Resource Management Assessment
Republican River Basin

Water Service Contract Renewal

July 1996

U.S. Department of the Interior

Bureau of Reclamation

Great Plains Region

No. 126, Orig.
Ex. K80

KS001295

Executive Summary

This Bureau of Reclamation Resource Management Assessment (RMA) describes the Republican River Basin and its resources. It also analyzes resource management scenarios that will provide information for National Environmental Policy Act compliance before renewing long-term water service contracts with irrigation districts along the Republican River in Kansas and Nebraska. These contracts are with the Frenchman-Cambridge, Bostwick in Nebraska, Kansas Bostwick No. 2, and Frenchman Valley Irrigation Districts.

The purpose of the RMA is to document historic and contemporary resource conditions associated with management of federally developed surface water supplies in the basin. The RMA addresses changes in resources within the basin since the original contracts were signed in the 1950's. Technological changes and new land use practices have affected the available surface water supplies.

The RMA is needed to provide a comprehensive consideration of the biological, economic, and social impacts related to the development of Federal surface water supplies and associated water service contracts in the Republican River Basin.

The document describes the characteristics of the basin and then presents current data on the following basin resources: water supply and uses; water quality; socioeconomics, including agricultural production and value; recreation; fish and fisheries; other wildlife, including endangered species; cultural resources; aesthetic values; and Indian Trust Assets. The document also describes additional data needs and management objectives.

Finally, the RMA presents possible water management scenarios. The purpose of developing and evaluating these scenarios is to measure how potential changes in the available flows in the river and/or storage in the reservoirs would affect water users in the basin. Users may include irrigators, recreationists, fishing enthusiasts, boaters, municipalities, industry, and others.

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Resource Management Assessment Republican River Basin Water Service Contract Renewal

Part I—Purpose and Need

Introduction

This Resource Management Assessment (RMA) describes the Republican River Basin and its resources, and it analyzes resource management scenarios that will provide information for National Environmental Policy Act (NEPA) compliance before renewing long-term water service contracts with irrigation districts along the Republican River in Kansas and Nebraska. Bureau of Reclamation (Reclamation) contracts with the Frenchman-Cambridge and Bostwick Irrigation District in Nebraska and the Kansas Bostwick No. 2 Districts and Frenchman Valley Irrigation District expire in 1996 and 1997, respectively. The contract for Almena Irrigation District No. 5 in Kansas expires in 2007. Contracts for the first four districts are being proposed for renewal under this process. Almena Irrigation District has chosen to renegotiate its contract before the contract expiration date in 2007. Because of their age, neither construction of the Federal irrigation projects nor their associated water service contracts have been comprehensively evaluated under NEPA or other appropriate Federal environmental statutes.

The RMA addresses changes in resources within the basin since the initial contracts were signed in the 1950's. In particular, technological changes in agriculture have affected the available surface water supplies. With the advent of center pivot irrigation systems, there was a marked increase in the number of irrigation wells constructed in the 1960's and 1970's. Many of these wells are located in aquifers adjacent to the Republican River and its tributaries. In some areas, well construction may have lowered aquifer levels, resulting in a decrease in the historical discharge from the aquifers to the streams. Reduced aquifer discharge has contributed to a reduction in the volume of surface water in the Republican River Basin.

Since the 1930's, surface runoff has been decreased by changes in land use practices such as terracing, contouring, crop residue management, and improved rangeland management. Stock ponds and other detention impoundment structures were constructed to prevent erosion. These practices have resulted in a significant reduction in surface runoff. Improvement of irrigation methods has brought about the development of areas previously thought nonirrigable. In addition to technological changes, there are some indications that the precipitation regime in some areas may have changed, with a decrease in the frequency of high surface runoff and flows.

Organization

This document includes four parts. Part I discusses the purpose of and need for the RMA, describes the study area, and cites existing and potential management objectives and scenarios. Part II describes the irrigation districts and the water resource and related resources. Part III discusses other area resources, including agriculture, recreation, and fish and wildlife. Part IV identifies possible scenarios for managing the area's water resource.

Purpose of and Need for the Resource Management Assessment

The expiration of several Federal water service contracts within a large watershed at approximately the same time affords Reclamation the uncommon opportunity to evaluate project operation, associated benefits and impacts, and all potential beneficial uses of federally developed surface water supplies on a watershed scale. This information is important for an understanding of the direct, indirect, interrelated, and cumulative effects associated with Federal development of surface water within a watershed. It also makes possible an understanding of the potential for integrated management of Federal surface water development projects. Integrated project operation could potentially enhance benefits associated with the reservoirs.

The purpose of the RMA is to document historic (pre-impoundment) and contemporary resource conditions associated with management of federally developed surface water supplies in the Republican River Basin. Where discernible, the RMA will also identify trends in resource use and management and, through the use of existing information, propose goals and objectives for resource management basin-wide. Ultimately, the RMA will identify feasible scenarios for management of water-related resources in the Republican River Basin. These scenarios will be further screened and evaluated prior to their consideration as reasonable alternatives in the comprehensive site-specific environmental impact statement (EIS).

Efforts will be made to balance the needs of the irrigation districts with water needs for fish and wildlife, recreation, and other beneficial uses. Establishing resource management goals in the basin and eliciting input from the public will allow development of operational and resource management goals and objectives that take into account broader interests in the basin. This study could also be used as a model for similar efforts in other basins where contract renewals are required.

The need for the RMA is reflected by the absence of previous comprehensive consideration of the biological, economic, and social impacts related to the development of Federal surface water supplies and associated water service contracts in the Republican River Basin. The consideration of all federally developed surface water supply projects in the basin simultaneously warrants an extraordinary effort to document the condition of existing resources and the significant issues associated with their management.

Compliance

In implementing any proposals related to the RMA or subsequent documents, Reclamation would follow provisions of acts which address NEPA, Fish and Wildlife Coordination, National Historic Preservation, Endangered Species, Reclamation Reform, Clean Water, Clean Air, Native American Graves Protection and Repatriation, and American Indian (Indian) Religious Freedom; Executive orders on flood plain management, wetlands protection, environmental justice in minority and low-income populations, and sport fisheries improvement; the Republican River Compact; and any other relevant and appropriate guidelines, legislation, or agreements, including that protecting Indian Trust Assets (ITAs).

Setting

The study area includes the entire drainage basin of the Republican River and its tributaries in Colorado, Nebraska, and Kansas down to the upper end of Milford Lake in Kansas, as shown on the accompanying map.

The Republican River is located along the Kansas-Nebraska border and drains portions of three states. The drainage area is approximately 24,900 square miles, of which 7,700 square miles are in Colorado, 9,700 square miles are in Nebraska, and 7,500 square miles are in Kansas. The river is formed by the junction of the Arikaree and North Fork Republican Rivers near Haigler, Nebraska. From Haigler, the river flows in an easterly direction to Junction City, Kansas, where it joins the Smoky Hill River to form the Kansas River. The watershed has an approximate length of 430 miles. The principal tributaries downstream from the confluence of the Arikaree and North Fork Republican Rivers are: South Fork Republican River and Frenchman, Blackwood, Driftwood, Red Willow, Medicine, Beaver, Sappa, Prairie Dog, and White Rock Creeks.

Four Reclamation water resource development divisions of the Pick-Sloan Missouri Basin Program are included in the study area. These include the Upper Republican, Frenchman-Cambridge, Kanaska, and Bostwick Divisions. The Frenchman-Cambridge and Frenchman Valley Irrigation Districts are in the Frenchman-Cambridge Division in Nebraska, with water for irrigation supplied from Hugh Butler, Harry Strunk, and Swanson Lakes and Enders Reservoir. Bostwick Irrigation District in Nebraska and Kansas Bostwick No. 2 Irrigation

District are in the Bostwick Division, with irrigation water supplied by Harlan County Lake and Lovewell Reservoir in Nebraska and Kansas, respectively. Almena Irrigation District No. 5 is in the Kanaska Division, with water for irrigation, municipal, and industrial use supplied by Keith Sebelius Lake. The Upper Republican Division contains Bonny Dam and Reservoir, which is operated and maintained primarily for flood control and fish, wildlife, and recreation use. In 1982, the State of Colorado purchased the conservation space in Bonny Reservoir for fish, wildlife, and recreation use.

The surface water area of the basin is nearly 41,000 acres. Over 40,000 acres are contained in reservoirs larger than 40 surface acres. Major reservoirs constructed between 1949 and 1964 include Bonny (Colorado); Swanson Lake, Enders Reservoir, Hugh Butler Lake, Harry Strunk Lake, and Harlan County Lake (Nebraska); and Keith Sebelius Lake and Lovewell Reservoir (Kansas). All are Reclamation facilities, except Harlan County Lake, which is a Corps of Engineers (Corps) facility.

The basin is located in one of the most productive agricultural regions of the United States, with large acreages of winter wheat, sorghum grain and silage, dry beans, corn, and sugar beets. Population has been slowly declining over the years, particularly in rural areas, as mechanization of farms and the farm economy have eliminated many jobs. Although the basin accounts for 10.1 percent of the total area in Kansas, Nebraska, and Colorado, the 169,025 people represented only 2.5 percent of the total population of the three states in 1980. The basin had 4.9 people per square mile in 1990, compared to 28 people per square mile on average in the three states, and 70.3 people per square mile in the Nation as a whole.

Over 90 percent of the area in the Republican River Basin is used for agricultural purposes, with over 50 percent cropland and less than 1 percent forest. The balance of the land is pasture and rangeland, farmsteads, wildlife areas, water, and miscellaneous areas (Reclamation, 1985). Public lands, managed for fish and wildlife resources, comprise only 0.8 percent of the 24,900 square miles of the basin. There are 45 public areas which include over 82,500 acres of upland habitat, over 4,700 acres of wetlands, over 40,000 surface acres of reservoirs and lakes, and 2.75 miles of river. Most of the land within the Republican River Basin is privately owned and, therefore, the public areas around reservoirs represent important wildlife management areas.

Fishing, hunting, and water-related recreation play an increasingly important component in the economy since there are 128,000 acres of public use areas in the basin. In 1995, approximately 99,000 anglers fished for 442,000 hours in the Nebraska portion of the Republican River and reservoirs. Channel catfish, drum, and white bass dominated the catch in the river, while white bass dominated the catch in all reservoirs except Enders, where walleye was most abundant in the creel. Hunters seek deer, antelope, ring-necked pheasant, bobwhite quail, wild turkey, mallard, green-winged teal, wood duck, pintail, and Canadian geese.

Physical Characteristics

The Republican River Basin displays considerable topographic diversity. Undulating tablelands dominate the landscape near the river's headwaters in northeastern Colorado. These tableland features grade north and eastward into a flat, dune-covered area having sandy soils, a poorly developed surface drainage network, and no through-flowing streams. Farther eastward and downstream, the width of the basin narrows considerably, with the river flowing through a flat-floored, bluff-lined valley averaging 200 to 400 feet in depth. Tributaries flowing into the river from the north have produced dissected areas of loess tables and steep-sided canyons with considerable local relief. Steep and narrow divides are common in this area. A notable feature among these canyons is their relatively flat grassy floors.

The long tributaries that flow into the river from the south developed in geologic formations which differ markedly from those found north of the river and have produced prominent upland divides. The complex drainage network associated with these tributaries has produced many small, rounded hills and interfluvial ridges. Many of these tributaries flow through deeply dissected areas with narrow, steep-walled canyons. These features contrast markedly with the flat uplands and their numerous undrained depressions and shallow swales also found in the watershed south of the river (Frye and Leonard, 1949; Walters, 1956). East of Harlan County Lake, tributaries entering the river from the north are generally short and are surrounded by broad, fertile loess plain uplands. As the river enters Kansas, the valley is characterized by broad alluvial bottoms and prominent divides with rocky ledges.

Sandhills located in the northwest section are the major topographic feature of the upper basin. The sandhills are sand dunes that have been stabilized by a cover of grass. During periods of high groundwater levels, small lakes may form in the troughs of the dunes. The uplands are dotted with many depressions, ranging from a few feet to several thousand feet in diameter and depths from shallow to 40 feet. After a heavy rain, these depressions may retain water for weeks or months.

The drainage pattern of the Republican River Basin is characterized by irregular branching of tributaries. This implies that the underlying strata is relatively flat, and there is a lack of structural controls such as faults and folds.

Climate

The Republican River Basin has a subhumid to semiarid continental climate. The variable weather is typical of the interior of a large land mass in the temperate zone: light rainfall, low humidity, hot summers, and cold winters. Rapid weather changes are caused by invasions of larger masses of warm, moist air from the Gulf of Mexico; hot, dry air from the southwest; cool, dry air from the Pacific Ocean; and cold, dry air from Canada. Temperatures vary from extremes of winter cold to those of summer heat.

There is a large variation in precipitation from year to year within the basin. The mean annual precipitation varies from nearly 18 inches in the western part of the basin to 30 inches in the eastern part. Seventy-seven percent of the annual precipitation usually falls during the growing season (April through September).

Soils

The soils of the Republican River Basin are very productive and are used primarily for growing both dryland and irrigated crops. The loessial soils of the uplands are the most important both in extent and productivity. This group is comprised primarily of deep, nearly level to strongly sloping, well-drained silty soils. Generally, these soils are found in the eastern two-thirds of the Nebraska portion and to a smaller extent the northern portion of Kansas.

The alluvial soils along the Republican River and its tributaries are deep and lie on nearly level flood plains. These soils are medium textured but are generally more calcareous in their subsoils than are the soils on the uplands. Some moderately deep soils in this group occur in the westernmost portion of the basin as well as the north-central portion of the Kansas counties.

Soils associated with the sandhills of southwestern Nebraska are generally deep, gently sloping to very steep, excessively drained, sandy soils formed in eolian sands on uplands. Between sandhill areas are soils which include both deep and shallow, nearly level to gently sloping, well-drained loamy and silty soils formed in weathered sandstone and loess on uplands.

Management Goals and Objectives

Introduction

Goals and objectives for the future management of water-related resources have been developed using public input, Reclamation studies and analyses, and existing Federal, state, and local planning and other documents. Identified trends, goals, and management objectives were used to develop a range of management scenarios that respond to the range of water needs in the basin. The scenarios, in turn, will be further evaluated to determine the range of reasonable alternatives that will be analyzed in the EIS. These goals and objectives will be used to compare and measure the impacts of the alternatives.

Aesthetic Values

Expansive grasslands and groves of trees represent the aesthetic ideal of the Great Plains to segments of our society. On the other hand, broken prairie and monocultural fields of grain represent economic vitality and are attractive to others. Individual perceptions of aesthetic quality depend upon a myriad of economic, social, and philosophical factors. Aesthetic qualities at a site can be both positive and negative, depending upon the individual.

It was difficult to locate existing goals for aesthetic values in the basin; however, it would not be unreasonable to establish a goal which maintains and/or enhances existing natural visual qualities. Attaining such a proposed goal could be accomplished by re-establishing grasslands, planting trees, establishing shelterbelts and windbreaks, increasing management of livestock and feedlots, and modifying the operation of surface impoundments to maintain minimum streamflows and minimize the area of exposed unvegetated shoreline.

Recreation

The Nebraska Game and Parks Commission (NGPC) and the Kansas Department of Widlife and Parks manage the lands associated with Reclamation reservoirs in the basin. Reclamation endorses their goals of providing diverse and quality outdoor recreation opportunities while protecting associated natural resources. Reclamation's goals, as landowner and resource steward, are to maintain public access to its reservoirs and associated lands and to operate them to sustain land- and water-based recreation.

One specific management goal would be to maximize recreational opportunities at Republican River Basin reservoirs. This could include preparing for draw-downs by proper placement of boat ramps. Other activities might include improving access to the river for fishermen or boaters.

Fish and Wildlife Resources

The NGPC and the Kansas Department of Wildlife and Parks have written management plans for reservoirs and state-managed lands in the Republican River Basin, but no basin-wide or state-wide management plans have been developed. Their reservoir management plans focus on conserving and enhancing game species by augmenting populations and enhancing habitat values. Reclamation supports the agencies' goals of providing fish and wildlife recreation opportunities and protecting threatened and endangered species. Reclamation's goals are to manage reservoir operations to sustain both reservoir sport fisheries and native riverine fishes and to encourage and support management practices which benefit biodiversity and game and nongame wildlife.

Management goals for fish and wildlife focus on increasing the population of game species (table 1). Fisheries goals are expressed in catch per unit effort, total catch by species, and minimum drawdown elevations. Stocking and maintaining a forage base for sport fish represents the most common recommendation for increasing populations. In addition to objectives for game species, state wildlife goals include habitat enhancement to benefit prairie dog populations, which are prey for the endangered black-footed ferret. In both game and

Table 1.—Species of concern in fish and wildlife management plans

Wildlife	Fishes
White-tailed deer	White bass
Mule deer	White bass x striped bass (wiper)
Ring-necked pheasant	Walleye
Waterfowl	Northern pike
Bobwhite quail	Crappie
Cottontail rabbit	Channel catfish
Mourning dove	
Turkey	
Fox squirrel	

nongame species, wildlife goals are achieved by maximizing diversity of habitat types. Vegetation is manipulated by planting food plots, shrubs, permanent cover, and mast-producing trees; and controlling vegetation with fire, grazing, and mechanical disturbance. The U.S. Fish and Wildlife Service (Service) does not have management goals for fish and wildlife that are specific to the Republican River (Service, 1996).

One goal for fisheries in the Republican River system might be to optimize walleye production within the reservoirs. Instream flow protections and removal of any migration barriers would also be desirable. Finally, efforts could be made to avoid fishkills through operational changes.

Wetland and Riparian Areas

The States of Nebraska and Kansas manage wetlands and riparian areas to maintain and enhance their contributions to society and the environment in harmony with socioeconomic considerations. Executive Order 11990 requires Reclamation and other Federal agencies to "provide leadership and . . . take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for . . . managing . . . Federal lands and facilities."

Endangered Species

Endangered species and critical habitat will be managed and protected in accordance with the Endangered Species Act (ESA). Various efforts will be directed at every opportunity towards improving habitat for endangered species.

Irrigation

Reclamation's goal is to supply irrigation water to the districts in accordance with the water service contracts and applicable law, policy, and regulations.

Socioeconomic

A goal is to assure that social and economic aspects associated with contract renewals in the Republican River Basin are thoroughly examined and addressed; and to manage, develop, and protect water and related resources in an economically and socially acceptable manner.

Cultural Resources

The primary goal for cultural resources management is to locate, evaluate, and inventory all sites that would be affected by operations of the Federal projects. The goal for those sites on the inventory determined to be significant and eligible for the *National Register of Historic Places* is to preserve and protect them, in place, when that is feasible. When preservation is not feasible, damage will be mitigated in a way that is determined in consultation with the appropriate entities. These would include the State Historic Preservation Office; Indian tribes which may be historically associated with site occupants; the Advisory Council on Historic Preservation; and other interested parties, when deemed appropriate. Mitigation measures might include scientific data recovery, interpretation, and public education of the sites' history, or other measures.

Water Quality

Reclamation initiated a water quality sampling program in September 1994 to assess the presence or absence of organic and inorganic compounds on selected sites within the study area. This investigation has been conducted in part under Public Law 99-294 of 1986, which requires an investigation of soil characteristics that might result in toxic or hazardous irrigation return flows.

The objective of this program is to determine potential environmental effects in the basin above and below suspected selenium source areas. Data results from water, sediment, and biota monitoring will be used in an aquatic hazard assessment of selenium in terms of potential for food chain bioaccumulation and reproductive impairment in fish. Once the degree of selenium hazard is identified, appropriate management actions can be considered.

Management Scenarios

After public meetings in 1995 to identify problems and needs, on February 29, 1996, Reclamation filed with the Council on Environmental Quality a notice of intent to prepare a draft EIS on the proposed renewal of the long-term water service contracts in the Republican River Basin. The filing is a legally required step to formally inform the public that Reclamation is commencing the preparation of a draft EIS.

As a preliminary step to preparing a draft EIS, Reclamation compiled this RMA, which is designed to describe existing resources in the basin, define water needs, and begin to consider ways to meet those needs. It also includes a range of potential future management scenarios.

The purpose of evaluating the potential management scenarios is to measure how potential changes in the available flows in the river and/or storage in the reservoirs would affect various water uses in the basin. The scenarios are a first step in developing and evaluating alternatives in a draft EIS, as required under NEPA. The ultimate goal of the EIS process is to select an alternative that will best fit all of the needs of the water users in the basin while keeping unavoidable impacts to a minimum.

This list will be refined so that the draft EIS considers only those options which are reasonable to implement (by NEPA definition). It is important to remember some of them might be beyond the scope of this study or outside Reclamation's authority to implement.

Initial, broad management scenarios included:

Scenario 1 (Historic Operations)

- This scenario represents the historic operation of the basin, assuming 1993 level of development flows. The historic reservoir operations (with the same target elevations and irrigated acres as in the past) are based on the authorized project purposes such as flood control and irrigation.

Remaining scenario groups and their major water management goals are to:

Scenario 2 (Irrigation)

- Continue present operations and attempt to provide water to irrigate the acres that have been developed.

Scenario 3 (Reservoir Fisheries)

- Emphasize reservoir fisheries while considering various levels of irrigation.

Scenario 4 (Reservoir Recreation)

- Emphasize reservoir recreation with various levels of irrigation.

