to June 30, 1975, estimated that 83,310 angler-days occurred in the stilling basin and the Arkansas River immediately below the Keystone dam. This ODWC angling pressure estimate (restricted to a

Table 33. -- Comparison of post-impoundment angler-day use predicted by the FWS's December 19, 1961, report and estimated angler-day use post-impoundment occurrence as derived from ODWC creel surveys from July 1, 1972 to June 30, 1975

	Predicted					
	w/o lake zoning and/or min. flow release	With lake zoning and/or min. flow release		Estimated Occurrence	Difference[1]	
	Angler-days	Angler-days	% inc.	Angler-days	Angler-days	%
River						
Between dam and Tulsa	10,000			82,310	+72,310	+723
Below Tulsa	4,000					
Total River	14,000	29,000[2]	107.1	82,310[3]	+68,310	+488
Lake	80,000	140,000	75.0	186,487	106,487	+133
Total project	94,000	169,000	79.8	278,797	184,739	+197

1/ Represents difference between estimated occurrence and predictions made without reservoir zoning and/or 300 cfs minimum as these recommendations were never implemented

2/ Predicted total number of angler-days were not differentiated by river segment

3/ Includes only the tailwater area immediately below dam

small area immediately below the dam) was almost 500 percent greater than the 14,000 angler-days predicted by the FWS for a vastly larger stream section which extended 129 km (80 mi) below the dam.

The ODWC average annual post-impoundment lake angler use estimate, 186,487 angler-days, was more than double the FWS report prediction of 80,000 angler-days, which assumed the absence of lake zoning to favor anglers. The ODWC post-impoundment angler use estimate was also higher than the 140,000 angler-days predicted by the FWS report assuming implementation of lake zoning recommendations.

As the observed post-impoundment angler-day use values were considerably higher than predicted, even though the FWS recommendation for lake zoning was never implemented, it appears doubtful that the substantial angling benefits (an increase of 75 percent) attributed to reservoir zoning in the FWS report were warrented. Apparently, the degree of competition between anglers and general recreationists was not as great as originally envisioned by the authors of the FWS report.

As indicated in Table 34, post-impoundment angler-day use within the area of project impact (both lake and tailwater) greatly exceeded without-the-project angler-day use estimates as projected in the FWS report. Total annual project post-impoundment angler-day usage (278,797 angler-days as estimated by ODWC creel surveys) was over 16 times greater than the potential 17,000 angler-days/year expected without-the-project.

The December 19, 1961, report of the FWS anticipated that Keystone Lake

would support a commercial fishery. An annual benefit of $19,000 was projected. Subsequent post-impoundment cove rotenone sampling conducted by the ODWC revealed a substantial population of commercially valuable species (buffalo, carp and drum) within the Keystone Lake fish community. However, commercial fishing was never allowed because of conflict with an ODWC regulation which prohibits commercial fishing in water stocked with striped bass.

SUMMARY

The project is located within the Arkansas River Valley about 14 miles west of Tulsa, Oklahoma, in Creek, Pawnee, Payne, Osage and Tulsa counties. The dam is located at kilometer 866.9 (mile 538.8) of the Arkansas River approximately 3.2 km (2 mi) downstream from the mouth of the Cimarron River.

Construction of Keystone Dam began in December 1956 and was completed for flood control operation in September 1964. Commercial operation of the power plant began in May of 1968. Under current operating regimes, the reservoir encompasses 10,530 surface ha (26,020 ac) at conservation pool elevation 220.4 m (723 ft) msl. At the top of the flood control pool elevation 229.8 m (754 ft) msl (which corresponds to the predicted 5 year flood frequency level), the reservoir covers 22,338 ha (55,320 ac) and impounds 2.3 x $10^9 m^3$ (1,879,000 ac ft). Project lands total 29,906 ha (73,896 ac), including 19,995 ha (49,308 ac) purchased in fee up to the five-year flood pool elevation and an additional 9,950 ha (24,587 ac) of flowage easements located between elevation 229.8 m (754 ft) and 231.3 m (759 ft) msl.