Scenario 5 (Future Depletions)

- Modify 1993 flows in the basin to reflect future flow depletions to the year 2025 to irrigate the acres that have been developed (to be compared to scenario 1).

Scenario 6 (Natural Hydrologic Regime)

- Maintain instream flows by passing all inflows as outflows.

Scenario 7 (Riparian)

- Sustain and enhance the riparian zone along the shoreline in Reclamation impoundments by fluctuating water levels.

Scenario 8 (Republican River Fisheries)

- Emphasize river fisheries in designated reaches of the Republican River.

Scenario 9 (Harlan County Lake Special Studies—1993 Level Flows)

- Use four minimum reservoir target elevations at Harlan County Lake with various levels of irrigation.

Scenario 10 (Harlan County Lake Special Studies—2025 Level Flows)

- Use target elevations as in scenario 9, above, but use projected 2025 level flows within the basin.

Scenario 11 (Combinations)

- Provide a combination of the best aspects of the other scenarios and subscenarios with various levels of irrigation.

Further, detailed information on the management scenarios is included after sections that describe the natural and human resources of the Republican River Basin.

Part II—Water and Related Resources

Surface Water

Overview

The surface water supply for the Republican River Basin originates as rainfall, accumulates as surface water runoff, and flows downstream to the confluence of the tributaries. Base flow from the alluvial aquifers and return flows from surface irrigation are other surface water sources.

Since the 1960's, significant decreases in instream flow have occurred. This has reduced the water supply for irrigation and other demands.

Predevelopment—to 1950

Streamflow records throughout the Republican River drainage basin for the pre-development period are sporadic, with most of the records beginning in the mid to late 1930's. However, an analysis of these flows for the pre-development period indicates a variety of streamflow patterns associated with plains-type runoff highly influenced by spring and summer rainfall events. In the majority of these locations, peak runoff periods occurred during the months of May, June, and July. Many stations display a substantial base flow during the fall and winter months. The surface water/groundwater relationship is responsible for the sustained base flow during these months.

Present Development Period—1950 through 1993

The period 1950 through 1993 was affected by reservoirs, canal systems, and irrigation districts' development within the Republican River Basin. Most of the reservoirs in the drainage were constructed between 1948 and 1964. These systems have changed flow patterns in the Republican River due to the irrigation releases, the capturing of floodflows, and the coordination of reservoir operations with the Corps during periods of high runoff and flood control operations.

Streamflows in the river and creeks below the reservoirs have been influenced by reservoir operations. Traditionally, runoff is captured during the nonirrigation season in an effort to refill the reservoir to the top of the active conservation storage pool. Once the irrigation season begins, releases are made in accordance with the need of the downstream irrigators. These releases are coordinated between the irrigation districts and Reclamation's McCook Field Office. Peak releases are generally made during July and August when precipitation is low and irrigation demands are high due to crop needs. In an effort to conserve storage, it became the practice to minimize releases during the nonirrigation season. For the most part, reservoir releases were eliminated during this period.

Surface water irrigation practices have contributed a significant amount of water to the groundwater system in several areas of the basin. Deep percolation from applied surface water and seepage from canals and reservoirs in the Platte River Basin have caused water level rises up to 50 feet along the northern edge of the study area in Nebraska. In Kansas, groundwater level rises due to surface water irrigation have occurred in the Grand Island Formation east of Lovewell Reservoir and in Pleistocene and Cretaceous deposits to the southwest. Small areas of rising water tables have also occurred near several reservoirs in the basin as a result of seepage.

Irrigation return flows have also increased base flows in several of the major streams. Streams showing large increases in base flow over historic conditions include Driftwood and Blackwood Creeks and the Republican River reach from Hardy, Nebraska, to Concordia, Kansas. The estimated average annual recharge from surface water irrigation in the Republican River Basin (including seepage from the Platte River Basin) for the historic period is 211,300 acre-feet.

Nevertheless, since the late 1960's, the area's overall water supply has decreased, in part because groundwater development in the Republican River Basin has increased. The drilling of wells and the use of groundwater has had an adverse effect on the available flow in the rivers above the reservoirs. Because of this development, inflows to Reclamation reservoirs have steadily decreased, diminishing the ability to capture nonirrigation streamflows at all reservoirs within the system (see figure 1). In addition, drought and heavy rainfall have affected reservoir operations and available water supply to the districts. For the most part, irrigation districts have experienced a reduced water supply.

Water supplies in the tributaries and at streamflow locations upstream of the reservoirs have also shown a decline over the years. This trend can be associated with increases in diversion due to irrigation, groundwater pumping, conservation practices, and stock ponds developed in the basin. Soil and water conservation practices (residue management, terracing, and farm ponds) contribute the largest depletions to the basin water supply. During the past 3 decades, soil and water conservation practices have increased dramatically. The purpose of the practices is to reduce soil erosion and increase the available soil moisture for plant growth by holding more moisture in the soil profile.

Overall, increased water usage has led to a decline in the available water supply in the Republican River and its tributary streams.

Operating Agreements

Operating agreements were developed between Reclamation and the Corps for the regulation of reservoirs in the Republican River Basin. The agreements for Harlan County Lake, Swanson Lake, and Harry Strunk Lake were drawn up between 1957 and 1973. They mandate storage and operation for such purposes

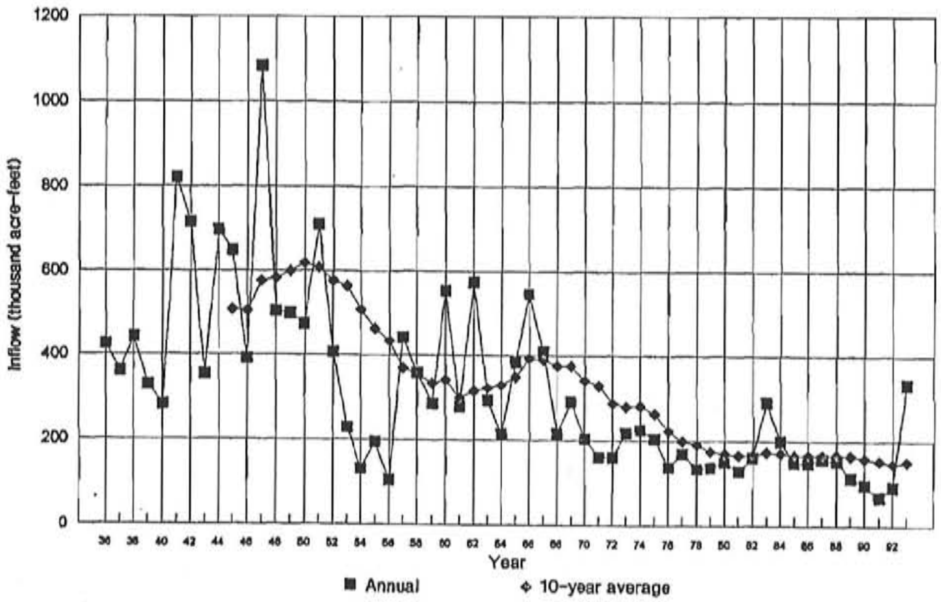

Figure 1.—Republican River above Harlan County Dam, Nebraska.

as flood control and irrigation and, in some instances, also for public health, recreation, and fish and wildlife preservation. A copy of the Harlan County Lake operating agreement is included in attachment E, part IV.

Reservoir Levels

Bonny Dam and Reservoir

Bonny Dam and Reservoir is the principal feature of the Armel Unit in eastern Colorado. Inflows are from the south fork of the Republican River and Landsman Creek. Irrigation plans were not economically feasible according to the concluding report on the Armel Unit, and irrigation below the reservoir was reduced to 700 acres (served by Hale Ditch). The reservoir water surface and reservoir lands upstream from the dam are administered by the Division of Parks and Outdoor Recreation of the Colorado Department of Natural Resources. Water stored in Bonny Reservoir is available for delivery to 700 acres served by Hale Ditch. The small number of acres served by project water explains the smaller fluctuations in reservoir elevation, as shown on the Bonny Reservoir elevation graph (figure 2).

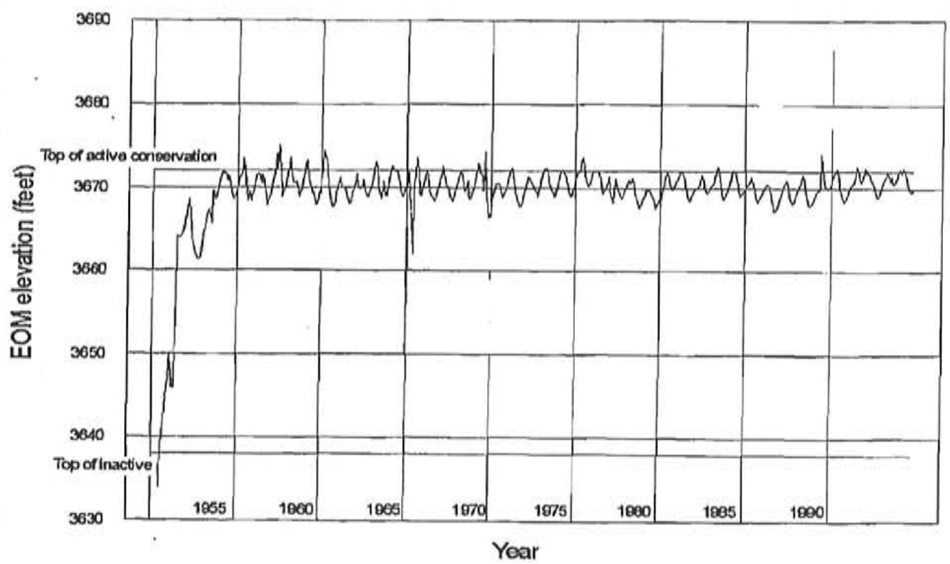

Figure 2.—Bonny Reservoir elevation.

Enders Dam and Reservoir

Enders Dam and Reservoir is supplied from flows of Frenchman Creek and provides off-season storage for the Frenchman Unit of the Frenchman-Cambridge Division. Water stored in Enders Reservoir, along with flows from Frenchman and Stinking Water Creeks, provides water for the Culbertson Canal and the Culbertson Extension Canal systems, which serve 9,600 acres in the Frenchman Valley Irrigation District and 11,490 acres in the H&RW Irrigation District. The conservation pool begins at elevation 3082.4 and extends to elevation 3112.3 and totals 34,512 acre-feet (figure 3). A decreasing water supply for Enders Reservoir is shown on the graphs depicting historic reservoir levels. The last time Enders Reservoir reached the top of conservation level (elevation 3112.30 feet) was in 1968. The smaller fluctuations in reservoir levels each year are due to the decreasing water supply available and the conservation of storage water by the irrigation district.

Trenton Dam and Swanson Lake

Trenton Dam and Swanson Lake provide off-season storage for irrigation of the Meeker Driftwood, Red Willow, and Cambridge Units of the Frenchman-Cambridge Division. Inflows to Swanson Lake are from the Republican River. Water is diverted from Swanson Lake to serve 16,476 acres by Meeker-Driftwood Canal, 6,539 acres by Bartley Canal, and 17,053 acres by Cambridge Canal (water for Bartley and Cambridge Canals is also supplied by off-season storage from Hugh Butler Lake and Harry Strunk Lake). Swanson Lake's conservation pool

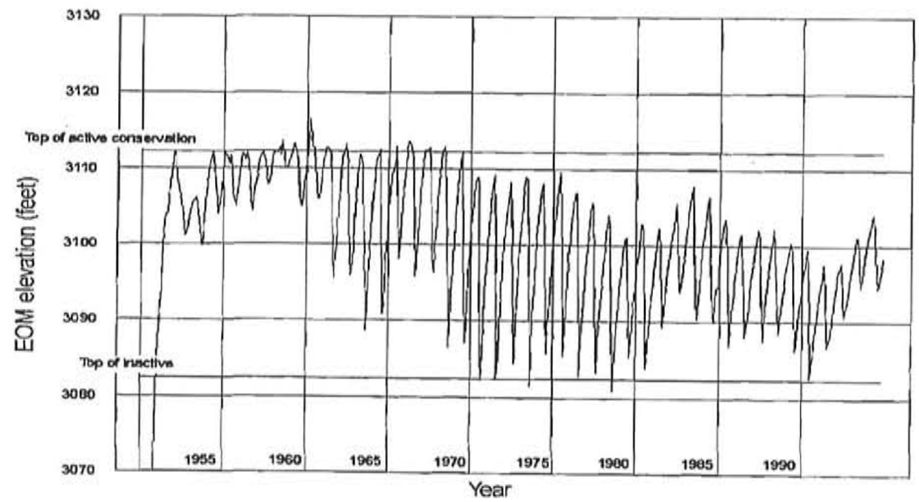

Figure 3.—Enders Reservoir elevation.

totals 99,784 acre-feet between elevations 2720.0 feet and 2752.0 feet (figure 4). Swanson Lake returned to the top of conservation in 1993 and 1994 after not reaching this level since 1985.

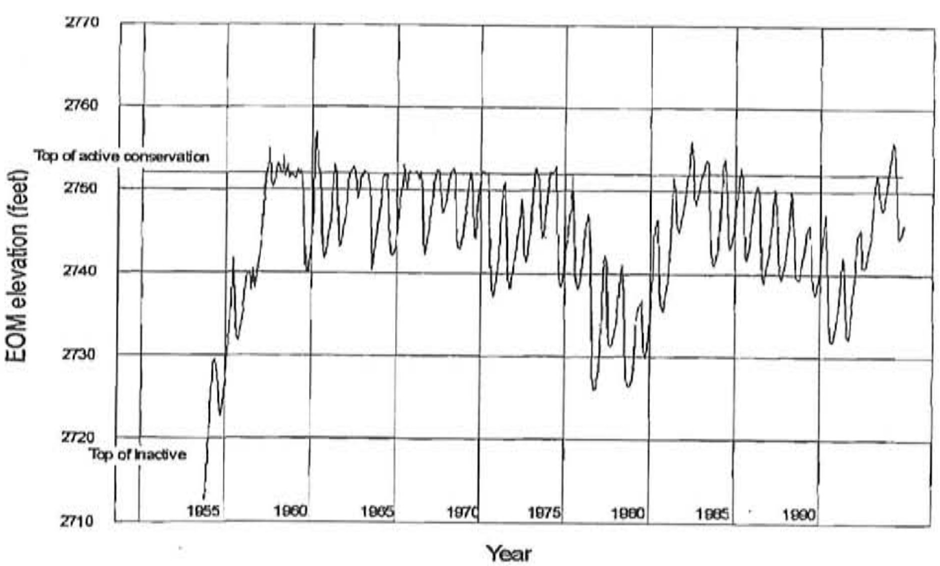

Figure 4.—Swanson Lake elevation.

Red Willow Dam and Hugh Butler Lake

Red Willow Dam and Hugh Butler Lake inflows are from Spring Creek and Red Willow Creek. The off-season storage in Hugh Butler Lake provides irrigation water for 4,932 acres by Red Willow Canal, 6,539 acres by Bartley Canal, and 17,053 acres by Cambridge Canal (water for Bartley and Cambridge Canals is also supplied by off-season storage from Swanson Lake and Harry Strunk Lake). The conservation pool in Hugh Butler Lake (elevation 2558.0 to elevation 2581.8) holds 27,326 acre-feet (figure 5). Large inflows and reduced demands in 1993 allowed Hugh Butler Lake to reach the top of conservation in 1994 after a period of 10 years of not filling.

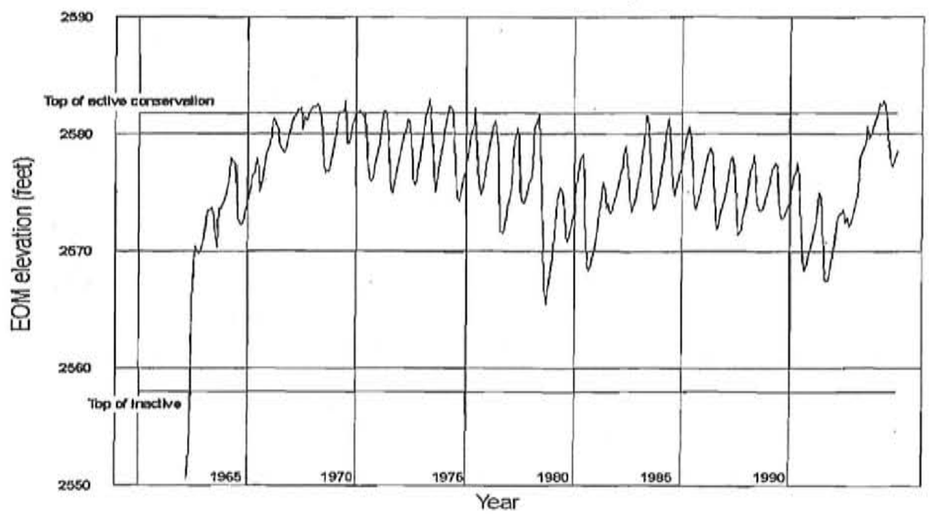

Figure 5.—Hugh Butler Lake elevation.

Medicine Creek Dam and Harry Strunk Lake

Medicine Creek provides inflows to Harry Strunk Lake. Harry Strunk Lake supplies water for 17,053 acres served by Cambridge Canal (along with water stored in Swanson Lake and Hugh Butler Lake). The conservation pool holds 26,846 acre-feet of water between elevations 2343.0 feet and 2366.1 feet (figure 6). Since initial filling in 1951, off-season inflows have filled Harry Strunk Lake every year except 1958. Consistent inflows and reduced diversions are the reasons that Harry Strunk Lake continues to fill each year.

Norton Dam and Keith Sebelius Lake

Keith Sebelius Lake inflows are provided by Prairie Dog Creek. Off-season storage in Keith Sebelius Lake and flows from Prairie Dog Creek supply water to 5,763 acres served by the Almena Irrigation District and provide a maximum

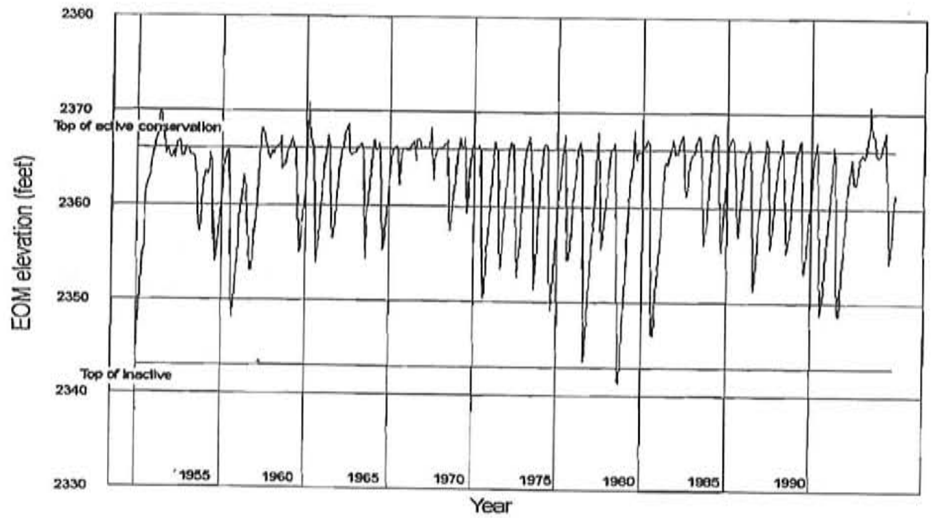

Figure 6.—Harry Strunk Lake elevation.

annual use of 1,600 acre-feet to the city of Norton, Kansas. The conservation pool is between elevation 2280.4 feet and 2304.3 feet and can store 30,651 acre-feet of water (figure 7). Declining inflows from Prairie Dog Creek have been experienced since Norton Dam was built. Keith Sebelius Lake has reached the top of conservation only once (in 1967) since closure. The Almena Irrigation District has operated on a reduced water supply and has not had enough water in Keith Sebelius Lake to deliver any project water in 8 of the last 16 years. Large inflows in 1992, 1993, and 1994 have brought the elevation of Keith Sebelius Lake to levels not reached since the late 1960's.

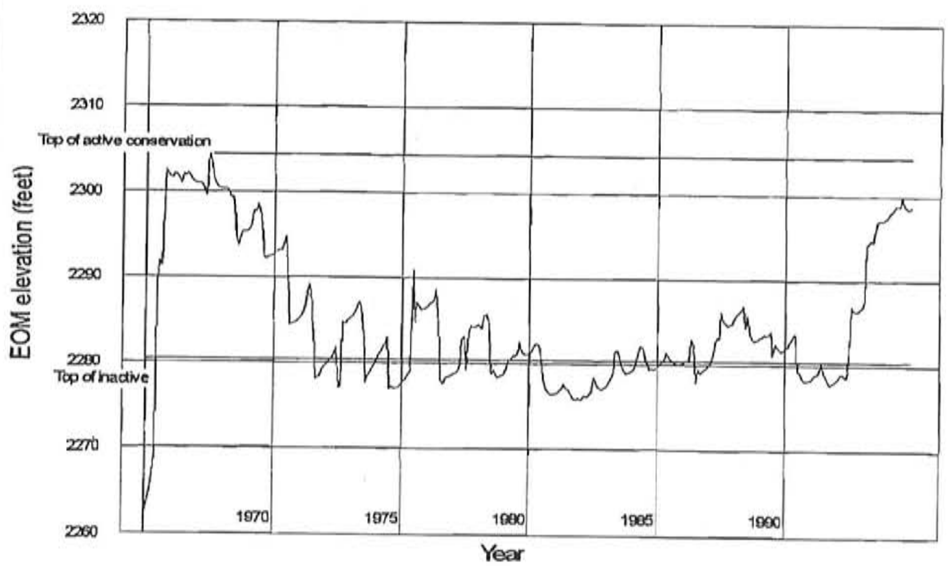

Figure 7.—Keith Sebelius Lake elevation.