The December 19, 1961, FWS planning report contained three well conceived recommendations pertinent to project wildlife resources. These recommendations included (1) a request for development of a zoning plan to insure that certain areas would be available for wildlife purposes without conflicting use for general recreation, (2) that all project lands acquired be clearly marked to delineate areas open to hunting and (3) that an ap-

proximate 3,701 ha (9,145 ac) contiguous tract located on the Cimarron arm of the reservoir be purchased in fee, fenced at project expense, and licensed to the ODWC for wildlife management purposes.

The recommendation for a zoning plan was subsequently implemented by the CE in cooperation with the ODWC and FWS. All areas off limits to hunting on CE administered lands, such as high density recreational areas and parks, have been identified and signed. Signing of areas open to public hunting is currently under way.

The CE rejected the FWS's recommendation for the purchase of the requested contiguous 3,701 ha (9,145 ac) tract on the Cimarron arm of the reservoir because of unfavorable cost-benefit ratio (0.1) as computed by the CE. Ultimately, however, a total of 6,273 ha (15,500 ac) of incidentally acquired project property, divided between the Cimarron and Arkansas River arms of the reservoir, was licensed to the ODWC in 1974 for wildlife management purposes. This tract included 4,970 ha (12,280 ac) of land and 1,303 ha (3,220 ac) of water. Including the lands licensed to the ODWC and an additional 1,305 ha (3,220 ac) managed by the CE for wildlife, a total of 6,274 ha (15,504 ac) of project lands are open to public hunting.

The prediction of severe terrestrial wildlife community losses in association with construction of Keystone Lake (unless compensated by acquisition of special mitigation lands) does not appear to be supported by post-construction information, although such information is severely limited. Hunting effort currently supported by the project [one hunter-trip/1.4 ha (3.2 ac)] is greater than the FWS predicted hunting levels for resident

terrestrial game species in the project area under without-project conditions. However, compensation has been achieved only as a result of intensive management involving substantial monetary outlays by the ODWC for fencing and habitat improvement programs.

The 1961 FWS report predictions of hunter-day use were far outside of estimated post-impoundment occurrences, particularly for waterfowl and big game hunter-day use. The 1961 FWS report predicted a total loss of big game hunting on project lands without implementation of the recommended mitigation plan, and only 130 hunter-days per year assuming the mitigation plan was implemented. The post-impoundment hunting effort estimated for big game species (905 hunter-days per year) was seven times higher than the level predicted assuming implementation of the mitigation plan.

The optimistic 1961 FWS report prediction for waterfowl hunter use (9,800 hunter-days) failed to materialize. This prediction, which was made independently of the implementation of any proposed mitigation recommendations, exceeded the ODWC estimate of current usage (350 hunter man-days) by some 28 times.

The significance of this excessively overly-optimistic waterfowl hunter man-day use prediction is further compounded by the fact that waterfowl hunter-day use constituted a majority of the total post-impoundment hunter-day use projected for the project (some 82 percent without mitigation and 60 percent with mitigation) which was used by the CE in computing the project cost-benefit ratio. A more accurate assessment of waterfowl hunter-day usage would have substantially lowered FWS estimates of project

wildlife benefits.

FWS report post-impoundment predictions for upland game hunter-day use (2,100 hunter-days without mitigation and 6,400 hunter-days with mitigation) were more accurate than for big game and waterfowl, although proving to be somewhat lower than ODWC estimated post-impoundment occurrences (6,690 hunter-days).

The Keystone Lake project was expected to impact approximately 322 km (200 mi) of existing stream fisheries, including 193 km (120 mi) of the mainstream section of the Arkansas and Cimarron Rivers and their tributaries which were subsequently impounded, and a 129 km (80 mi) segment of the Arkansas River downstream from the Keystone dam.