Harlan County Dam and Lake

Harlan County Lake is supplied from inflows from the Republican River and Prairie Dog Creek. Project water from Harlan County Lake supplies water for 22,787 acres in the Bostwick Irrigation District in Nebraska and 13,550 acres in Kansas-Bostwick Irrigation District No. 2 above Lovewell Reservoir. Flows from Harlan County Lake also supply water to Lovewell Reservoir, which serves 28,338 acres in the Kansas-Bostwick Irrigation District. According to Corps documents, Harlan County Lake's irrigation pool presently holds 145,658 acre-feet of water between elevations 1932.8 feet and 1946.0 feet (figure 8). Reduced inflows experienced in 1989 through 1991 brought elevations below the bottom of the irrigation pool (historic minimum elevation 1928.22, content 129,947 acre-feet reached on October 17, 1991). The higher inflows of 1993 raised Harlan County Lake to nearly 10 feet above the top of the irrigation pool.

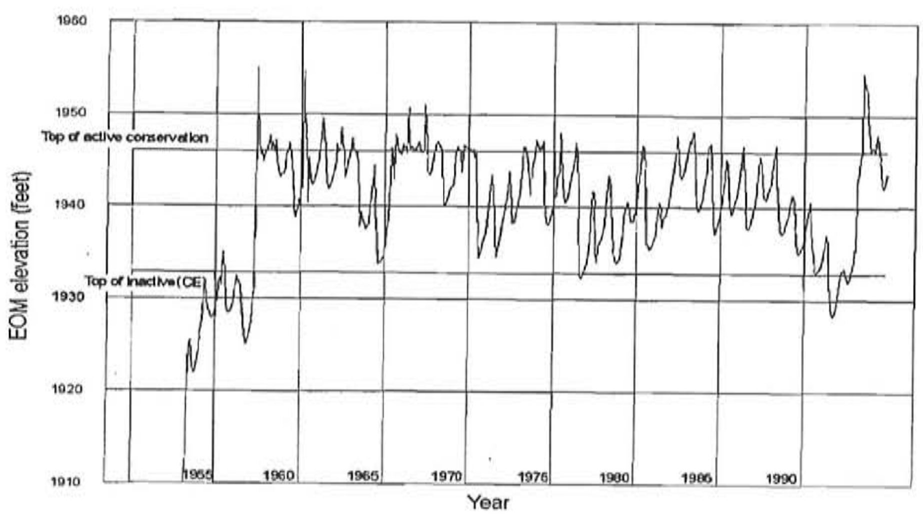

Figure 8.—Harlan County Lake elevation.

Lovewell Dam and Reservoir

Inflows from White Rock Creek and flows from the Courtland Canal (from the Republican River and Harlan County Lake) provide water to be stored in Lovewell Reservoir. Lovewell Reservoir (along with Harlan County Lake and Republican River flows) provides project water to 28,338 acres of Kansas-Bostwick Irrigation District No. 2. The conservation pool holds 24,930 acre-feet between elevations 1571.7 feet and 1582.6 feet (figure 9). Recent history illustrates the fluctuations in Lovewell Reservoir, as the historic minimum elevation of 1570.20 feet (content of 14,310 acre-feet) occurred on August 22, 1991, and the historic maximum elevation of 1595.34 feet (content of 92,354 acre-feet) was reached 21 months later on July 22, 1993.

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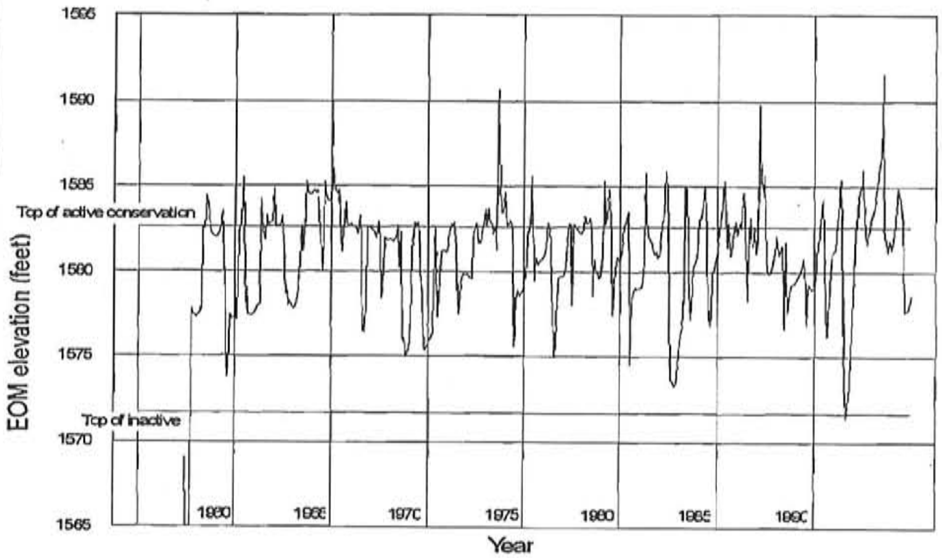

Figure 9.—Lovewell Reservoir elevation.

Republican River Basin

A total of 136,528 acres is served by project water in the Republican River Basin. The water supply for these lands is furnished by flows from Frenchman Creek, Stinking Water Creek, Prairie Dog Creek, White Rock Creek, the Republican River, and off-season storage in Bonny Reservoir, Swanson Lake, Enders Reservoir, Hugh Butler Lake, Harry Strunk Lake, Keith Sebelius Lake, Harlan County Lake, and Lovewell Reservoir.

As noted earlier, increased water usage has reduced available supplies in the Republican River and tributary streams. This reduced water supply has caused water deliveries throughout the Republican River Basin to decline over the last 30 years, as shown in the following tables. Each irrigation district in the basin has experienced a declining water supply, which in turn reduces the length of time that the surface water can be delivered. The tables that follow show averages of acres irrigated, diversions, and deliveries over three 10-year periods (1965-74, 1975-84, 1985-94) for the total Republican River Basin and each irrigation district. The total acres irrigated with project water has essentially remained the same, while the amount of water diverted and delivered to each acre has steadily declined. Some farmers supplement their project water supply from private irrigation wells. As the water supply continues to deplete, Reclamation and the irrigation districts continue to examine methods of conserving the limited water supply. The Frenchman-Cambridge Irrigation District has replaced their open ditch laterals with pipe laterals, which has significantly increased both system and onfarm efficiencies.

Republican River Basin

Year	Average acres irrigated	Average diversion (acre-feet)	Average delivery (acre-feet)	Diversion per acre (feet)	Delivered per acre (feet)
1965-74	107,982	258,474	147,311	2.39	1.36
1975-84	115,958	240,834	134,527	2.08	1.16
1985-94	116,195	198,180	102,908	1.71	0.89

Frenchman Unit

Culbertson Canal and the Culbertson Extension Canal systems serve a total of 21,090 acres in the Frenchman Valley Irrigation and H&RW Irrigation Districts. The water supply for these lands is furnished by flows from Frenchman Creek, Stinking Water Creek, and off-season storage in Enders Reservoir.

Frenchman Valley and H&RW Units

Year	Average acres irrigated	Average diversion (acre-feet)	Average delivery (acre-feet)	Diversion per acre (feet)	Delivered per acre (feet)	Days in operation
1965-74	18,587	51,464	29,003	2.77	1.56	158
1975-84	19,099	35,044	16,577	1.83	0.87	145
1985-94	18,748	24,368	10,104	1.30	0.54	135

Meeker-Driftwood, Red Willow, and Cambridge Units

The Meeker-Driftwood, Red Willow, Bartley, and Cambridge Canals serve 45,000 acres of the Frenchman Cambridge Irrigation District. The water supply for these lands is provided by flows from the Republican River, Red Willow Creek, Medicine Creek, and off-season storage in Swanson Lake, Hugh Butler Lake, and Harry Strunk Lake.

Meeker-Driftwood, Red Willow, and Cambridge Units

Year	Average acres irrigated	Average diversion (acre-feet)	Average delivery (acre-feet)	Diversion per acre (feet)	Delivered per acre (feet)	Days in operation
1965-74	38,363	86,209	53,765	2.25	1.40	141
1975-84	42,447	81,233	52,425	1.91	1.24	95
1985-94	42,088	71,231	43,853	1.69	1.04	86

Almena Unit

The Almena Canal system serves a total of 5,763 acres of the Almena Irrigation District. The water supply for these lands is furnished by flows from Prairie Dog Creek and off-season storage in Keith Sebelius Lake.

Almena Unit

Year	Average acres irrigated	Average diversion (acre-feet)	Average delivery (acre-feet)	Diversion per acre (feet)	Delivered per acre (feet)	Days in operation
1965-74	4,871	7,105	4,753	1.46	0.98	125
1975-84	5,188	3,959	2,104	0.76	0.41	49
1985-94	4,951	2,029	1,011	0.41	0.20	29

Note: Project water first delivered in 1967.
No water supplied in 1979, 1981-85, and 1991-92.
No water delivered in 1993 due to excessive rainfall during irrigation season.

Franklin, Superior-Courtland, and Courtland Units—Nebraska

The Franklin, Superior-Courtland, and Courtland Units of the Bostwick Division serve 22,787 acres of the Bostwick Irrigation District in Nebraska. The water supply for these lands is provided by flows from the Republican River and off-season storage in Harlan County Lake.

Franklin, Superior-Courtland, and Courtland Units—Nebraska

Year	Average acres irrigated	Average diversion (acre-feet)	Average delivery (acre-feet)	Diversion per acre (feet)	Delivered per acre (feet)	Days in operation
1965-74	19,549	49,608	24,907	2.54	1.27	95
1975-84	20,170	47,786	23,562	2.37	1.17	72
1985-94	19,582	44,859	18,175	2.29	0.93	75

Courtland Unit—Kansas

The Courtland Unit of the Bostwick Division serves 13,550 acres above Lovewell Reservoir and 28,338 acres below Lovewell Reservoir of Kansas-Bostwick Irrigation District No 2. The water supply for lands above Lovewell Reservoir is provided by flows from the Republican River and off-season storage in Harlan

County Lake. The water supply for lands below Lovewell Reservoir is provided by flows from the Republican River, and off-season storage in Harlan County Lake, White Rock Creek, and Lovewell Reservoir.

Courtland Unit—Kansas

Year	Average acres irrigated	Average diversion (acre-feet)	Average delivery (acre-feet)	Diversion per acre (feet)	Delivered per acre (feet)	Days in operation
1965-74	27,587	65,509	35,833	2.37	1.30	104
1975-84	31,648	74,791	40,911	2.36	1.29	116
1985-94	32,256	56,358	30,170	1.74	0.94	110

Surface Water Supply—Historic and Present

The following sections are a summary of the historic changes that have occurred to reservoir inflows within the Republican River Basin. For each reservoir, a comparison between pre-development inflows (assumed to be prior to 1950 since most irrigation development in the basin occurred since 1950) and recent level inflows (considered to be 1980 to 1993) is shown, along with a comparison of the historic average inflow versus projected inflows based on the 1993 level of basin development. The 1993 level-of-development flows represent potential future flows that could occur if the historic hydrologic cycle were to repeat itself under the 1993 level of basin development. A more detailed explanation in the development of the 1993-level flows can be found in attachment B. Also presented is a brief description of estimated depleted future reservoir inflows that were estimated in the project's Definite Plan Report (DPR).

In general, inflows to all the reservoirs have been declining at a significant rate since pre-development. The cause of those declines appears to be a combination of reduced streamflow due to effects from surface water diversions, irrigation well pumpage, conservation practices, upstream reservoir development, and what appears to be a reduction in annual precipitation variability. However, on a subbasin level, some stream reaches have shown increases in average flow due to return flows from irrigation and seepage from hydraulic structures.

Attachment B includes graphs of historic inflows and graphs comparing historic inflows and 1993 level-of-development inflows for reservoirs in the upper reaches of the Republican River and its tributaries where reach gains were the same as reservoir inflows. For the mainstem reservoirs of Swanson, Harlan County, and Milford, their historic and 1993-level inflows were constructed from data obtained from Hydromet, U.S. Geological Survey gauged streamflow records, and modeled inflows calculated from data presented in the inflow analysis attachment and a related appendix. Graphs showing both historic and 1993-level flows for the mainstem reservoirs can be found in the following respective sections.

Bonny Reservoir Inflows (Subbasin 1)[1]

Total inflows into the reservoir have been declining since the pre-development period, although the decline appears to have stabilized somewhat since the late 1970's. Historic average flows and change in average are:

Historic mean annual inflow for 1929-50	37,300 acre-feet
Historic mean annual inflow for 1980-93	18,300 acre-feet
Change in mean annual inflow	-19,000 acre-feet

The DPR for St. Francis Unit, Upper Republican Division, showed that historic flows at the Bonny Dam site for 1927 to 1947 averaged 34,500 acre-feet. Future depletions due to upstream private development were estimated to be 3,700 acre-feet, resulting in a projected annual average depleted inflow of 30,800 acre-feet.

Projection of future average annual flow based on a 1993 level of development and a repeat of the 1929-93 hydrologic cycle, as compared to the historic annual average, is as follows:

	Historic	1993 development level	Flow change
Mean annual inflow for 1929-93	28,200 acre-feet	17,800 acre-feet	-10,400 acre-feet

Swanson Lake Inflows

Long-term average flows into Swanson Lake have been declining since the 1960's along with a reduction in the variability of the annual inflow. This decline reflects not only depletions to streamflow from increased agricultural uses and conservation practices, but it also reflects impacts to streamflow from Bonny Reservoir operations beginning in 1950. The 10-year moving average for the inflows suggest that they are still exhibiting a slight general decline at the present time:

Historic mean annual inflow for 1929-50	150,500 acre-feet
Historic mean annual inflow for 1980-93	65,700 acre-feet
Change in mean annual inflow	-84,800 acre-feet

Note: Above data derived from computed inflows from Hydromet data base.

[1] References to subbasins apply to units also used in attachment B.

The DPR for the Meeker-Driftwood Unit anticipated an average annual depleted inflow of 115,300 acre-feet based on the 1929 to 1947 hydrologic cycle, taking into account the development of the Upper Republican Division. That inflow is almost twice the present-level average inflow.

Following is a comparison of average annual inflow to the reservoir based on the historic level of basin development versus the 1993 level of development:

	Historic	1993 development level	Flow change
Mean annual inflow for 1931-93	102,000 acre-feet	60,700 acre-feet	-41,500 acre-feet

Note: Above data derived from river-model calculated inflows to Swanson utilizing historic and 1993-level flows.

Enders Reservoir Inflows (Subbasin 4)

Most of the inflow into Enders Reservoir is derived from groundwater discharge to Frenchman Creek. This has resulted in flows that generally, throughout the year, exhibit less variability than in many of the other drainage basins within the Republican River Basin. However, since the 1950's, the streamflow into Enders has been showing a progressive decline, and there is no indication that the decline is leveling off:

Historic mean annual inflow for 1929-50	63,100 acre-feet
Historic mean annual inflow for 1980-93	23,600 acre-feet
Change in mean annual inflow	-39,500 acre-feet

The cause of the decline appears to be mainly the result of a high degree of well development in the subbasin.

This level of development was not anticipated when the DPR for the Frenchman-Cambridge Division was prepared. The DPR recorded a historic annual average flow of 60,700 acre-feet for the period of 1929 to 1947. The DPR made estimates of future depletions due to additional private irrigation and pond development upstream of Enders but considered that additional groundwater development would only take place to a "limited extent." Hence, the DPR estimated the future annual average depleted flows for the 1929 to 1947 hydrologic cycle to be 55,100 acre-feet. That depleted flow estimate is over two times the present-level average flows of 23,600 acre-feet.

Following is a comparison of average annual inflows for the historic period and average 1993 level-of-development inflows:

	Historic	1993 development level	Flow change
Mean annual inflow for 1929-93	47,900 acre-feet	22,700 acre-feet	-25,200 acre-feet

Hugh Butler Lake Inflows (Subbasin 11)

Historic inflows into Hugh Butler have exhibited a relatively small decline on average since about 1970. Present inflow trends indicate that the decline will probably continue into the near future. The change in the average flows from pre-development to the present is as follows:

Historic mean annual inflow for 1929-50	20,600 acre-feet
Historic mean annual inflow for 1980-93	18,200 acre-feet
Change in mean annual inflow	-2,400 acre-feet

The DPR for the Frenchman-Cambridge Division utilized a 1929 to 1947 historic annual average inflow of 19,900 acre-feet at the dam site. Projected depletions due to future upstream private irrigation and pond development were 600 acre-feet, resulting in a future average annual depleted inflow of 19,300 acre-feet.

Future average inflow based on the 1993 level of development versus the historic average is:

	Historic	1993 development level	Flow change
Mean annual inflow for 1929-93	20,500 acre-feet	17,400 acre-feet	-3,100 acre-feet

Harry Strunk Lake Inflows (Subbasin 14)

Inflows to this reservoir have exhibited a significant change since the late 1960's. Prior to that period, the annual flows exhibited a much higher degree of variability in flows from year to year rather than after the late 1960's. There was also a reduction in the average annual flow after that period. Recent trends suggest that the inflow decline to this reservoir may be stabilizing. Average annual pre-development flow versus more recent average flows are:

Historic mean annual inflow for 1929-50	60,000 acre-feet
Historic mean annual inflow for 1980-93	40,700 acre-feet
Change in mean annual inflow	-19,300 acre-feet

The DPR for the Frenchman-Cambridge Division utilized an estimated average annual flow for the 1929 to 1947 period of 58,500 acre-feet at the Medicine Creek Dam site. At that time, it was estimated that upstream private irrigation and pond development would deplete those flows by an additional average of 1,700 acre-feet. This resulted in a projected future annual average flow of 56,800 acre-feet.

For the present study, the projected 1993 level-of-development inflow versus historic, assuming a repeat of the historic hydrologic cycle, is:

	Historic	1993 development level	Flow change
Mean annual inflow for 1929-93	52,100 acre-feet	35,200 acre-feet	-16,900 acre-feet

Keith Sebelius Lake Inflows (Subbasin 16)

Inflows to the reservoir from Prairie Dog Creek have shown a significant decline since about 1965. The variability of the annual flow values after 1965 has been greatly reduced as compared to those before then. It is not anticipated that there will be significantly greater reductions in streamflow since average flow values are approaching near zero flow:

Historic mean annual inflow for 1929-50	26,200 acre-feet
Historic mean annual inflow for 1980-93	4,800 acre-feet
Change in mean annual inflow	-21,400 acre-feet

The DPR for the Almena Unit greatly underestimated the future depletions of flows into the reservoir when the project was authorized. The 1929 to 1956 historical average inflow presented in the DPR was 27,500 acre-feet. Future depletions to the inflows from upstream development were estimated to be 900 acre-feet, resulting in a future average annual inflow of 26,600 acre-feet.

The projected future average inflow based on the 1993 level of development, as compared to the historic average, is:

	Historic	1993 development level	Flow change
Mean annual inflow for 1929-93	17,300 acre-feet	4,700 acre-feet	-12,600 acre-feet

Harlan County Lake Inflows

This reservoir has been exhibiting a general decline in average inflows since the 1950's. Present inflow trends suggest that this decline will continue, but at a much lower rate, and may be stabilizing:

Historic mean annual inflow for 1936-50	534,900 acre-feet
Historic mean annual inflow for 1980-93	160,400 acre-feet
Change in mean annual inflow	-374,500 acre-feet

Note: Above data derived from computed inflows from Hydromet data base.

The DPR for the Bostwick Unit projected an average annual depleted inflow of 359,000 acre-feet, twice the present-level average inflow. A comparison of average annual inflow for the historic period versus the 1993 level of development is:

	Historic	1993 development level	Flow change
Mean annual inflow for 1931-93	247,500 acre-feet	124,000 acre-feet	-123,500 acre-feet

Lovewell Reservoir Inflows (Subbasin 21)

The natural inflow to this reservoir from White Rock Creek has not demonstrated any long-term declines, and there are no indications that future flows will be significantly different from the present-flow averages. Pre-development and present average natural inflows are:

Historic mean annual inflow for 1929-50	23,900 acre-feet
Historic mean annual inflow for 1980-93	50,900 acre-feet
Change in mean annual inflow	+27,000 acre-feet

The above table shows a significant increase in average inflows from pre-development to present; however, this reflects the high runoff of 1987 and 1993 which skewed the later period average higher, along with relatively low flows occurring from 1929 to 1940. From 1941 on, it appears that the average flows have remained about the same. The average flow for 1941 to 1950 is 43,600 acre-feet.

The DPR for the Bostwick Division utilized a projected average annual inflow from White Rock Creek of 19,000 acre-feet. Since there were no long-term changes in the flow regime over the historic period, no 1993 level-of-development flows were developed. It is believed that the historic flow levels will probably represent future flow conditions.