The FWS recommended a minimum instantaneous release of 300 cfs from Keystone dam during the period preceeding initiation of power generation in order to provide adequate water quality to sustain attractive fishing in the Arkansas River between the dam and Tulsa. It was assumed that power generation and navigation releases planned by the CE would provide, at least in part, protection of the downstream fishery after initiation of power production. Contrary to guarantees extended by the construction agency that power production would supply a minimum of 520 cfs below the reregulation dam, flows in the Arkansas River as measured at Tulsa have been less than 300 cfs, an average of 20 days annually in 6 of the 13 years since impoundment. Water quality problems continue to adversely impact the assemblege of game fish that congregate below Keystone dam during the summer months. No water is released when power is not being generated,

and as a consequence, fish kills have occurred immediately below the dam.

The FWS 1961 report also recommended that a mutually acceptable reservoir clearing plan be developed cooperatively by the Corps of Engineers, the U.S. Public Health Service, the Oklahoma Department of Wildlife Conservation, and the Bureau of Sport Fisheries and Wildlife. This recommendation was subsequently accepted and implemented by the CE. However, judging by the recent activities on behalf of both the CE and ODWC to construct artificial fish attractors, an insufficient number of such timbered locations were protected originally. The adopted plan, currently considered inadequate by the ODWC, resulted from cooperative planning efforts of all agencies involved, and was not the result of a failure to coordinate or failure to implement recommended actions.

The third fishery resource related recommendation requested that appropriate consideration be given to the development of a reservoir zoning plan in cooperation with the ODWC to insure that certain areas will be available for fishing and other wildlife purposes without conflicting use for general recreation. Although accepted by the CE, this recommendation, as it affected fishery resources, was never implemented.

Planning for fishery-related matters failed to address water level manipulation within the reservoir except to note an anticipated maximum fluctuation of 21.8 m (42 ft) and an annual average fluctuation of 4.7 m (15.3 ft). Over the period of record (1965-1978), the actual maximum water level fluctuation for the Keystone pool has been 11.5 m (37.8 ft) and has averaged 5.2 m (17.0 ft), annually. No specific requests were made by the

pre-construction planner with regard to the possibility of minimizing water level fluctuations during the spring spawning season.

FWS prediction of angler-day use in both the lake and tailwater were substantially exceeded by post-impoundment estimates derived from ODWC conducted creel surveys. The combined post-impoundment ODWC lake and tailwater angler-day use (estimated at 278,797 angler-days) was almost three times greater than the 94,000 angler-days predicted by the FWS report. An estimated 83,310 angler-days occurred in the stilling basin and the Arkansas River immediately below the Keystone dam, which was almost 500 percent more than the 14,000 angler-days predicted by the FWS for a vastly larger stream section extend 129 km (80 mi) below the dam.

The ODWC average annual post-impoundment lake angler use estimate of 186,487 angler-days, was more than double the FWS report prediction of 80,000 angler-days, which assumed the absence of lake zoning to favor anglers, and also higher than their 140,000 angler-days prediction which was predicated on the assumption that lake zoning would be implemented.

Also, estimated post-impoundment angler-day use within the area of project impact (both lake and tailwater) greatly exceeded FWS without-the-project angler-day use projections for streams within the project impact area. Total annual project post-impoundment angler-day usage (278,797 angler-days as estimated by ODWC creel surveys) was over 16 times greater than the 17,000 angler days/year estimate expected without the project by the FWS.

REFERENCES

1. Tulsa District. 1975. Final environmental statement, operation and maintenance program, Keystone Lake, Arkansas River, Oklahoma. Tulsa District, Corps of Engineers, Tulsa, Oklahoma.

2. Hardridge, Joe. 1974. Keystone Public Hunting Area -- Program narrative development, Oklahoma Department of Wildlife Conservation, Pittman-Robertson Proj. W-115-D-1.

3. Bennett, Carey H. 1961. Report on the fish and wildlife resources in connection with the Keystone Reservoir project, Arkansas River, Oklahoma. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. December 19, 1961.

4. Tulsa District. 1973. Appendix D, fish and wildlife management plan, to design memorandum 12B, the master plan for Keystone Reservoir. Tulsa, Oklahoma. May 1973.