Milford Reservoir Inflows

Inflows to Milford Reservoir have been declining since pre-development; however, there has not been as significant a decline into this reservoir as there has been for inflows to Harlan County Lake. Several of the river reaches between Harlan County Lake and Milford Reservoir (Harlan to Hardy, subbasins 19 and 20) have experienced an apparent increase in streamflow with time. This could be explained by the onset of return flows from irrigation and seepage from Harlan County Lake. The remaining river reach from Hardy to Milford (subbasins 22 and 23) has demonstrated relatively little change in long-term streamflows. Average inflows into this reservoir have not changed significantly since 1960.

Historic mean annual inflow for 1929-50	976,500 acre-feet
Historic mean annual inflow for 1980-93	795,900 acre-feet
Change in mean annual inflow	-180,600 acre-feet

Note: Above data based on streamflows gauged at Clay Center, Kansas, plus flow gains between Clay Center and Milford Dam.

The comparison between the historic average and 1993 level-of-development inflows is:

	Historic	1993 development level	Flow change
Mean annual inflow for 1931-93	641,200 acre-feet	547,000 acre-feet	-94,200 acre-feet

Groundwater Supply

Groundwater in the area generally flows eastward, converging toward the Republican River. Irrigation wells are the primary groundwater users, with relatively smaller amounts used for municipal, industrial, domestic, and stock water purposes.

A total of 12,246 wells are registered in subbasins of the area for irrigation, municipal, and industrial uses. Some of the heaviest concentrations of such wells are near (within 12 miles of) Frenchman Creek above Enders Reservoir; near Beaver and Sappa Creeks; and near the Republican River below Harlan to Guide Rock.

Well development has resulted in groundwater level declines in some areas, as is analyzed in greater detail in attachment B. The way in which geologic formations in the area are related to the groundwater system is described below.

Geology

Upper Republican Basin

The major geologic formations are the Ogallala Formation, alluvium, and eolian deposits that make up the aquifer system. The base for the aquifer system is comprised of the Niobrara Formation, Pierre Shale, and White River Group, which are relatively impermeable consolidated deposits that restrict the downward movement of water from the overlying aquifer system.

The semiconsolidated Ogallala Formation of Pliocene age is the major source of groundwater due to its extent, accessibility, and saturation. The formation is present throughout the upper basin, except where major streams have eroded through it to the bedrock. The formation consists of clay, silt, sand, and gravel that is loosely cemented; the material becomes coarser or less cemented in the lower part.

An important element of the aquifer system is sand deposited by the wind during the Pleistocene and Holocene epochs in the northwest section of the upper basin. These deposits, with a maximum thickness of 170 feet, have high permeability, which allows rapid recharge to the underlying Ogallala Formation.

The next most important sources of groundwater are alluvium and terrace deposits of Holocene age. They are found in the valleys and under the flood plains of the larger streams and are comprised of varying mixtures of clay, silt, sand, and gravel. Thickness of these deposits varies from 0 to 90 feet.

Lower Republican Basin

The principal aquifer system in the lower basin is comprised of alluvium and terrace deposits and the Ogallala, Grand Island, and Dakota Formations. The base of the aquifer system consists of Pierre Shale, the Niobrara and Wellington Formations, and the Chase Group.

The alluvium and terrace deposits of recent and Pleistocene age are a major source of municipal and irrigation water. They are made up of unconsolidated clay, silt, sand, and gravel that have been deposited in the valleys and flood plains of the major streams. The deposits generally become more coarse with depth, which ranges up to 130 feet.

Covering the uplands of the lower basin are undifferentiated deposits of loess, volcanic ash, and gravels formed locally by weathering or stream action. Where saturated, these deposits provide small to moderate amounts of water for domestic and stock wells. Thickness ranges up to 100 feet.

The Grand Island Formation is a major source of irrigation water in a small area of north-central Kansas. It consists of coarse sand and medium-to-coarse gravel interbedded with silty clay, with thickness ranging up to 120 feet.

The Ogallala Formation, found in the Nebraska portion of the lower basin, is underlain by a relatively impermeable base made up of Pierre shale and the Niobrara Formation. Of marine origin, the Pierre is a dark gray fissile shale and the Niobrara consists of chalky shale and limestone.

The Dakota Formation is one of the principal aquifers in northeast central Kansas for supplying municipal, domestic, and stock wells. The quality of water varies; water obtained in most of northwestern Cloud County contains high chloride concentrations, 250 parts per million or higher. In the same area, small to moderate amounts of water for domestic and stock use can be obtained from several formations within the underlying Chase Group.

Groundwater Future Conditions

It is anticipated that the base flow of mainstem and tributary streamflows will continue to decrease throughout the years, especially if groundwater development is continued.

Water Conservation

As required by the 1982 Reclamation Reform Act, irrigation districts within the Republican River Basin have developed water conservation plans. These plans outline water conservation objectives and lists their accomplishments to date. Details of these conservation plans are described below.

Frenchman Valley Irrigation District

- Reduce seepage losses from the lateral system.

  Approximately 3,000 feet of underground pipe have been installed.

- Improve flow efficiency of canals and laterals.

  Control the growth of vegetation within the canal. In addition, clean, reshape, and recompact the canal.

- Promote efficient onfarm use of water.

  In cooperation with the Natural Resource Conservation Service, promote soil and water conservation measures, including terracing, diversions, furrowing, check dams, strip cropping, crop rotation, cover crops, and others.

- Improve district personnel operation efficiency.

  Through continuing education, district personnel attend training sessions, workshops, and trade shows.

Frenchman-Cambridge Irrigation District

- Reduce seepage losses from the laterals and main canals.

  Approximately 122 miles of buried laterals have been installed. In addition, turnouts are being upgraded and water meters and new hook-ups are being installed.

- Save water in Swanson, Hugh Butler, and Harry Strunk Lakes by improving water delivery to irrigators.

  Coordinate scheduling of water releases with Reclamation to eliminate bypasses at diversion dams as much as possible. In addition, Reclamation's original design of canal slopes will be maintained to reduce seepage.

- Reduce seepage to prevent a lawsuit with Burlington- Northern Railroad.

  Installed 4,400 feet of vinyl lining at the Cambridge Main Canal.

Bostwick Irrigation District In Nebraska

- Reduce seepage losses from the main canals and laterals.

  Approximately 1,000 linear feet of polyvinyl chloride (PVC) pipe have been buried to replace open ditch laterals. In addition, about 26,700 feet of vinyl lining have been installed in the canal.

- Implement measures to increase the efficient operation of the distribution system.

  Water budgeting activities have been implemented. These activities include shortening the irrigation season, upgrading the system measurement devices, limiting the number of water orders that will be accepted by the district, and determining the number of irrigators using gated pipe.

- Improve district personnel operation efficiency.

  Schedule training sessions concerning water measurement techniques. Established "advance notice" parameters to help alleviate scheduling problems.

Kansas Bostwick Irrigation District No. 2

- Reduce losses from the lateral system.

  Laterals replaced with PVC pipe and buried where sufficient head exists. Continue to monitor turnouts and structures and upgrade or replace where necessary.

- Improve operations efficiency.

  A continuing education program will be implemented by the district. This includes proper techniques of setting turnouts, logging water deliveries, holding bays at the surface, completing reports, and reviewing district policies and regulations. The district will conduct a review of the previous irrigation season to make suggestions for delivery improvements.

- Encourage onfarm efficiency.

  The Kansas State University Irrigation Experimental Farm is located in the district. Irrigators will be encouraged to attend the annual field day and consult with the farm manager regarding irrigation practices. Information from the university will be made available to irrigators.

Water Quality

Surface Water

Surface waters of the Republican River Basin are turbid, containing a moderate concentration of dissolved minerals. Streams display good oxygen concentrations to support warm-water aquatic life. They carry a fairly high level of nutrient materials, as evidenced by the high concentrations of nitrates and phosphates.

Water quality trends in the Republican River Basin are altered by the nine major lakes and reservoirs located in the basin. Within these storage facilities, there are reductions in suspended solids, biochemical oxygen demands (BOD), chemical oxygen demands (COD), turbidity levels, and dissolved solids. Biological and chemical reactions cause the reduction in BOD, COD, and dissolved solids as well as small increases in pH. Water retention reduces velocity and allows particulate matter to settle out. This causes reduced turbidity and suspended solid concentrations in these lakes and reservoirs. Keith Sebelius Lake and Lovewell Reservoir are both very eutrophic (nutrient rich); Milford Lake is slightly eutrophic. Pesticides have been detected in both Milford Lake and Lovewell Reservoir water. Diminished streamflow is lowering water quality; with high quality low flows being depleted, reservoirs will become more dependent upon high flows of lower quality, which will cause their quality to further deteriorate.

Within the upper areas of the Republican River Basin, water quality parameter values are altered by the addition of water of lesser quality from the Frenchman River and Red Willow and Medicine Creeks. Agricultural practices and agricultural runoff contribute to the increase in fecal coliform, turbidity, suspended solids, and nitrates throughout the basin. Additionally, sewage treatment plant and industrial discharges and animal feedlot runoff contribute to increases of suspended solids, fecal coliform, and BOD.

The major factor in determining surface water quality conditions is the amount of flow. BOD, nutrients, bacterial numbers, and turbidity are at their lowest level during low flow periods. During periods of high flow, most surface waters display their poorest quality with significant increases in these parameters. In terms of total yearly load, land runoff is by far the largest contributor of BOD and nutrient materials to streams.

Groundwater

The Ogallala Formation, which is the largest supply of groundwater in the basin, contains water that is of good to excellent quality. Water from the Ogallala tends to be a calcium-magnesium-bicarbonate type when the formation overlies the Pierre Shale and a calcium-bicarbonate type when it overlies the Niobrara Chalk (attachment B).

Alluvium and terrace deposits show a decline in quality of the water. A high proportion of samples from these deposits exceed the maximum contaminant levels for total dissolved solids, sulfate, chloride, and nitrate-nitrogen. When compared to Ogallala water, water from alluvial deposits shifts to a sodium-bicarbonate-sulfate type.

There are several reasons for the increase in dissolved solids in the alluvial deposits. These deposits act as collection zones for dissolved salts moving in from the adjacent aquifer system to the major streams. Water tables are also generally more shallow in these deposits, resulting in higher evaporation rates and an increase in salt concentrations. Agricultural practices may also be contributing to the decrease in water quality in these deposits; in northeast central Kansas, wells pumping in alluvium of the Republican River may be causing a local influx into the alluvial aquifer of more brackish water from underlying formations.

Metals and Chlorinated Hydrocarbons in Sediments and Fish

Background

In 1989 and 1990, Region VI of the Service sampled sediments at 29 locations and fish at 30 locations on the Republican River and tributaries to assess background concentrations of metals and long-lived organochlorine compounds in aquatic habitats in the Republican River Basin. Sampling was completed in October 1990, and study results were presented in the 1993 report, *Background Contaminants: Evaluation of the Republican River Drainage, Colorado, Kansas, and Nebraska*. Significant findings from this report are summarized below and presented in attachment B.

Metals in Sediments

- Except for very high arsenic concentrations at the upper end of Lovewell Reservoir and White Rock Creek below the reservoir, arsenic and mercury concentrations were comparable to those for Western United States soils and sediments in all locations.

- Copper and nickel concentrations in White Rock Creek, upper Lovewell Reservoir, and Keith Sebelius Lake were well above the means for Western United States and northern Great Plains soils.

- Lead concentrations from the upper end of Lovewell Reservoir were much higher than the means from United States soil studies.

- Manganese concentrations were higher than United States norms at the upper end of the Lovewell Reservoir.

- Strontium concentrations were high at the upper end of Lovewell Reservoir.

- The concentration at the one location where tin was found—the upper end of Harlan County Lake—was very high compared to means for Western United States soils (the reported value, however, is viewed with suspicion).

- Zinc concentrations in many locations were well above the mean concentrations in the Western United States and northern Great Plains soils.

Metals in Fish

- Nearly every fish sample analyzed by atomic absorption for this study contained a selenium concentration greater than the National Contaminant Biomonitoring Program (NCBP) means.

- Barium concentrations were higher than those from other studies in Kansas rivers. Effects (if any) of observed levels of concentration could not be estimated due to very limited information on this subject.

- Fish composites at 10 locations were contaminated with chromium (assessment of the concentrations was considered difficult due to lack of information regarding a source of chromium at some locations).

- Copper concentrations in 11 fish composites exceeded the 1978-79 1.1 micrograms per gram (μg/g) NCBP 85th percentile concentration.

- Manganese concentrations at several locations were high. A review of the sources of the manganese may be necessary at numerous locations.

- Nickel was detected in a variety of species, but the source and effects of the metal were not known.

- Strontium was detected in almost every fish composite analyzed, but means to assess the body burdens observed in Republican River drainage fish composites were not available.

- Tin concentrations were detected in two samples. The effects of these concentrations were not known.

Chlorinated Hydrocarbons in Fish

- The cyclodiene concentration (chlordane compounds, heptachlor, aldrin, endrin, dieldrin, and endosulfan) in a composite species from Junction City, Kansas, was the only fish sample that exceeded the 0.1 µg/g whole body wet weight concentration recommended by the National Academy of Science and National Academy of Engineering to protect aquatic life.

- Toxaphene concentrations were observed in fish from Lovewell Reservoir and from the Republican River at Scandia in 1989. They were not detected, however, in fish from these locations analyzed in 1990.

- Mirex was detected in a composite sample taken from the head of the Bartley Diversion Canal in 1989. It is conjectured that mirex may have been recently used in the vicinity although banned for all uses in 1978.

Selenium

A water quality screening (site characterization) investigation was initiated on September 7, 1994, to determine the presence or absence of organic and inorganic compounds at selected sites within the Republican River Basin study area. The water samples were collected from buried pipe drains at 10 locations which were determined to be representative of land form, soil type, drainage area, and cropping pattern. Trace element analysis indicated selenium was present at concentrations that warrant concern. Nine out of 10 samples exceeded the Environmental Protection Agency (EPA) water quality aquatic criteria (chronic) for selenium of 5 parts per billion (ppb). Two of the 10 samples exceeded the EPA water quality criteria (acute) of 20 ppb. Observed selenium concentrations ranged from below detection to 25 ppb. Followup sampling supports the conclusion that soils are derived from wind-blown materials overlaying marine shale sediments within irrigation district lands. Artificial drainage of irrigation water and natural precipitation from seleniferous soils may result in loading of selenium in open channels, wetlands, or waterways receiving drain flow.

Selenium is a naturally occurring trace element present in many geological formations in the West. Humans and animals require selenium in small quantities for good health, but when it becomes concentrated, it can cause death, birth defects, and reproductive failures in fish, wildlife, and livestock. The irrigation process may cause elevated selenium concentrations because when irrigation water is applied, selenium may enter the water as it percolates through the soil.

These results from the Republican River Basin can be related to those from other studies currently underway as part of the Department of the Interior National Irrigation Water Quality Program (NIWQP). The program targets water quality problems in irrigation return flow from Reclamation projects. For instance, selenium concentrations ranging from 1 ppb to 300 ppb have been observed on Reclamation's Kendrick Project in Wyoming. The median dissolved selenium concentration at Kendrick is 7.5 ppb. The Kendrick Project is now in Phase IV of the NIWQP process, which includes development of possible mitigation alternatives.

Part III—Other Area Resources

Socioeconomics

Introduction

Part III describes the area in terms of social and cultural values and issues, population numbers, and employment; agricultural and recreation resources; and fish and wildlife, including stream and reservoir fisheries and game and nongame species.

Overview

The socioeconomic structure in the Republican River Basin is characterized by a rural, agriculture-based lifestyle. The area is sparsely populated, and the business and commerce centers in the area are smaller towns which reflect a genuine "heartland" sense of community: church and civic groups are active; elementary and secondary schools show a gradual, steady decline in enrollment but enjoy the active support of the communities; and medical, law enforcement, and utility services are effective without being elaborate. A high percentage of trade and service businesses are still locally owned, though many are struggling to compete with expanding chain and franchise businesses.

In many ways, the social and cultural values represented in the study area are traditional, but they are inevitably changing because of technological and economic change. Population in the area is in decline from the continued mechanization and modernization of agricultural methods—fewer farmers and ranchers are needed to produce more and more yield, and corporate farms continue to challenge all but the most robust family farms. While overall population has decreased, per capita income has remained steady when inflation is factored in, indicating that the basic quality of life has not deteriorated significantly for the remaining population.

Many of the social and lifestyle issues in the area are closely associated with the purpose of and need for the RMA:

- Aquifer water has been depleted by years of pumping for crop needs.

- Reduced aquifer supplies have resulted in erratic surface and instream flows.

- Reduced aquifer supplies have affected water levels at several reservoirs, which in turn have affected such recreational uses as boating, swimming, and fishing.

- Reduced reservoir levels have created several water quality and habitat concerns.

Farming and ranching as a way of life, and as the primary economic force in the region, are sometimes influenced and complicated by other factors, including recreation and tourism, environmental management and protection requirements, and (slight) potential for manufacturing or other nontraditional purposes. However, the fact remains that agribusiness is the driving force of the region's economy, and a rural, agriculture-ranching lifestyle is the lifestyle of choice in the area.

Perhaps the most prominent nonagricultural issue associated with water resources in the Republican River Basin is that of recreation. The great majority of land in the study area is in private ownership. Public/recreational access is, accordingly, confined to facilities adjacent to federally developed water projects; recreation use and the associated businesses are concentrated at and around the reservoirs; and growth is restricted. These high-use areas are of economic significance—especially to the individuals who operate campgrounds, small marinas, bait shops, sporting goods stores, and related businesses. Recreation-related income represents only a fractional amount of the area's overall agriculture-based economy.

In the context of the need for water contract renewals, several issues have far-reaching social and lifestyle impacts:

- Continued depletion of aquifer water supplies will inevitably have an adverse impact on the already declining agricultural economy throughout the study area.

- Competing demands (agricultural, environmental, and recreational) for available water, regardless of its source, necessitate more prudent and equitable allocation of those supplies—various interests and entities in the study area must accept responsibility for water allocation and use beyond that which can be accomplished through renewal of Federal water supply contracts. In other words, Reclamation is responsible for many aspects of regulatory compliance for contract renewals (habitat enhancement and protection, water quality, water delivery), but the agency cannot be responsible for assuring economic growth or lifestyle stability in the study area.

The socioeconomic characteristics of the Republican River Basin were derived using data from 4 counties in Colorado, 14 counties in Nebraska, and 10 counties in Kansas. Data derived from these counties, including the cities and towns, were representative of the basin. Agriculture has been a major influence on both past trends and present conditions in almost every area of socioeconomic concern because the basin is located in one of the most agriculturally productive regions of the United States.

This section is organized into the following major subsections: population, employment, and income.

Population

Agricultural areas are often characterized by low population density and a relatively high proportion of persons living in rural areas. Although the Republican River Basin accounted for 11.9 percent of the total land area in the 3-state area in 1990, the 152,925 people represented only 2.08 percent of the total population in all 3 states. The Republican River Basin had 4.9 persons per square mile in 1990 compared to 28 persons per square mile in the 3-state area and 70.3 persons per square mile in the Nation.

A much larger proportion of the people live in rural areas in the basin as compared to the three-state area as a whole, with 69.8 and 25.6 percent, respectively. This proportion has been decreasing and corresponds to national trends. For example, between 1950 and 1990, the percentage of the basin's population living in rural areas decreased from 80.8 to 69.8 percent. The rural population of the three-state area as a whole decreased by an even greater amount—from 46.3 percent to 25.6 percent. Between 1980 and 1990, the basin rural population decreased by 2.7 percent.

Another pattern of change has been a slow but steady decline in the actual size of the overall population. Between 1930 and 1990, the population of the basin decreased from 266,457 to 152,925. Between 1970 and 1980, nine counties in the basin experienced growth; however, the trends between 1980 and 1990 reversed, with no counties showing an increase. The only counties that had a larger population in 1990 than in 1930 were Phelps County in Nebraska and Thomas County in Kansas. These population changes are typical of many rural/agricultural areas in the Nation. As agriculture becomes more capital intensive, fewer jobs exist, and rural residents either leave or migrate to urban areas in search of employment and higher education. Table 2 shows population trends and rates of change for the years 1930 through 1990.

Employment

Employment data for the Republican River Basin is depicted in table 3 for 1970, 1980, and 1990, respectively. The total number of employed decreased 6 percent from 1980 to 1990, from 74,000 to 69,517, while agricultural occupations decreased 15 percent from 18,363 to 15,574. Seven of the 10 employment sectors had decreases. The sectors that recorded increases were finance/real estate, services, and public administration. Agricultural employment in 1990 remains a

Table 2.—Population—1930, 1950, 1970, 1980, and 1990 (Republican River Basin)

	1930	1950	1970	1980	1990	Growth rate 1980-90 (percentage)
Basin total	266,457	215,507	173,581	169,025	152,925	-9.53
Colorado	1,035,791	1,326,089	2,207,259	2,889,964	3,294,394	13.99
Kansas	1,880,999	1,905,299	2,246,578	2,363,679	2,477,574	4.82
Nebraska	1,378,000	1,326,000	1,483,493	1,569,825	1,578,285	0.55
Tri-state total	4,294,790	4,556,388	5,937,330	6,823,468	7,350,353	7.72
Basin vs. tri-state	6.20%	4.73%	2.92%	2.48%	2.08%	-16.01

significant percentage of the total, 22.4 percent, down from 24.8 percent in 1980. The agricultural employment percentage for the three states in 1990 was noticeably lower—2.8, 5.2, and 8.3 for Colorado, Kansas, and Nebraska, respectively.

Income

Total personal income is shown in table 4 for the Republican River Basin and for the three states for the periods 1970, 1980, and 1990. The total personal income in the basin was $2.828 billion in 1990, an increase of 72 percent from 1980 and 742 percent from 1970. Personal income for the three states was $134.827 billion in 1990, an increase of 79 percent from 1980 and 899 percent from 1970.

The basin per capita income (table 5) was $10,677 in 1990, an increase of 79 percent from 1980 and 332 percent from 1970. Per capita income for the three states was highest in Colorado—$14,821 in 1990, an increase of 85 percent from 1980 and 377 percent from 1970. Per capita income in 1990 is lowest in Nebraska—$12,452, an increase of 79 percent from 1980 and 345 percent from 1970. Per capita income for the three states averaged $13,524.

Agricultural Production and Value

This section discusses the number of farms, farm size, and value of crop production within the Republican River Basin counties and the three states.

Introduction

From the early 1800's, the agricultural industry has traditionally dominated both the economic base and land use in the Republican River Basin and continues to do so. This section shows the number of farms, farm size, and value of crop production for several time periods within the basin counties and the three states.

Table 3.—Employment by industry 1970, 1980, and 1990 (Republican River Basin)

	Agriculture	Mining	Construction	Manufacturing	Transportation, communication, public utilities	Wholesale trade	Retail trade	Finance, insurance, real estate	Services	Public adminis-tration	Total	Agriculture (% total)
1970												
Basin total	18,978	306	4,180	3,698	3,919	2,019	12,149	1,887	16,254	2,765	66,155	28.69
Colorado	38,093	14,232	54,668	120,581	60,688	37,798	145,813	46,409	252,594	54,900	825,776	4.61
Kansas	74,794	10,228	51,423	147,933	64,642	37,873	148,236	40,162	234,528	42,494	852,313	8.78
Nebraska	79,067	2,181	34,070	79,127	44,385	24,917	103,902	29,841	153,406	25,169	576,065	13.73
Tri-state total	191,954	26,641	140,161	347,641	169,715	100,588	397,951	116,412	640,528	122,563	2,254,154	8.52
Basin vs. tri-state	9.89%	1.15%	2.98%	1.06%	2.31%	2.01%	3.05%	1.62%	2.54%	2.26%	2.93%	
1980												
Basin total	18,363	700	4,764	5,087	4,884	3,970	11,804	2,671	19,219	2,538	74,000	24.81
Colorado	42,185	36,632	107,063	192,305	108,668	61,712	236,814	96,725	402,846	77,067	1,362,017	3.10
Kansas	69,466	16,526	64,562	207,474	82,715	51,727	172,495	59,504	306,496	47,776	1,078,741	6.44
Nebraska	77,086	1,754	43,296	99,046	66,834	33,961	120,958	44,014	200,940	28,744	716,633	10.76
Tri-state total	188,737	54,912	214,921	498,825	258,217	147,400	530,267	200,243	910,282	153,587	3,157,391	5.98
Basin vs. tri-state	9.73%	1.27%	2.22%	1.02%	1.89%	2.69%	2.23%	1.33%	2.11%	1.65%	2.34%	
1990												
Basin total	15,574	657	4,081	4,374	4,270	3,122	11,357	2,804	20,335	2,943	69,517	22.40
Colorado	46,010	20,438	94,849	207,423	133,341	70,951	286,630	119,707	570,739	83,193	1,633,281	2.82
Kansas	61,324	11,554	61,897	196,485	87,555	50,637	193,262	73,632	383,995	51,873	1,172,214	5.23
Nebraska	64,381	2,095	40,821	98,344	62,510	35,726	138,179	52,137	248,611	30,009	772,813	8.33
Tri-state total	171,715	34,087	197,567	502,252	283,406	157,314	618,071	245,476	1,203,345	165,075	3,578,308	4.80
Basin vs. tri-state	9.07%	1.93%	2.07%	0.87%	1.51%	1.98%	1.84%	1.14%	1.69%	1.78%	1.94%	

Table 4.—Total personal income (Republican River Basin)
($1,000)

	Total personal income (1970)	Total personal income (1980)	Total personal income (1990)
Basin total	335,775	1,647,700	2,828,400
Colorado	5,226,520	33,257,400	62,279,700
Kansas	5,056,268	25,789,900	44,906,200
Nebraska	3,203,558	16,344,500	27,641,200
Tri-state total	13,486,346	75,391,800	134,827,100
Basin vs. tri-state	2.49%	2.19%	2.10%

Table 5.—Per capita income (Republican River Basin)
($1,000)

	Per capita income (1970)	Per capita income (1980)	Per capita income (1990)
Basin total	2,470	5,973	10,677
Colorado	3,106	7,998	14,821
Kansas	2,929	7,350	13,300
Nebraska	2,797	6,936	12,452
Tri-state total	2,944	7,428	13,524
Basin vs. tri-state	83.90%	80.41%	78.95%

Number of Farms

The number of farms in the three-state area has been gradually declining over time (from more than 284,155 in 1949 to fewer than 143,400 in 1992). Farm numbers have decreased in the Republican River Basin counties from over 27,800 in 1949 to about 14,000 in 1992 (table 6). The total number of farms located on Reclamation project lands has decreased from 1,306 to 1,249 between 1982 to 1992.

Full-time farm operations on Reclamation projects in the basin declined 6 percent between 1982 and 1992. This was somewhat offset by an increase in part-time farm numbers from 31 in 1982 to 53 in 1992, an increase of 71 percent (table 7).

Table 6.—Farms, cropland, and irrigated cropland
Republican River Basin and tri-state area

Year	Farms	Land in farms	Average size farm	Total cropland: Farms	Total cropland: Acres	Total cropland: Average	Harvested cropland: Farms	Harvested cropland: Acres	Harvested cropland: Average	Irrigated land: Farms	Irrigated land: Acres	Irrigated land: Average
Summary of basin 1949-92												
1949	27,847	16,003,770	575	26,488	9,403,132	355	26,015	5,900,926	227	1,236	105,751	86
1954	25,873	16,416,160	634	24,568	9,333,067	380	24,138	5,814,279	241	2,134	199,686	94
1964	20,042	16,400,805	818	19,071	9,243,984	485	18,671	4,828,481	259	4,064	507,931	125
1974	17,579	15,762,156	897	16,546	9,200,718	556	15,998	5,671,226	354	5,183	1,306,017	252
1982	16,203	15,695,810	969	14,761	9,157,496	620	14,229	6,053,400	425	5,562	1,897,646	341
1987	15,890	15,944,408	1,003	14,417	10,219,245	709	13,792	5,611,478	407	5,705	1,754,547	308
1992	14,041	15,493,265	1,103	12,490	10,042,579	804	11,654	5,439,361	467	4,872	1,888,252	388
Summary of tri-state 1949-92												
1949	284,155	134,031,293	1,646	1,375,709	64,243,667	518	258,962	47,793,628	545	37,967	3,887,293	102
1954	261,762	135,895,352	1,829	242,990	63,507,367	806	235,781	45,534,262	554	38,591	3,765,841	98
1964	202,401	136,322,406	2,424	189,024	61,150,308	988	182,867	38,115,199	612	42,252	5,863,545	139
1974	172,286	130,019,899	2,696	160,138	62,709,545	1,217	152,282	42,136,834	833	38,968	8,753,779	225
1982	160,669	125,551,582	2,625	143,377	63,585,301	1,343	135,418	43,299,278	947	44,679	11,915,401	267
1987	156,365	125,982,393	2,677	137,449	65,694,105	1,437	128,443	38,527,761	889	44,861	11,158,681	249
1992	143,353	125,048,346	2,828	124,619	64,454,866	1,535	114,800	40,474,569	1,025	41,064	12,161,815	296

Table 7.—Republican River Basin reclamation projects
(full- vs. part-time farmers)

Irrigation district	1982 Full time	1982 Part time	1987 Full time	1987 Part time	1992 Full time	1992 Part time
Frenchman Cambridge	362	13	348	19	343	19
Frenchman Valley	64	0	64	0	64	0
Bostwick in Nebraska	228	18	198	25	184	34
Kansas Bostwick	495	0	499	0	488	0
Almena	56	0	56	0	56	0
H&RW	70	0	71	0	60	1
Total	1,275	31	1,236	44	1,195	54
Full- and part-time total	1,306		1,280		1,245	

Value of Crop Production

The annual value of crop production in Republican River Basin counties ranged between $1.336 and $2.569 billion between 1978 and 1992. The annual value of crop production in the area ranged between $17.976 and $20.641 billion between 1978 and 1992. The Republican River Basin counties produced 12.45 percent of the three-state market value in 1992 (attachment D).

The market value of crops and pasture products from the irrigation districts served by Reclamation for the same years is shown in table 8. The annual value ranged from $26.2 million to $35.9 million for the districts. The basin had crop and pasture values ranging from $564.2 million to $862.5 million during the same timeframe.

The per-acre value for the irrigation districts' production was approximately double that of the basin overall, which includes both irrigated and less productive dryland operations. The districts ranged from $234.58 to $299.54 per acre, while the basin was $130.50 to $154.64.

Agricultural Taxable Value

The agricultural taxable value accounts for 57 percent of the total taxable value in the Republican River Basin counties. In the tri-state area, the agricultural sector accounts for 16 percent of the taxable value (table 9).

Table 8.—Market value ($) of crops and pasture products from irrigation districts

	1978	1982	1987	1992
Frenchman Valley	2,100,471	2,335,665	1,859,747	2,143,257
Frenchman Cambridge	10,851,659	14,524,769	9,553,516	12,181,334
Kansas Bostwick No. 2	7,618,349	8,312,430	7,031,334	7,810,267
Bostwick in Nebraska	4,895,154	6,192,971	4,581,313	6,448,007
Almena	1,311,100	1,813,461	1,042,698	1,663,575
H&RW	2,267,058	2,718,394	2,155,415	2,837,520
Total	29,043,791	35,897,690	26,224,023	33,083,960

Total harvested cropland and pasture acres in irrigation districts

	1978	1982	1987	1992
Frenchman Valley	8,352	8,712	7,420	8,215
Frenchman Cambridge	42,513	43,580	38,178	43,512
Kansas Bostwick No. 2	31,806	33,980	33,585	23,589
Bostwick in Nebraska	20,600	20,486	18,415	19,359
Almena	5,227	4,535	4,520	5,145
H&RW	10,812	10,558	9,674	10,630
Total	119,310	12,1851	111,792	110,450
Value per acre ($)	243.43	294.60	234.58	299.54

Market value ($) of crops and pasture products from basin

	1978	1982	1987	1992
Value ($)	564,228,000	862,510,000	732,315,000	841,152,000
Harvested cropland		6,053,400	5,611,478	543,9361
Value per acre ($)		142.48	130.50	154.64

Table 9.—Tax base (Republican River Basin)

	Total agricultural taxable ($)	Total taxable ($)	Agricultural vs. total taxable (%)
Basin total	2,938,438,219	5,114,169,313	57.46
Colorado	687,304,530	29,831,046,660	2.30
Kansas	4,886,862,468	63,946,045,651	7.64
Nebraska	18,432,100,466	56,207,563,555	32.79
Tri-state total	24,006,267,464	149,984,655,866	16.01
Basin vs. tri-state	12.24%	3.41%	

Recreation

The public use areas associated with the Republican River reservoirs are considered valuable for recreation because so much of the land in Nebraska and Kansas (approximately 97 percent) is privately owned. Reservoirs represent a significant portion of the standing water in both states. Also, within the basin, water surface acres are limited and, thus, existing areas are heavily used. Public use recreation occurs primarily on reservoirs and the immediately adjacent lands; thus, recreation opportunities are highly water related. Recreation opportunities can be grouped mainly into water contact and water-related activities such as boating, swimming, water skiing, fishing and hunting, picnicking, sightseeing, hiking, and camping. Most of the Republican River reservoirs include features such as boat-launching ramps, courtesy docks, picnic and camping sites, sanitary facilities, shelters, access roads, and parking areas.

Data on the recreational use of the river between reservoirs is lacking, but it is known that fishing, boating, and tubing take place. Much of the river access in both Nebraska and Kansas is private and, therefore, recreators must obtain landowner permission, a common practice in both states.

The following discussion includes information on visitation, recreation opportunities, trends in use, and availability of public facilities within the Republican River Basin.

Historical and Current Visitation

Although public use areas are open year round, many of the modern facilities are not available during the off season. The main season of use for reservoir recreation occurs between May 1 and the end of October, weather permitting. Winter season hunting and ice fishing occur at most of the reservoirs.

People visit Harlan County Lake and Lovewell and Bonny Reservoirs more frequently than the other lakes (figure 10). Keith Sebelius Lake also receives significant visitation.

Trends in visitation (figure 11) indicate that reservoir recreational uses are either stable or slightly decreasing since 1984. The amount of recreational use occurring at Republican River reservoirs is often affected by regional drought conditions. The most probable explanation for post-1984 visitation trends is that lower than normal water levels in reservoirs resulted in unusable recreation facilities.

For example, three main factors are known to influence recreational use at Enders Reservoir and Swanson, Hugh Butler, and Harry Strunk Lakes: (1) boating access, (2) the need to keep facilities close to the users, and (3) shoreline erosion. Fishing is the main use of these lakes (camping occurs to support the fishing effort) and, therefore, lack of boat access is very important.

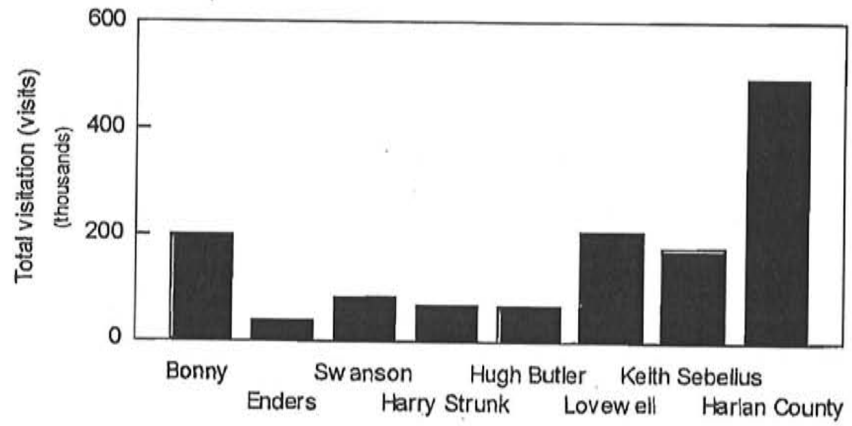

Figure 10.—Recreational visits at Republican River reservoirs in 1994.

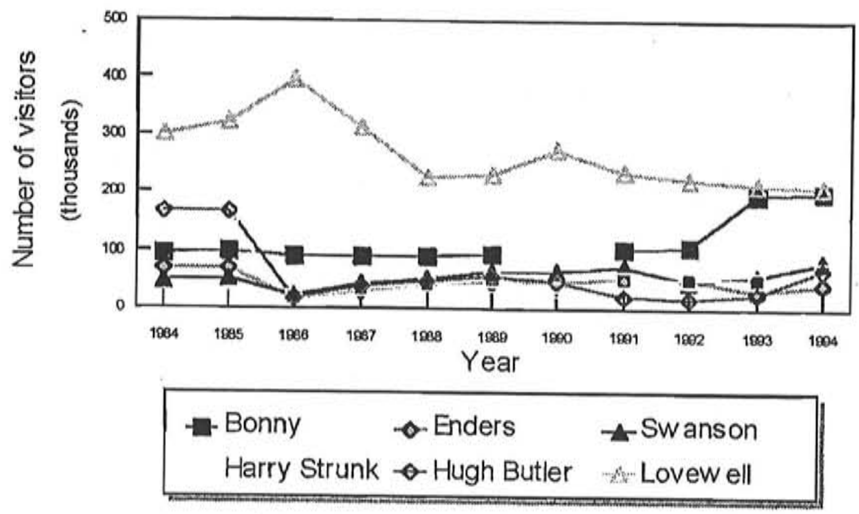

Figure 11.—Republican River Reservoir visit trends.

Boat launching ramps are available at several different elevations, maximizing use across the season as water levels fluctuate. However, if people cannot launch their boats, recreation falls off. In addition, as water levels fall, people follow the water, and this distances them from the facilities during periods of low water. In some cases, shoreline erosion can be a problem when lake elevations do not fluctuate at all.

Recreation Opportunities

Recreational opportunities within the Republican River Basin differ slightly by reservoir, but fishing and camping appear to be the most frequent activities. At many of these reservoirs, people camp in order to enhance their fishing opportunities. Also, if the fishery resources within a reservoir decline, those who fish move elsewhere. Picnicking, motor-boating, waterskiing, sightseeing, swimming, and hunting are also important activities to those visiting the reservoirs. Detailed information on hunting and fishing activities can be found in the *Wildlife* and *Fish and Fisheries* sections of this RMA.

Fishing, tubing, and canoeing also occur between reservoirs, although use level is not known. Access is limited by private property rights.

The facilities available at each reservoir are summarized in table 10. Bonny Reservoir is managed by the Colorado Department of Parks and Outdoor Recreation and Colorado Department of Wildlife. Enders Reservoir, Swanson Lake, Hugh Butler Lake, and Harry Strunk Lake are managed by the NGPC. Harlan County Lake is managed by the Corps. Keith Sebelius Lake and Lovewell Reservoir are managed by the Kansas Department of Wildlife and Parks.

Bonny Reservoir

Bonny Reservoir is located in the southwest corner of Yuma County, Colorado, on the south fork of the Republican River. The dam and reservoir are about 2 miles west of the town of Hale, approximately 9 river miles upstream from the Colorado-Kansas state line, and 18 miles north of Burlington, Colorado.

Bonny Reservoir is readily accessible by several major highways. U.S. Highway 385 brings travelers from the north and south to within 4 miles west of Bonny Reservoir. U.S. Highway 34 is located to the north about 34 miles and brings visitors from the east and west. In addition, various county roads lead to the reservoir. Other means of transportation to within 50 miles of the reservoir include airline service (both Wray and Burlington), the Burlington-Northern and Rock Island Railroads, and the Greyhound bus line.

Existing facilities include four campgrounds, four single-lane boat ramps, a marina-concession area, and day-use facilities located primarily on the south shore. A group picnic shelter and parking area are located at Center Beach and are available for use by reservation only. To the west of the group shelter are the swim and ski beaches with two vault toilets and parking areas. Fishing, boating, and waterskiing are important activities. Shoreline erosion is a problem. Boat ramp access is an infrequent problem because the reservoir is not drawn down for irrigation purposes.

Swanson State Recreation Area

Swanson Lake is located approximately 2.5 miles upstream from the town of Trenton in Hitchcock County, Nebraska. Swanson Lake is 4,974 surface acres surrounded by 1,157 acres of land. There are nondesignated campsites, pads, showers, a concession, and two dump stations. The area also offers grills, picnic tables, modern restrooms, vault toilets, shelters, boat ramps, and fish cleaning

Table 10.—Recreational facilities at Republican River reservoirs, 1994

Facilities	Bonny	Enders	Swanson	Hugh Butler	Harry Strunk	Keith Sebelius	Harlan County	Lovewell
Campgrounds	4	2	2	1	1	5	—	4
Regular campsites	174	160	150	110	34	200	646	154
Electrical campsites	26	15	70	45	43	42	—	63
Cabin sites	8	27	12	8	16	0	—	57
Picnic tables	90	163	193	160	180	156	>1,000	314
Picnic shelters/sites	18	27	20	20	12	9	110	2
Group shelters/group sites	1	—	—	—	—	—	18	1
Latrine buildings with flush toilets	2	1	—	1	1	—	—	—

stations. Potable water is available at Macklin Bay day-use area and campground, Spring Canyon day-use and camping area, and the Trail 6 and Trail 10 fisherman and wildlife access areas. The six developed recreational use areas at Swanson Lake include: an overlook area located north of the dam, picnic area located just west of the overlook area, Macklin Bay campground and day-use area, beach area located at the south end of the dam, Spring Canyon campground and day-use area, and Trail 7 or Northside Beach area.

The city of Trenton is the nearest transportation center serving Swanson Lake. U.S. Highway 34 runs from Trenton past Swanson Lake to the Nebraska/Colorado border. U.S. Highway 25 runs from Swanson Lake south to the Nebraska/Kansas border. A railway branch line runs parallel to U.S. Highway 34 from Trenton to Benkelman, Nebraska. In addition, a commercial airport at McCook serves the area.

Visitor use patterns are heavily dependent on reservoir drawdown. In years when the reservoir level is up near the developed recreation areas, annual visitation increases dramatically, and visitor participation is more water oriented.

Enders State Recreation Area

Enders Dam and Reservoir is located in Chase County in southwest Nebraska on Frenchman Creek about 79.2 miles upstream of the confluence of Frenchman Creek and the Republican River and approximately 1.5 miles south of Enders, Nebraska. Highways 6 and 34 provide east to west access, and Highway 61 provides north to south access.

At Enders State Recreation Area (SRA), the 1,707-acre lake and approximately 1,111 acres of land around the lake are available to the public. Part of the lake is set aside as a waterfowl refuge. The park has nondesignated camping sites, camp pads, and hookups. The area offers grills, picnic tables, modern restrooms, vault toilets, shelters, boat ramps, and fish cleaning stations.