5. Wiecking, E. H. 1960. Report on the panel on recreational values of the Subcommittee on Evaluation Standards (Inter-Agency Committee on Water Resources). May 24, 1960.

6. Tulsa District. 1963. Supplement no. 1 to design memorandum no. 4, general design for Keystone Dam and Reservoir, Arkansas River, Oklahoma, Tulsa, Oklahoma. April 2, 1963.

7. Oklahoma Department of Wildlife Conservation. 1971. Letter from Director to U.S. Army Corps of Engineers, Tulsa District, dated January 7, 1971.

8. U.S. Army Corps of Engineers, Tulsa District. 1972. Letter from District Engineer to Director of Oklahoma Department of Wildlife Resources dated August 23, 1972.

9. Oklahoma Department of Wildlife Conservation. 1972. Letter from Director to U.S. Army Corps of Engineers, Tulsa District, dated October 13, 1972.

10. U.S. Fish and Wildlife Service. 1972. Letter from Acting Regional Director, Albuquerque, New Mexico to U.S. Army Corps of Engineers, Tulsa District dated October 27, 1972.

11. Hardridge, Joe. 1978. Keystone Public Hunting Area -- progress report Oklahoma Department of Wildlife Conservation. Pittman-Robertson Proj. W-115-D-4.

12. Hardridge, Joe. 1977. Keystone Public Hunting Area -- progress report Oklahoma Department of Wildlife Conservation. Pittman-Robertson Proj. W-115-D-3.

13. Garrison, Neil. 1978. Letter of March 19, 1978, from Tulsa Audubon Society to Pete Wilkerson, U.S. Fish and Wildlife Service, Tulsa, Oklahoma.

14. Derdeyn, Clark. 1975. Keystone Public Hunting Area -- progress report Oklahoma Department of Wildlife Conservation. Pittman-Robertson Proj. W-115-D-1.

15. Hardridge, Joe and Clark Derdeyn. 1976. Keystone Public Hunting Area -- progress report. Oklahoma Department of Wildlife Conservation. Pittman-Robertson Proj. W-115-D-2.

16. Linton, Thomas L. 1961. A study of fishes of the Arkansas and Cimarron Rivers in the area of the proposed Keystone Reservoir. Oklahoma Fishery Research Laboratory, Report Number 81. Norman, Oklahoma. July, 1961.

17. Tulsa District. Unpublished. Monthly reservoir regulation charts, Keystone Reservoir, Arkansas River Basin. Tulsa District, U.S. Army Corps of Engineers (Multilith). Tulsa, Oklahoma.

18. Mason, Loren M. 1972. Memorandum regarding Keystone Lake - development of plan and method to prevent fish kills immediately below the dam. Tulsa District, U.S. Army Corps of Engineers. Tulsa, Oklahoma. September 27, 1972.

19. Bishop, B. J. 1975. Memorandum - Keystone Lake - Operational procedures to prevent fish kills below the dam. Tulsa District, U.S. Army Corps of Engineers. Tulsa, Oklahoma. June 24, 1975.

20. Erickson, Kim E. 1972. The effect of lake level fluctuation on largemouth bass production, Keystone Reservoir, 1965-1972. Oklahoma Department of Wildlife Conservation. Tulsa, Oklahoma. November 3, 1972.

21. Oklahoma Department of Wildlife Conservation. Unpublished. Cove rotenone sampling forms for Keystone Lake. (Multilith). Tulsa, Oklahoma.

22. White, Thomas F. Unpublished. Reservoir predator-stocking evaluation, sport fish harvest estimates for Keystone Lake. Field form PSE-9 for July, 1972 through June 1974. Oklahoma Department of Wildlife Conservation, Fisheries Research Lab. Norman, Oklahoma.

23. Summers, Gregory L. 1978. Sportfishing statistics of Oklahoma reservoirs. Oklahoma Department of Wildlife Conservation, Oklahoma Fishery Research Laboratory, Bulletin No. 14. Norman, Oklahoma.

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