Red Willow (Hugh Butler Lake) State Recreation Area

Red Willow SRA offers 1,358 acres of land around a 1,628-acre lake. Basic park facilities include nondesignated campsites, pads, showers, a swimming beach, a concession, and a dump station. The area offers grills, picnic tables, modern restrooms, vault toilets, shelters, boat ramps, and fish cleaning stations.

U.S. Highways 6, 34, and 136 serve from east to west; U.S. Highways 83, 183, 281, and 283 serve from north to south; and both passenger and freight trains (Amtrak and Burlington Northern) serve the basin. McCook has the only airport in the Republican River Basin that provides regularly scheduled commercial flights.

Medicine Creek (Harry Strunk Lake) State Recreation Area

Harry Strunk Lake is located in Frontier County on Medicine Creek, approximately 7.5 miles northwest of Cambridge, Nebraska. Access is the same as for Red Willow State Recreation Area. Medicine Creek SRA has a 1,768-acre lake with about 1,200 acres of land around it. There are nondesignated campsites and camp pads. The recreation area has a swimming beach, a concession, showers, and a dump station.

Existing public-use facilities are concentrated in the two major use areas. Cove 4 on the east shore just north of the spillway contains a campground with back-in spaces, comfort station/shower building, vault toilets, a swimming beach, a boat ramp, and a car/trailer parking area. Medicine Creek area on the west shore of the reservoir, located on a bay just north of the dam, contains a concession area, double boat launching ramp, and picnic area. The concessionaire provides rental cabins, rental boats, gasoline, a short-order cafe, and 46 trailer spaces. The two-lane boat ramp has adjacent car/trailer parking. The area also contains picnic shelters and tables, sanitary facilities, and parking areas. In both areas, the roads and most parking areas are paved. Also, potable water and sanitary facilities are provided.

Harlan County Lake Area

Nine public use areas and five recreation out-grants (leases) provide recreational facilities for visitors to Harlan County Lake. Corps-managed public use areas include: Cedar Point (a part of Patterson Harbor), the Outlet, Gremlin Cove, Hunter Cove, North Cove, and Methodist Cove.

Quasi-public recreation facility developments on project lands supplement those recreation facilities provided by the Corps. Quasi-public recreation facilities are located on project lands out-granted to lessees specifically for recreation development. Developments include the 4-H camp, the Camp Joy Bible Camp, the Patterson Harbor Marina (located on the south side of the lake), and the North Shore Marina (located on the north side of the lake), both of which provide marina services for lake visitors.

The Harlan County Lake area is served by Federal and state highways and county roads. The major recreation areas at the lake are served by a system of hard-surfaced, all-weather roads. Lesser-used areas, such as North Cove, Camp Joy, and the 4-H camp, are served by gravel roads maintained by the county. The condition of these roads generally ranges from fair to poor, depending on the season.

Seven boat ramps, with a total of 17 boat-launching lanes, provide access to Harlan County Lake for recreational boaters.

Prairie Dog (Keith Sebelius Lake) State Park

Recreation at Keith Sebelius Lake is managed as Prairie Dog State Park by the Kansas Department of Wildlife and Parks. The lake is located on Prairie Dog Creek in Norton County, Kansas. The lake is approximately 2.5 miles southwest of Norton, Kansas.

Seasonal use patterns at Keith Sebelius Lake are typical of most Kansas reservoirs and consist of heavy fishing use in the spring followed by general reservoir recreation activities during the summer.

The park presently provides 440 parking spaces in the boat launch and day use areas, 52 designated campsites, 4 vault toilet buildings, 2 shower buildings, a swimming beach, and a ramp with 2 launch lanes. The developed areas on the wildlife lands provide two conservation pool level boat launch ramps, six vault toilet buildings, and four water wells. The ramps on wildlife lands were not usable for many years because of the lowered water levels.

The highway department operates a roadside park along U.S. Highway 383 on reservoir lands which provides picnic shelters, water wells, and a vault toilet.

Ready access to the state park is provided by U.S. Highway 283, which runs east and west. The city of Norton is served by a branch line of the Burlington-Northern Railroad.

Lovewell State Park

Lovewell Reservoir and park is located 12 miles south of Superior, Nebraska, and 4 miles east and 10 miles north of Mankato, Kansas, on Kansas Highway 14. Lovewell State Park is managed by the Kansas Department of Wildlife and Parks.

Seasonal use patterns at Lovewell Reservoir are typical of most Kansas reservoirs and consist of heavy fishing use in the spring followed by general reservoir recreation activities during the summer. The heaviest use occurs from May through July and use may drop off in August, because of the heat, especially if water levels also fall off. There are not enough of some facilities, especially electrical hookups, to meet existing demand. Shoreline erosion becomes a problem if lake elevations exceed 1582.6 feet. Boat ramps are accessible most years but become unusable if the level falls below 1574.6.

Fish and Fisheries

The Republican River represents an important refuge for aquatic species in an otherwise dry region. Factors affecting the distribution and abundance of stream fishes include temperature, oxygen, current, substrate, water quality, discharge, and periods of reduced discharge. Republican River fishes reflect the sometimes harsh conditions associated with prairie streams that typically suffer significant periods of reduced discharge during the dry seasons. Some of the native Republican River species (plains killifish, fathead minnow, creek chub, black bullhead, red shiner, white sucker) are known to be tolerant of low-flow conditions occurring in intermittent prairie streams.

Before major Republican River dams were in place, the Republican River was used as a fishery resource. The human population of the area was fairly low, so fishing pressure was not great. The river had been impacted by previous human development activities including agriculture, tree growth in the riparian zone, and grazing. In addition, several species of fish had already been introduced into the Republican River, including carp and channel catfish. Many native species (minnows and darters) probably were not highly valued nor well inventoried.

In general, the effects of impoundment on the Republican River were to decrease the flows downstream of the dams during nonirrigation seasons and to increase the flows during the irrigation season. Also, because many of the dams were built for irrigation diversion, stream discharge decreased in many areas (see *Surface Water* section). The dams created reservoirs which served as new fish habitat while simultaneously reducing stream habitat. Major dams and diversion dams also act as barriers to fish migrating upstream.

These changes in flow and stream structures would have caused some changes in the composition of the fish populations within the river basin. Overall, at the time the dams were built, the potential reservoir fisheries were viewed as having more value than existing stream fisheries (Service, 1949). Thus, fishes more compatible with reservoirs (walleye, white bass, largemouth bass) increased, while populations of some of the stream fishes (various minnows) probably decreased. Data are not available to describe how the native fishes responded to the presence of the dams, but they were likely impacted because of the changes in flow regimes.

Streams

Historical Assessment

When the Republican River reservoirs and lakes were planned, the Service recommended that sufficient water be bypassed to ensure healthy river conditions and maintain fish and wildlife resources downstream. However, fish resources within the basin, especially, have suffered losses at times due to insufficient amounts of water flowing past the storage reservoirs and diversion dams (Service, 1966). The severe effect of dewatered channels can also be associated with direct pumping from the channel for irrigation of adjacent fields.

July and August are critical months for fish populations in minimal flow environments because low flows during these months then become associated with high water temperatures and insufficient oxygen. Low flow depth also becomes a critical factor. Service (1949, 1966)-recommended minimum flows below the dams in the area have not been met, at least in some months, especially at Enders, Harry Strunk, and Harlan County impoundments.

Downstream sections of the Republican River have experienced decreasing flows due to upstream irrigation projects; irrigation delivery system efficiencies; groundwater development; and implementation of various soil and water conservation practices, such as contour farming, conservation tillage, ecofallow cropping programs, construction of terraces and farm ponds, and development of small watershed projects. The decreasing flows from these practices would likely have negatively impacted the stream fishes. In addition, water quality degradation from pesticides, fertilizers, livestock operations, and other factors, may have had an adverse impact on fisheries (see *Surface Water Quality* section).

Studies of native fishes in Republican River Basin headwaters in Colorado (Cancalosi, 1981) found several species known for tolerance in extreme flow conditions (plains killifish, fathead minnow, creek chub, black bullhead, red shiner, white sucker, and green sunfish). The sand shiner was found to be the most abundant species. The fishes of the Republican River Basin in Kansas also represent some tolerant species. Although native fishes are tolerant of and adapted to low flows in the lower end of the Republican River, the low flows now occur at a different time of year than under pre-dam conditions.

During the Colorado 1977 collection (Cancalosi, 1981), orangethroat darter represented 18 percent of the fishes captured in the Colorado portion of the basin. Other abundant species included the sand shiner (24 percent), stoneroller and flathead minnow (14 percent each), creek chub (8 percent) and plains killifish (7 percent). The abundance of these fishes may have changed since 1977.

The fisheries in the Republican River are predominantly warmwater. During a 1972 survey, several games species were collected in the Republican River: channel catfish, black bullhead, black crappie, northern pike, bluegill, large-mouth bass, rock bass, smallmouth bass, white bass, white crappie, walleye, and yellow perch (Bliss and Schainost, 1973); channel catfish are the primary game fish in the river (Reclamation, 1984). This represents some change from pre-dam catches, which seemed to be less diverse; channel catfish, however, appear to still be the primary game species present.

The Republican River fishery below the Superior-Courtland Diversion is probably reduced, compared to prior years (Hilgert, 1982). Reduced streamflows and increased water use demands have greatly contributed to the decline of the Republican River stream fisheries. Additionally, channelization, dewatering, and turbidity contribute to decreased stream health. Bliss and Schainost (1973) found that the Republican River Basin (in Nebraska) included 1,135 miles of flowing stream and that 39 miles had been lost to channelization at that time.

As a generalization, the stream fish and fisheries of the Republican River represent local value. Recreational values associated with fishing have shifted from the river system to the reservoirs. For example, the Service (1983) found that stream fishing comprised only 20 percent of total fisherman days in the Republican River Basin.

Reclamation (1984) developed a rating system for the Republican River Basin, as shown in the table 11, that incorporates not only angling but also special status species and the riparian zone condition.

Table 11.—Fishing values of various reaches of the Republican River[1]

Stream	Reach	Value	Reason
Frenchman	Near CO state line	IV (limited)	
	State line to Culbertson Dam	III (moderate)	
	Culbertson to confluence with Republican	I (excellent)	
	Stinking Water Creek	I	
North Fork and Chief Creek	10 miles west of Wray, east to state line	I	Orangethroat darter
Arikaree	South of Mildred, CO, to Beecher Island	IV	
	Beecher Island to NE state line	I	Orangethroat darter
South Fork	Flagler to Yuma County line	II	CO State T&E species stream
	Yuma County line to the state line	I	CO State T&E species stream
	Landsman Creek	I	CO State T&E species stream
NW Kansas tributaries	Beaver Creek	II	
	Prairie Dog Creek		
Red Willow Creek	Above Hugh Butler	II	
	Below Hugh Butler	IV	
Medicine Creek	Above Harry Strunk	I	
	Below Harry Strunk	III	
White Rock Creek			
Mainstem	Cambridge to Harlan	IV	
	Harlan to Superior Courtland		
	Superior Courtland Diversion Dam to Milford	II, III	

[1] Bureau of Reclamation. 1984. *Republican River Basin Water Management Study.* Instream flow analysis, Republican River Basin, Colorado, Kansas, and Nebraska.

Table 12 provides some indication of the historical importance of fishing within the Republican River Basin.

Table 12.—Historical recreational stream fishing within the Republican River Basin[1]

	Republican River	Nebraska Tributaries	Total	Republican River	Kansas tributaries	Total
Stream length	285	850	1,136	176	1,234	1,410
Fishable miles	285	481	767	176	372	548
4-hour fishing days	40,236	13,817	54,053	22,710	7,603	30,313
Fishing days/ stream mile	141	29	71	129	21	55

[1] Reclamation 1985 Republican River Water Management Study.

Current Assessment

The Republican River is typical of rivers found in the agriculturally impacted areas of the central Great Plains (NGPC, 1995[a]). It can be characterized as a shallow, low-velocity, sand-bottomed river hosting an assemblage predominated by widespread, generalist species of fishes (i.e., red shiner, river shiner, fathead minnow, and channel catfish) with a few species that exhibit more limited distributions (i.e., plains killifish). Although seasonal flow patterns have changed from pre-dam conditions, noteworthy native species are still present.

Much of the Republican River has a shifting sand streambed that is poor habitat for benthic invertebrates. Native fishes probably relied upon terrestrial food sources and small areas of benthic invertebrate productivity in areas of stable substrate (Kansas Department of Wildlife and Parks, 1995).

The fish community in the Republican River is fairly diverse (table 13). Recent sampling of the Republican River in Nebraska found several species that were rated as common, including river shiner, red shiner, fathead minnow, central stoneroller, channel catfish, plains killifish, creek chub, common carp, river carpsucker, channel catfish and bluegill (NGPC, 1995[a]). Two species that historically occurred in the lower Republican River, the sturgeon chub and the flathead chub, did not occur in recent sampling efforts (Kansas Department of Wildlife and Parks, 1995). The structure of the fish community is likely influenced by reservoir fishes moving into the streams.

NGPC (1995[a]) examined the Republican River between Cambridge Diversion Dam and Harlan County Lake for spawning habitat that could be used by white bass, walleye, channel catfish, and flathead catfish. Some spawning habitat was available, mostly in the form of log jams, undercut banks, and gravel bars.

Creeks and small tributaries may represent important refugia for native, threatened, or rare species due, in part, to their being outside the influences of

Table 13.—Fishes of the Republican River Basin[1]

Species	Location (state)	Native (N), introduced (I), common in 1995 river samples
Longnose gar	NE, KS	N
Shortnose gar	KS	N
Gizzard shad	NE, KS	N, common
Goldeye	NE, KS	N
Rainbow trout	CO	I
Brown trout	CO	I
Northern pike	NE	I
Central stoneroller	CO, NE, KS	N, common NE
Creek chub	CO, NE, KS	N, common NE
Speckled chub	KS	N
Red shiner	CO, NE, KS	N, common
Golden shiner	NE	N
Emerald shiner	NE, KS	N, common KS
River shiner	CO, NE	N, common NE
Bigmouth shiner	NE, KS	N
Sand shiner	CO, NE, KS	N
Western silvery minnow	NE	N
Plains minnow	CO, NE, KS	N
Suckermouth minnow	CO, NE, KS	N
Fathead minnow	CO, NE, KS	N, common
Brassy minnow	CO, KS	N, common KS
Common carp	CO, NE, KS	I, common NE
Goldfish	CO, KS	I
Buffalo	KS	
Quillback	KS	N
River carpsucker	NE, KS	N, common NE
White sucker	CO, NE, KS	N
Black bullhead	CO, NE, KS	N, common KS
Yellow bullhead	NE	
Channel catfish	CO, NE, KS	N Kansas River Basin, common
Flathead catfish	NE, KS	N

[1] Lists from: Bliss, Quentin P. and Steve Schainost. 1973. Nebraska Parks and Game, NGPC, 1995 (NE); Cancalosi, John Joseph. 1981. *Fishes of the Republican River Basin in Colorado.* MSC thesis. Colorado State University, Fort Collins, Colorado (CO); Kansas Department of Wildlife and Parks, 1995 (KS).

Table 13.—Fishes of the Republican River Basin (continued)

Species	Location (state)	Native (N), introduced (I), common in 1995 river samples
Stonecat	CO, NE, KS	N
Plains killifish	CO, NE, KS	N, common
Plains topminnow	NE	N
Western mosquitofish	NE, KS	I
Brook silverside	NE, KS	
White bass	NE, KS	N, Kansas River Basin
Wiper	NE, KS	I
Rock bass	NE	I
Green sunfish	NE, KS	N
Bluegill	CO, NE, KS	N Kansas River Basin, common NE
Orangespotted sunfish	NE, KS	N, common KS
Smallmouth bass	NE	I
Largemouth bass	CO, NE, KS	N, Kansas River Basin
Black crappie	CO, NE, KS	I, common KS
White crappie	NE, KS	N,common KS
Orangethroat darter	CO, NE	N
Walleye	NE, KS	N?, Kansas River Basin
Saugeye	NE, KS	I
Yellow perch	CO, NE	I
Freshwater drum	NE, KS	N, lower basin

dam-related water fluctuations. In a 1995 survey for rare plants and animals, NGPC found eight occurrences of the orangethroat darter and two occurrences of the Plains topminnow in such tributaries (NGPC, 1995[b]).

NGPC (1995[a]) conservatively estimated that about 7,400 anglers fished for about 32,300 hours in the Republican River between Guide Rock Diversion Dam and Harlan County Lake and about 3,400 anglers fished for 9,500 hours between Harlan County Lake and Cambridge Diversion Dam. River catches were dominated by channel catfish, drum, and white bass. Some areas between Cambridge Diversion Dam and Harlan County Lake may represent potential spawning habitat for sport fishes like walleye, white bass, channel catfish, and flathead catfish.

The most critical factor for stream fishes and fisheries within the Republican River Basin remains instream flows. Water quality is also important and can be related to streamflow (see *Water Quality* section). Discharge in stream reaches is often dependent upon reservoir release levels. Reservoir outflows for all the dams in 1994 were low between October and December, more variable between January and April, and then generally increase dramatically during the irrigation season. Outflows from Enders, Swanson, Harlan County, and Keith Sebelius impoundments may not be adequate to support stream fisheries. There have been fishkills related to low flow within the Republican River Basin, particularly in low water years (attachment A, table A-6). This is an area where, potentially, the way the river is managed could be altered to benefit aquatic resources.

Summary

Current information on Republican River streams is not complete; however, it is probably safe to say that the fishes and fishery have been impacted since the major dams were closed. For example, the timing, duration, frequency, and rate of reservoir discharge can be important factors to fish populations and crucial to the success or failure of a single year class. This success or failure can affect the fishery for extended periods of time. Of particular interest concerning instream fisheries are flows during the spawning, hatching, and fry life stages which can also drastically affect fish populations (Reclamation, 1985). The dams did change the discharge and discharge timing in the streams, and reservoir release schedules have not always been adequate for stream fishes. Water quality issues that could affect fish can also be related to reservoir release schedules and agriculture. It may also be true that the value of the reservoir fisheries outweighs the value of the stream fisheries to local residents.

The Republican River does not represent an area of high endemism and, therefore, it is unlikely that endangered stream fishes will be a major issue. However, native fish populations have almost certainly been altered by the influences of human development. Remaining native assemblages may require protection and appear to be doing well in some areas.

Reservoirs

Historical Assessment

All of the reservoirs in the Republican River Basin[2], except Lovewell, are supplied with water from upstream drainages and mainstem reservoirs. Lovewell is supplied by the Courtland Canal, which begins at the Superior-Courtland Diversion Dam at Guide Rock, Nebraska, and by White Rock Creek.

The reservoirs represent recreational fishing opportunity and were originally considered, overall, to add value to the Republican River fishery (Service, 1946, 1949). The fisheries in the Republican River reservoirs are a coolwater-warmwater mixture and are managed for recreational fishing. Walleye is

[2] Milford Reservoir is not covered in this discussion because it is outside the study area.

considered an important game fish. White bass, wipers (white bass/striped bass hybrid), channel catfish, northern pike, and white and black crappie make up the remaining preferred sport fisheries (Service, 1982).

Some basic reservoir parameters (inflow, lake surface area, and lake level fluctuation) changed over the years, and these parameters affected the lake fisheries (Service, 1982). For example, reservoir inflows have declined precipitously over the past 30 years. Inflow declines for Enders, Harlan County, Swanson, and Keith Sebelius continue to be serious, and this reduces the habitat available for reservoir fish and wildlife resources (detailed information on Republican River reservoir operations can be found in *Annual Operating Plan: Niobrara, Lower Platte and Kansas River Basins* [Reclamation 1995]) and in *Water Supply* sections.

Mean lake surface areas appear to have declined at Enders Reservoir and Swanson, Harry Strunk, Hugh Butler, Harlan County, and Keith Seblius Lakes from 1961 to 1994. Reduced reservoir surface area decreases fish habitat throughout the basin. In 1981, the Service (1982) found statistically significant decreases in surface acreage between 1961 and 1980 at Swanson, Enders, Harry Strunk, Harlan County, and Keith Sebelius (but not Hugh Butler). It appears likely that these declines continued from 1980 to 1992 or 1993, although this was not tested statistically.

Annual fluctuation in surface area (difference between the maximum and minimum surface area) can also cause problems for fish and wildlife because shorelines are alternately watered and dewatered, spawning or rearing habitat may be dewatered, or water quality reduced. A historical view of lake fluctuation in the Republican River Basin shows that several of the reservoirs sustained high levels of change yearly. For the past 20 years, Bonny Reservoir has remained near the top of the conservation pool and also shows little fluctuation; it is not subject to irrigation drawdown. Enders Reservoir, Swanson Lake, Harry Strunk Lake, and Harlan County Lake show higher levels of annual fluctuation in water surface acres. Keith Sebelius Lake remained near the top of the inactive pool until inflow expanded the water surface in 1993. Fluctuations may have increased during the 1980's at Lovewell. The meaning of such fluctuations for reservoir fisheries is described below; the impact of drawdown and surface area fluctuations depends upon which species are considered important.

The walleye is one of the most desirable sport fish to anglers in the Republican River reservoirs, which makes it an important species from a management perspective. Reservoir fisheries decreased overall as a result of drawdowns, with walleye showing the greatest decline (Service, 1982). Walleye populations likely decreased in Swanson Lake, Harry Strunk Lake, and Keith Sebelius Lake from the combined effects of both reservoir drawdowns and fluctuations between the years 1961 and 1980 (Service, 1982). Declines in walleye at Enders Reservoir and Harlan County Lake were attributed to drawdowns only.

The Swanson Lake fishery is affected by factors such as drought and reservoir water levels and inflows (Madsen et al., 1986). From 1975 to 1980, the reservoir pool was drawn down due to irrigation demands and drought conditions. During this extended period of drawdown, a dense terrestrial growth of willow and cottonwood occurred around the shoreline perimeter above elevation 2740 mean sea level (msl). In 1981, the reservoir pool reached the top of the irrigation pool (2752 msl). When this occurred, an area of thick terrestrial growth approximately 1,200 acres in size, primarily in the upper end, was inundated for the first time since 1975. From 1981 through 1983, the reservoir pool did not fluctuate severely, and a fishery of crappies and black bass was established. Crappies can benefit the most from these conditions and yet high densities of crappie likely adversely affect young-of-the-year walleye survival.

Long-term mean (1961-80) productivity in the Republican River reservoirs (figure 12) was also estimated by the Service (1982), providing some insight into the relative differences among the productive potentials of the individual reservoirs. The various reservoirs appear to have different capacities for sustaining walleye productivity, and Harlan County Lake, by its size alone, could produce more walleye overall.

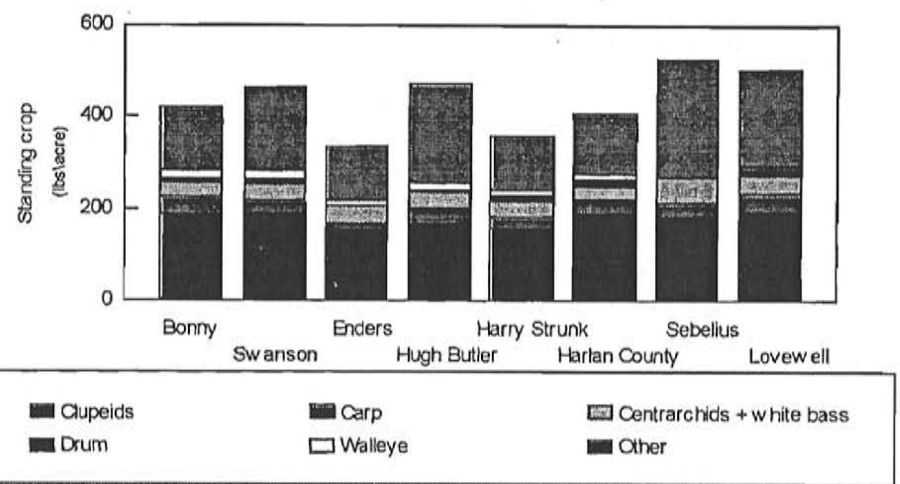

Figure 12.—Estimated long-term means based on 1961-80 reservoir conditions (Service, 1982; p. 22). These estimates are based on multiple regression models and are not measured mean values.

Harry Strunk Lake was known for outstanding crappie fishing during the first 15 years of impoundment (1949-64). Through the 1970's, a stable walleye, white bass, and channel catfish fishery was present (Madsen et al., 1986). The walleye fishery has experienced periods of decline. Fishkills were verified during the summers of 1983 and 1985 in the stilling basin due to high temperatures and low dissolved oxygen.

Enders Reservoir initially contained abundant bullhead, largemouth bass, carpsuckers, white suckers, and white crappie. The largemouth population subsequently declined, and black crappie populations grew. Walleye and channel catfish were present in fair numbers (Brezenski et al., 1990).

Before closure of Red Willow Dam, Red Willow Creek was treated with rotenone to eradicate rough fish, with the goal of maximizing game fish in the reservoir. Hugh Butler Lake was known for its quality largemouth bass, crappie, and northern pike fishery until the mid 1970's. These populations subsequently declined.

Current Assessment

Harlan County Lake is the largest of the nine Republican River reservoirs, followed by Swanson Lake and Lovewell Reservoir. Table 14 describes some of the current basic features of the reservoirs that could affect fishery resources. Clearly, Harlan County Lake provides much more water volume and total surface acres for fish habitat than do the other reservoirs. Mean depths do not differ dramatically among the reservoirs, most of which are about 20 feet deep.

The number of visitors fishing at the various lakes is shown in figure 13. Trends in fishing show that fishing pressure is probably remaining steady or increasing at most Republican River reservoirs except during drought years. Fishing pressure at Bonny Reservoir may have dropped off around 1980. Harlan County fishing pressure appears to have decreased since 1989, followed by a rebound in 1994.

Harlan County Lake

Fishery management activities at Harlan County Lake are the responsibility of the State of Nebraska, NGPC. The NGPC initiated an intensive 3-year creel survey in 1988, providing valuable data for the Harlan County Lake fishery. In anticipation of record low lake levels, the Corps and the NGPC cooperatively conducted creel surveys in 1992, 1993, and 1994. The cooperative creel surveys will be continued at least through 1996. In conjunction with the creel survey, the NGPC statistically estimated the number of angling hours occurring on Harlan County Lake.

Harlan County Lake was full in 1994 and 1995, and lake drawdown was not severe, thus providing good fish habitat. Overall catch information suggests that declining trends for walleye and white bass were reversed in 1994 and will likely continue strong in 1995 (figure 14). Channel catfish catches have remained stable, except for a decline in 1992. Crappie contributed significantly to the Harlan County angler catch for the first time since 1988, a result of higher lake elevations and increased shoreline habitat over the past 2 years.

Table 14.—Reservoir statistics important to current fishery issue

	1994 lake elevations (feet)				1994			
	Top of inactive pool	Top of active pool	Annual minimum	Annual maximum	Mean area (acres)	Mean volume (acre-feet)	Lake mean depth (feet)	Most popular game fish
Bonny	3638	3672	3670	3672	1,996	3,998	20	walleye wiper crappie white bass channel catfish bluegill
Swanson	2720	2752	2744	2756	4,776	106,687	22.3	walleye black bass crappie northern pike catfish
Enders	3082	3112	3094	3105	1,228	26,036	21.2	walleye crappie black bass white bass catfish
Hugh Butler	2558	2582	2577	2583	1,588	36,151	22.8	walleye crappie black bass white bass northern pike
Harry Strunk	2343	2366	2354	2368	1,304	23,972	18.4	walleye crappie black bass white bass catfish
Harlan County	1933	1946	1942	1948	13,345	317,885	23.8	walleye white bass channel catfish wiper
Keith Sebelius	2280	2304	2297	2300	1,662	24,480	14.7	wiper white crappie black crappie walleye black bass
Lovewell	1572	1583	1578	1585	2,978	41,540	13.9	walleye catfish white bass

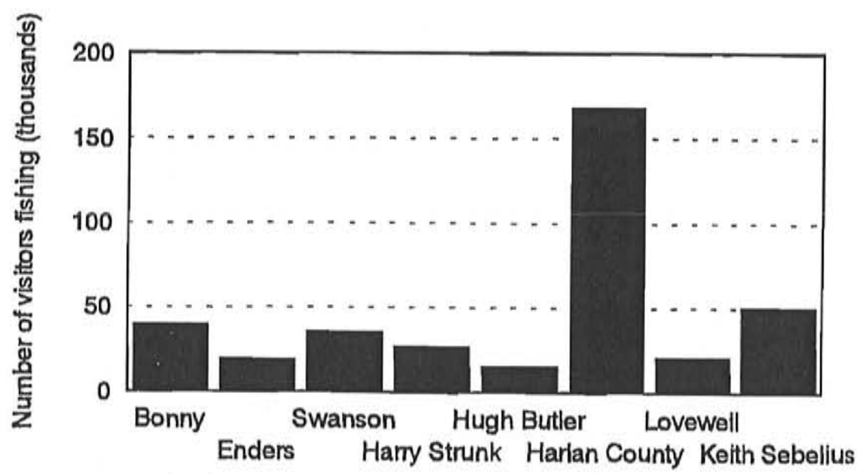

Figure 13.—The number of recreational visitors that fish at each reservoir.

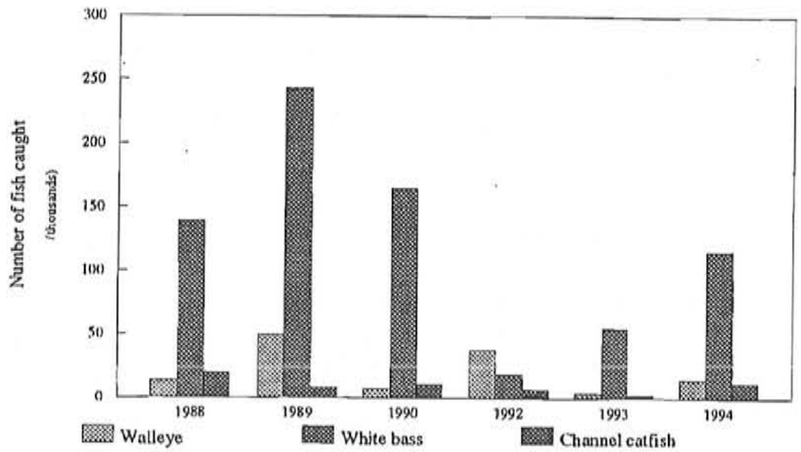

Figure 14.—Historical Harlan County angler catches of specific fish.

Gill net catches at Harlan County Lake provide useful information on the abundance of fish in the lake. Although walleye catches were fairly stable from 1973 to 1983, catches since that time have been somewhat higher and clearly more variable. Based on both abundance and size class information, walleye and white bass fishing is expected to be average over the next few years (NGPC, 1995).

Natural reproduction of walleye resulted in no walleye stockings at Harlan County Lake during the 1970's. The Harlan County Lake walleye fishery traditionally inaugurates the Nebraska open water fishing year. Walleye spawning along the face of the dam and the resultant increase in fishing pressure have been well documented. Biological data indicate that fishing along the face of the dam at Harlan County Lake when the walleye are spawning (April) has not been detrimental to the walleye fishery.

Gizzard shad has been the primary forage base and prey species in Harlan County Lake since impoundment. The high annual densities appear to inhibit growth of the juvenile shad, thus providing a usable forage late into the fall. Periodic winter and spring die-offs of shad occur at Harlan County Lake depending on climatic stress factors. The last major die-off of adult shad was documented in 1984. Other fish species present in Harlan County Lake also serve as forage at certain life stages (carp, quillback, redhorse sucker, drum, and golden shiner).

A large stocking of northern pike fingerlings in 1979 created a strong year class and a brood stock base for future years. The drought cycle of the early 1980's created conditions which allowed densities of northern pike to increase. Plantings of cereal grains on exposed shoreline, along with naturally occurring annual weeds and grasses, created ideal littoral spawning conditions for northern pike.

Flathead catfish over 20 pounds are commonly taken from Harlan County Lake. According to the 1988 and 1989 creel surveys, harvest of this species, native to the Republican River, is relatively small. The size of this species, however, makes it important as a true trophy fish.

Crappie were an important component of the Harlan County Lake fishery in its early years (1954-60). The crappie population grew rapidly in response to the newly inundated vegetation, which provided favorable habitat for spawning. The drought cycle of the late 1970's and early 1980's allowed shoreline areas to be exposed for 3 to 4 years, allowing the establishment of numerous cottonwoods and willows along the lakeshore. Inundation of the newly established vegetation duplicated pre-impoundment conditions, although on a much smaller scale. A short-term crappie fishery resulted from 1982 through 1985.

White bass, and to a lesser extent walleye and channel catfish, migrate up the Republican River from March through May. While the riprap protection on the dam south of the spillway is the predominant spawning area for walleye, the white bass population is heavily dependent on migration up the Republican River to ensure a successful spawn and subsequent strong year class.

Bonny Reservoir

The most sought-after species at Bonny Reservoir include walleye, wiper, crappie, white bass, channel catfish, and bluegill. Catch data (creeled and released) at Bonny Reservoir collected in 1994 were as follows: walleye (23 percent), crappie (22 percent), channel catfish (22 percent), white bass (20 percent), wiper (6 percent), bluegill (5 percent), and all others (2 percent). The reservoir is stocked yearly with walleye, wiper, largemouth bass, and channel catfish. The most sought-after fish appear to be reasonably abundant and, therefore, the recreational fishery seems healthy.

Enders Reservoir

Species stocked include channel catfish, northern pike, and walleye. Forage was thought to be limiting in 1990, and rough fish was estimated to account for 70.6 percent of the total biomass. Objectives at this lake are to maintain walleye populations and to increase forage levels.

NGPC estimated that 8,705 anglers spent 39,294 hours fishing Enders Reservoir during April through October 1995. Creel data (NGPC, 1995) are reported below:

	Catch (%)	Harvest (% by number)
Walleye	46	12
White bass	17	36
Bluegill	9	18
Northern pike	8	7
White crappie	7	16
Yellow perch	5	2
Largemouth bass	2	1

Channel catfish represented less than 1 percent of the total catch but 11 percent of the harvest by weight. Eight rudd, a European carp, were collected in Enders Reservoir during 1995 sampling, and the effect of this exotic species on the reservoir fisheries will need to be monitored. Gizzard shad appeared to be abundant and should provide a good prey base for future year classes of walleye (table 15).

Swanson Lake

Fishes stocked over the years include rock bass, northern pike, spottail shiner, fathead minnow, tiger musky, and walleye. NGPC estimated that 12,406 anglers fished for 49,270 hours at Swanson during April through October 1995. Creel data (NGPC, 1995) are reported below:

Table 15.—Fish sampling results at Republican River reservoirs[1] (1995)

	Enders		Swanson		Red Willow		Medicine Creek		Harlan County		Keith Sebelius		Lovewell	
	Catch per unit effort	Relative abundance	Catch per unit effort	Relative abundance	Catch per unit effort	Relative abundance	Catch per unit effort	Relative abundance	Catch per unit effort	Relative abundance	Catch per unit effort	Relative abundance	Catch per unit effort	Relative abundance
Gizzard shad	24	6%	51.7	30%	11	5%	12	13%	53.5	44%	47	6%	228	2%
Northern pike	<1		2.5	2%	2.4	1%			<1	3%				
Common carp				1%					1.7	1%		1%		<1%
River carpsucker	18.8	5%	6.8	5%	3.2	1%	1	2%	5.8	5%		1%		1%
Channel catfish				1%	6.5	3%	8.9	8%	6.5	5%		2%		1%
Black bullhead									1	1%		2%		<1%
Wiper	5	1%	2.9	2%	5.2	2%				2%	11	1%	28.4	1%
White bass	4.4	1%	3.1	1%	2.1	1%	10	11%	18.3	15%				57%
Largemouth bass												4%		<1%
White crappie					2.1	2%	1.7	2%			20	21%	9.3	14%
Black crappie	10.6	6%	56.7	38%	11.6	8%	29.4	35%	10	6%	49	21%		10%
Rock bass	4.2	2%												
Bluegill	123.1	64%	13	9%	107.5	61%	10.1	11%				33%		11%
Green sunfish				1%								<1%		<1%
Walleye	29.8	8%	6	4%	4.9	2%	5.8	5%	20.7	17%		1%	21.6	1%
Yellow perch	5.2	3%	3.5	3%	11.8	9%								
Freshwater drum			1.3	2%	2.2	1%	6	7%		1%				

[1] Data from NGPC, 1995 and Kansas Department of Wildlife and Parks, 1995.

	Catch (%)	Harvest (% by number)
White bass	44	22
Black crappie	19	42
Walleye	10	9
Yellow perch	7	10
Drum	6	2
Wipers	4	8
Largemouth bass	3	<1

Channel catfish and northern pike represented 26 percent and 12 percent of the harvest by weight, respectively, even though each species represented 2 percent or less of the catch.

Hugh Butler (Red Willow)

Northern pike, walleye, largemouth bass, and flathead catfish have been stocked in the lake. Fishery objectives at this lake include increasing the walleye and northern pike fisheries.

NGPC estimated that 8,420 anglers fished for 47,777 hours at Red Willow during April through October 1995. Creel data (NGPC, 1995) are reported below:

	Catch (%)	Harvest (% by number)
White bass	53	66
Northern pike	10	7
Largemouth bass	10	<1
Bluegill	10	14
Yellow perch	4	2
Walleye	3	2

Channel catfish and wipers represented less than 2 percent of the catch each, but 10 percent and 6 percent of the harvest by weight, respectively.

Harry Strunk (Medicine Creek)

Objectives at Harry Strunk Lake include increasing both the walleye and the northern pike populations. When this reservoir spills, large numbers of fish can be flushed out of the reservoir through the spillway notch (Madsen et al., 1986).

In recent years, Reclamation and the NGPC have cooperated in maintaining the lake level below the notched spillway during the spawning season to prevent the loss of spawning females.

NGPC estimated that 6,722 anglers fished for 32,077 hours at Medicine Creek during April through October 1995. Creel data (NGPC, 1995) are reported below:

	Catch (%)	Harvest (% by number)
White bass	51	64
Walleye	13	6
Drum	8	3
Black crappie	7	10
Largemouth bass	6	1

Channel catfish and wipers represented 5 percent and 3 percent of the catch respectively, but 20 percent and 10 percent of the harvest by weight.

Keith Sebelius (Norton)

Management objectives at Keith Sebelius Lake include maintaining healthy shad, wiper, walleye or saugeye, crappie, largemouth bass, and catfish populations. Another objective is to create a fish, wildlife, and recreation pool that eliminates drawdowns below elevation 2282 feet and to avoid drawdowns in excess of 30 percent of total reservoir content.

Kansas Department of Wildlife and Parks (1995) estimated the fishing pressure at Keith Sebelius as 21,887 angler days and 61,269 hours. Creel survey results showed that white crappie represented 53 percent of the catch (79 percent of the harvest by weight). Channel catfish ranked second in numbers of fish harvested, followed by bluegill, black crappie, black bullhead, and largemouth bass. Wiper and saugeye contribute to the fishery. Fish population sampling results are reported in table 15.

Lovewell Reservoir

Management objectives at Lovewell include maintaining strong walleye, white bass, and wiper populations.

Kansas Department of Wildlife and Parks (1995) estimated the fishing pressure at Keith Sebelius as 16,573 angler days and 56,592 hours. Creel survey results showed that walleye, channel catfish, and white bass were the top three species harvested by anglers in 1995. Fish population sampling results are reported in table 15.

Summary

The reservoirs in the Republican River Basin have similar fish assemblages. Gizzard shad dominates the sport fish prey base. The main sport fishes include walleye, white bass, bluegill, and channel catfish, with a mixture of other species abundant in some reservoirs.

Wildlife

Historically, wildlife on public lands within the Republican River Basin was managed primarily for game species. In recent years, wildlife management activities have broadened to include both game and nongame species. This section first discusses types of habitats within the Republican River Basin and then wildlife associated with those habitats.

Habitats

Historical Assessment of Habitats

Prior to settlement, most of the Republican River Basin, except near the river, would have been grasslands (short, mixed, and tall going from west to east). The lands within the Republican River Basin were settled by the 1870's; it was estimated that nearly half of the pre-project area was under dryland cultivation prior to the placement of Harlan County Dam (Service, 1946). For example, the Harlan County Lake area was estimated to consist of 10 percent grasslands, 14 percent broadleaf trees, 71 percent crops, and 5 percent other areas. In other parts of the basin, like Bonny and Enders Reservoir areas, native grasses made up the principal cover type prior to water development. At Swanson, Hugh Butler, Harry Strunk, Harlan County, Keith Sebelius, Lovewell, and Milford, agricultural crops were the principal cover type followed by native grasses (Service, 1949). Thus, the major transition from grassland habitats to croplands mostly occurred prior to major water development activities; however, water development caused some remaining grasslands to be converted to cropland.

Important wetland areas, like the Rainwater Basin area of south central Nebraska, were far more extensive in the late 1800's than at present (Farrar, 1988). These wetlands were highly valuable to waterfowl because they provided important foraging and staging habitat within the Central Flyway.

Those areas inundated by the reservoirs were altered from grassland, cropland, or riparian habitat to open water habitat (the reservoir) and a newly developing riparian zone, or shoreline habitat, around the reservoir. This caused some direct loss of fur bearer and upland game habitat and increased waterfowl migration and wintering habitat.

Changes in riparian vegetation within this basin are not well documented. The construction and filling of reservoirs has eliminated some streamside vegetative growth along reservoir shorelines. There may have been some loss of vegetation in areas where the water table declined. Increases in vegetative growth could have occurred in areas where the water table rose and along streams where the streamflow increased or stabilized to a more consistent annual flow (such as below reservoirs). It also is not known how much vegetation has been removed to make space for agricultural land development (Reclamation, 1985).

Cover types such as grasslands, croplands, woodlands, and water provide habitat for many species of wildlife. Woodland, native grasslands, and open water represent valuable habitats and yet these areas are small compared to croplands areas and other land use areas with lesser habitat value. Thus, woodland, native grassland, and open water habitats within the Republican River Basin are important because they are otherwise so limited.

Habitats Associated with Reservoirs

Public lands (128,000 acres) provide an important part of the habitat available to wildlife within the Republican River Basin. Most of the public use area openwater habitat is associated with reservoirs, and over 75 percent of the upland acres occur around reservoirs. Habitats available within these public use areas include upland, wetland, and open water areas (table 16). Elaboration on habitat is included in attachment A.

.The upland habitats mainly consist of grasslands, riparian areas, and crops. Typical vegetation associated with reservoirs includes upland, riparian, and wetland plants.

Shoreline miles provide some indication of the amount of land-water edge habitat available to wildlife (table 16). The number of acres specifically managed for wildlife varies from reservoir to reservoir and likely represents the areas of most abundant wildlife.

Typical wildlife management programs at the reservoirs include tree and shrub plantings, food plots, and herbaceous cover. Food plots are used for several species and increased efforts are being made to provide diversity in both plot locations and crop species. The importance of the reservoir lands (Reclamation and Corps project lands around each reservoir) was estimated in the late 1970's. Habitat areas at selected reservoirs are shown in table 17.

Riparian Areas

Riparian areas are land areas that are closely associated with water and usually support vegetation which is considerably different from that growing in adjacent uplands. Riparian areas vary in size and vegetative composition because of the numerous combinations that result from the interaction of water and physical characteristics. Because they generally support plants which require greater

Table 16.—Reservoir statistics associated with wildlife

Reservoir	Shoreline miles	Conservation pool (acre-feet)	Acres available for wildlife	Acres managed for wildlife	Acres of prairie/nesting cover	Acres of refuge	Acres of food plots	Acres of tree plantings	Burning program
Bonny	15	39,920	Land: 3,351 Water: 2,042	4,500	4,100	400	20	0.75	Yes
Enders	26	36,010	Land: 3,643 Water: 1,707	4,599	2,000	2,146	35	20	No
Swanson	30	116,060	Land: 4,664 Water: 4,974	7,350	1,500	0	7	100	No
Hugh Butler (Red Willow)	35	31,470	Land: 4,320 Water: 1,629	6,016	3,500	0	10 - 15	75	No
Harry Strunk (Medicine Creek)	29	32,230	Land: 6,644 Water: 1,850	7,254	3,500	0 1,000	50 138	200 100	Yes Yes
Keith Sebelius (Norton)	32	33,220	Land: 3,475 Water: 2,181	6,000	4,000	1,000	138	100	
Harlan County	75	315,090	Land: 30,249 Water: 13,240						
Lovewell	44	36,640	Land: 2,029 Water: 2,986	2,029	1,039	0	20	0	No

Table 17.—Habitat areas associated with reservoirs[1]

Reservoir lands	Cropland (acres)	Grassland (acres)	Riparian (acres)
Enders	20 (.4%)	4,598 (97%)	116 (2.6%)
Swanson	469 (6.5%)	5,916 (82.5%)	786 (11%)
Harlan County	3,961 (17.7%)	15,920 (70.6%)	2,669 (11.8%)
Lovewell	195 (5%)	3,172 (82%)	500 (13%)
Keith Sebelius	1,400 (26.8%)	3,216 (61.7%)	600 (11.5%)

[1] Data from U.S. Fish and Wildlife Service (1982).

quantities of water, riparian areas often are readily distinguished from adjacent upland areas. Although riparian areas within the basin constitute only a minor proportion of the overall area, they are genetically more productive in terms of plant and animal biomass than the remainder of the basin and are a critical source of diversity within the grassland environment.

Riparian areas constitute the only native forested environment in the basin and, as such, they provide essential habitat for many vertebrate species (Brinson et al., 1981). The dramatic contrast between upland and riparian plant communities adds to the structural diversity of the basin. Wildlife use riparian areas disproportionately more than any other type of habitat (Hubbard, 1977). Native cottonwood-willow stands provide important cover, foraging, and breeding habitat for 82 percent of all bird species in northeastern Colorado (Knopf, 1985). Almost 250 species and subspecies of vertebrates were recorded in similar stands (Beidleman, 1978).

Riparian areas also produce microclimates which are markedly different from surrounding areas due to increased humidity, higher rates of transpiration, more shade, and increased air movement. Riparian areas along streams and rivers provide linear migration routes and serve as forested connections between forest habitats for migratory birds. Livestock are attracted to riparian areas for many of the same reasons that attract wildlife. Riparian areas are also considered important for aquatic habitat enhancement, recreation, flood storage, water quality enhancement, groundwater recharge, and aesthetic qualities (Brinson et al., 1981).

Riparian communities in the basin grade from grasses and forbs in the more arid headwater areas to cottonwood and willow communities to cottonwood, green ash, burr oak, American elm, box elder, and hackberry communities in the moister lower reaches of the basin. Based upon historical references, it has been suggested that much more riparian habitat exists in the basin today than did at the turn of the century (Knopf and Scott, 1990). The Republican River flood of 1935 widened the channel and scoured the flood plain, creating ideal germination sites for pioneer riparian species. The subsequent development of irrigation and flood control reservoirs reduced flood events, causing the channel to narrow. Both events combined to produce ideal conditions for the establishment and maintenance of substantial riparian forests in the basin (Northrop, 1965). Many of these forests are reaching maturity, are not regenerating because of controlled flows, and are being affected by groundwater withdrawal. The most likely trend in riparian areas in the basin is for the pioneer forests to succeed to forests dominated by more mesic species such as oak, elm, juniper, and Russian olive (Johnson et al., 1976). Such succession is considered a natural process; however, the process may occur faster and be more widespread as a result of groundwater withdrawal.

Based upon an analysis of aerial photography, it has been estimated that approximately 53,000 acres of riparian vegetation existed in the basin above Harlan County Lake in 1978. Approximately 12,000 acres of riparian vegetation exist along the Republican River between Harlan County Lake and the headwaters of Milford Reservoir. The acreage of riparian vegetation is distributed through the basin as shown in table 18.

Table 18.—Estimated acres of riparian vegetation in the Republican River Basin—early 1980's[1]

Subbasin	Acres
South Fork Republican	3,625
Arikaree	941
North Fork Republican	2,528
Frenchman	2,313
Blackwood	365
Red Willow	1,186
Medicine	2,458
Driftwood	254
Beaver and Sappa	9,261
Prairie Dog	3,300
Republican above Harlan County Dam	26,949
Republican from Harlan County Dam to state line	9,920
Republican from state line to Milford Reservoir	5,568

[1] Reclamation, 1985.

The Nebraska Parks and Game Commission has identified five significant riparian communities. They are located below Enders Reservoir, in the Harlan County Reservoir Basin, and near the towns of Stratton, Arapahoe, and Edison. During 1996, these area and others will be surveyed more extensively. Likewise, the Kansas Biological Survey has identified the reach of the Republican River between the state line and Clay Center as containing the most important riparian areas in the basin in Kansas.

Wetlands

Wetlands are areas which are transitional between open water and uplands. The dominant feature in the development and maintenance of wetlands is the abundance of water on or near the surface. Wetlands in the basin differ in their nature and appearance because of their geographic location, water source, water permanence, and chemical properties. Wetland types in the basin range from riparian shrub communities adjacent to streams, ponds, and reservoirs to wet meadows associated with springs and flood plains to depressional marshes. The Rainwater Basin, located immediately north and east of the basin, covers approximately 4,000 square miles and has been recognized as one of three major wetland complexes in Nebraska which have international importance for migratory wildlife (Gersib, 1991). The Rainwater Basin has been identified as an important waterfowl habitat area in North America by the North American Waterfowl Management Plan, and a joint venture among public and private interests to enhance habitat values has been developed (U.S. Fish and Wildlife Service and Canadian Wildlife Service, 1986). The proximity of the Rainwater Basin increases wildlife values for wetlands in the basin.

Wetlands are important to a wide range of wildlife species because they provide specialized habitat values not found in upland areas. Wetlands provide cover, water, shade, forage habitat, breeding habitat, brood rearing habitat, loafing areas, and winter habitat; provide relief from extreme summer or winter temperatures; and contribute to biodiversity. Almost 35 percent of animals listed as threatened or endangered under the ESA are located in or depend upon wetlands for portions of their life cycles (Kusler, 1983).

Wetlands provide a host of other values. They provide flood conveyance, shoreline protection, flood storage, water quality enhancement, sediment control, recreation, groundwater recharge, timber production, preservation of archeological and paleontological values, aesthetics, and research values.

Nebraska has lost approximately 40 percent of its wetlands since 1780, while Kansas has lost approximately 50 percent (Service, 1990). It has been estimated that approximately 10 percent of the original 94,000 acres of wetlands in the adjacent Rainwater Basin have been lost (Gersib, 1991). Most of these wetland losses have been attributed to agricultural drainage, livestock grazing, housing development, transportation development, and water pollution. It is assumed that wetland losses and sources of impacts in the basin mirror those of the Rainwater Basin to a lesser degree.

The basin lies in the heart of the Central Flyway and is used extensively by migratory waterfowl, shorebirds, wading birds, and neotropical migratory birds. Because of the loss of wetlands in the Rainwater Basin, wetlands remaining in the basin provide high values for these ducks, geese, sandhill and whooping cranes, and other migratory birds. During extreme winter conditions, reaches of the Republican River below dams constitute the only open water in the basin and, as such, are critical for wintering waterfowl and bald eagles. However, during these events, crowding contributes to waterfowl death by the infectious fowl cholera. During milder winters, reservoirs in the basin provide important winter habitat for waterfowl.

Many of the values attributed to wetlands in Nebraska hold true for wetland areas in the Kansas portion of the basin. The Kansas Department of Wildlife and Parks manages wetland habitats at the Jamestown and Norton wildlife areas.

Based upon data obtained for the Rainwater Basin, it is assumed that historic wetland loss and degradation in the basin has been extensive. Even with wetland protection laws in place, wetland degradation continues. The primary impact to wetlands in the basin remains agriculture related. In addition to drainage, filling, siltation, and fertilizer and pesticide pollution, Nebraska state law requires people using groundwater for irrigation to take measures to prevent or control surface runoff. Much of the surface runoff is controlled by excavating wetlands to capture runoff for reuse (Gersib, 1991). With existing laws in place, it is expected that the acreage of wetlands in the basin will continue to decrease.

Windbreaks and Associated Habitat

Approximately 0.8 percent of Nebraska is in shelterbelts, windbreaks, and single row plantings too narrow to be considered as forest. However, they constitute an important habitat class because of their interspersion with other cover types. This interspersion leads to an abundance of edge or interfaces between woodland and other habitat types, a condition which is conducive to a diverse and relatively abundant wildlife population (nongame as well as game species).

Wildlife Management Areas

Wildlife management areas exist near most of the reservoirs in the Republican River Basin and also in areas that are not near reservoirs. These wildlife management areas are of particular importance for the preservation of wildlife habitats. Wildlife areas are managed by the State of Kansas as stipulated in the master lease agreement between the United States and the State of Kansas. They include: Almena, Lovewell, and Norton Wildlife Areas. Nebraska wildlife management areas include Enders, Swanson, Red Willow Diversion Dam, Red Willow , and Medicine Creek. Bonny Wildlife Management Area is near Bonny Reservoir in Colorado.

Approximately 97 percent of land in Nebraska (NGPC, 1991) and Kansas (Kansas Department of Wildlife and Parks, 1991) is privately owned. This means that the bulk of the potential wildlife habitat within the Republican River Basin is controlled privately. Both Kansas and Nebraska have specific programs which encourage wildlife management on private property. Natural Resource Districts, the private portion of the Habitat Program of Nebraska Game and Parks Commission, within the Republican River Basin include the Upper, Middle, and Lower Republican. Through Nebraska's Wildlife Habitat Improvement Program, landowners can receive assistance to improve habitat on their own land. Kansas Department of Wildlife and Parks also administers a Wildlife Habitat Improvement Program.

Current Assessment of Habitats

Recent surveys of 72 sites found the following plant communities within the Republican River Basin in Nebraska: 35 eastern flood plain forests, 13 wet meadows, 11 flood plain savannas, 6 loess mixed-grass prairies, 5 lowland freshwater marshes, and 2 sand sage prairies (NGPC[b]). Five sites were identified as significant due to their quality, including a grazed wet meadow/savanna; a gayfeather, wet meadow; a flood plain savanna on the Arikaree River; a gayfeather/prairie gentian wet meadow; and a savanna-type ravine with *Lobelia cardinalis* (NGPC[b]).

Several woodland and bluff areas were also identified along the Republican River in Kansas (Kansas Biological Survey, 1995). Various managed areas and natural communities identified as potentially important habitats include: Farnum Creek Park, School Creek Park, Ft. Riley Military Reservation, Timber Creek Park, northern areas of Milford State Wildlife Area, Flint Hills Tallgrass Prairie, Lovewell State Park, and the Norton Wildlife Area. Natural community types within the study area include forest, woodlands, sparse woodlands, shrubland, and herbaceous areas.

Wildlife

Historical Assessment of Wildlife

Early settlers engaged in many activities like agriculture and grazing which decreased grasslands and wetlands and shifted the types of wildlife present. The indigenous grassland animals like bison, elk, antelope, and pronghorn have been replaced by the now more common woodland wildlife (deer, turkey, quail, cottontail, etc). In general, upland game and fur animals probably were considered most valuable (especially pheasant and beaver), while big game and waterfowl may have been of lesser importance (table 19).

Various covertypes for wildlife in Nebraska included: grasslands (grouse and bobwhite quail); croplands (pheasant, quail, cottontail, squirrel, and deer);

Table 19.—Wildlife considered of value within the water development area of the Republican River in the late 1940's

Big game	Upland game	Fur animals	Waterfowl
Only a very few white-tailed deer	Pheasants, quail, cottontails, and squirrel	Beaver (including the upper basin), muskrat, mink, skunk, raccoons, opossums, weasels, badgers, and jack-rabbits	A few ducks stop over during fall and spring migrations; Frenchman Creek represented the best waterfowl area in the Republican River drainage

woodlands (squirrels, wild turkeys, cottontails, white-tailed deer, pheasants, and quail); and water (waterfowl, fur bearers, and other wetland and riparian species) (Service, 1972).

Wildlife that can be found near Republican River reservoirs and associated lands are listed in attachment A. Information on trends is available for some game species, but little is known about the status of amphibians, reptiles, and nongame animals.

Big Game

White-tailed deer and mule deer occur throughout most of the Republican River Basin. Mule deer and white-tailed deer occurred in the 1970's throughout the Republican River Basin in Nebraska at densities from scarce (less than 1 per square mile) to high (more than 8 per square mile); most of the area included low to moderate density (Service, 1972). Deer populations have stabilized in most parts of Kansas (Kansas Department of Wildlife and Parks, 1991). A few areas maintained scarce to low densities of turkey, including Spring Creek and Red Willow Creek. Turkeys have been released in the Republican River area. Turkey populations have increased steadily from about 1975.

Upland Game

Ring-necked pheasants occur in relative abundance in northwestern Kansas. Bobwhite quail populations do well in areas of abundant grassland, hedgerows, shelterbelts, and woodland areas. In 1972, ring-necked pheasant occurred in moderate densities (50-200 per square mile) from most of Chase and Dundy Counties to Franklin County. Scarce to high densities of bobwhite quail were located within the basin, with much of the middle to upper basin producing low (10-100 per square mile) to moderate (100-300 per square mile) populations. Prairie grouse were scarce (less than 5 per square mile) and mainly within the upper basin. Most of the riparian area produced moderate (100-300 per square mile) populations of cottontails. Quail populations appear to be relatively stable throughout most of the Republican River Basin.

A habitat evaluation study completed in the early 1980's showed irrigated cropland areas had relatively low habitat value for white-tailed deer, ring-necked pheasant, and American kestrel and moderate value for mourning dove and eastern meadowlark. Reservoir lands, however, had fairly high values for ring-necked pheasant and red-tailed hawk, with somewhat lower values for American kestrel, mourning dove, and Eastern meadowlark (Service, 1982).

Waterfowl

The Republican River falls within the Central Flyway and therefore provides important migratory habitat for several species of waterfowl. Reservoirs on the Republican River support large numbers of waterfowl during fall migrations and are major wintering areas for mallards and some geese. Hunting areas on and adjacent to the reservoirs constitute important duck and goose harvest regions in the state. Goose refuges have been established on parts of Enders Reservoir, increasing its importance as a hunting area. Harlan County Lake is located in an area of Nebraska considered to be an enzootic (endemic) area for avian cholera because annual outbreaks have occurred since 1975.

Many shorebirds pass through the Republican River area during migrations and may stop over at some of the reservoirs. These species may include pectoral sandpipers, spotted sandpipers, and Virginia rail. These birds are not well inventoried within this drainage.

Recreational Use of Wildlife

All of the Republican River reservoirs accommodate winter hunting. Although modern facilities are not available, the areas still represent open access. The most desired species are listed in attachment A.

The number of hunter days at the various reservoirs is shown in figure 15; Keith Sebelius Lake receives relatively high hunting pressure.

Current Assessment of Wildlife

Species groups within the Republican River Basin are diverse. Vertebrate groups are well represented, with birds representing the greatest number of species (see attachment A, table A-1, for a partial listing). Many of the birds are extremely mobile and migrate latitudinally between wintering and breeding areas. Many of the neotropical species that visit the Republican River Basin would be affected not only by habitat changes within the basin but also by heavy pesticide use and habitat destruction of their wintering grounds (neotropics), which is where they spend most of their life cycle. Raptors, shorebirds, waterfowl, colonial waterbirds, and upland game birds represent other important groups of birds that inhabit the basin at least during some parts of the year. There is a known need in the Republican River Basin to protect open water habitats for waterfowl. Open water habitats in this area are limited due to past habitat destruction and because the area is within the Central Flyway.

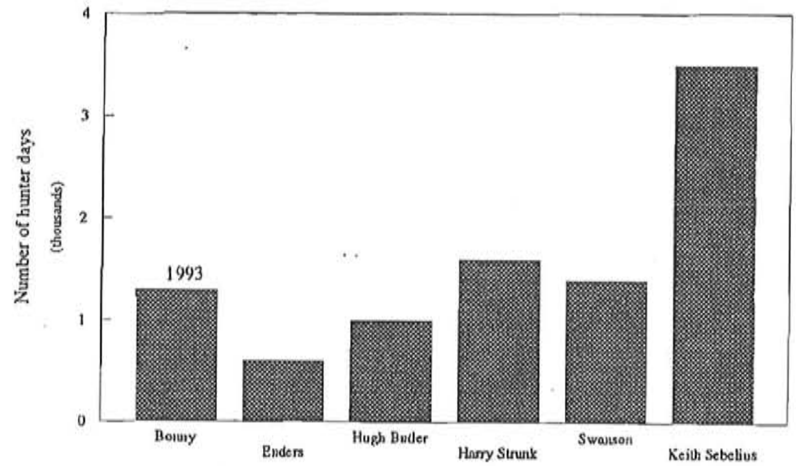

Figure 15.—Hunter days, 1994.

Amphibians and reptiles can be important indicators of ecosystem health because they depend upon diverse microhabitats and because they are sensitive to habitat losses and pollution. These animals can also be important to the food chain. Several groups are represented in this basin (see attachment A, table A-1).

Mammals are well represented in the basin (attachment A, table A-1). Some mammals, like rodents, jackrabbits, and cottontails, represent an important source of food for other animals. Other species, like deer, are an important component of recreation in the area.

Information on wildlife within the basin is currently being gathered for this contract renewal effort. The studies aim to identify particularly valuable habitats, sensitive (endangered or threatened) species and their habitats, and wildlife and habitats that could be affected by changes in Republican River water levels, which is the parameter most likely affected as a result of contract renewal. Preliminary results are summarized below.

Recent surveys (NGPC[b]) found 95 vertebrate species within the Nebraska portion of the Republican River Basin. Of these species, 67 percent were birds, 16 percent mammals, and 12 percent herptiles. Frequently encountered birds during the survey were black-capped chickadees, house wrens, and mourning doves. White-tailed deer and raccoon represent mammals encountered at high relative frequencies. The softshell turtle was a herptile encountered relatively frequently during these surveys. The great blue heron was common throughout the area. The wood pewee was observed at seven sites. Cooper's hawks were found at three sites, Swainson's hawks were observed at two locations, and the northern harrier was found at one site. A juvenile coachwhip snake was collected in the Frenchman Creek drainage.

Endangered Species

- *Definition*

Endangered species are plant and animal species that the Service has determined to be in danger of extinction (endangered) and those that may become so in the foreseeable future (threatened). These species are protected under the authority of the ESA of 1973 (Public Law 93-205), as amended.

- *Policy*

Reclamation will carry out its activities in a manner to fully support the goals of, and comply with, the requirements of the ESA.

- *Process*

Section 7 of the ESA requires Federal agencies to ensure that all federally associated activities within the United States do not have adverse impacts on the continued existence of the threatened or endangered species or on designated areas (critical habitats) that are important to conserving the species. Action agencies must consult with the Service, which maintains current lists of species that have been designated as threatened or endangered, to determine the potential impacts a project may have on protected species. This section also considers those species protected by state laws.

Recent surveys within the Nebraska portions of the Republican River (NGPC, 1995[b]) found 16 occurrences of rare or protected species (including species of concern to the state) within the study area, including cutleaf cyclanthera, cardinal flower, Fremont's virgin's-bower, plains topminnow, orangethroat darter, the coachwhip snake, and Cooper's hawk. The Nebraska Game and Parks Commission will continue work in 1996 to identify locations of endangered, threatened, and rare plants and animals and their habitats.

The Kansas Biological Survey (1995) has determined that 37 protected and rare species (including species of concern to the state) are known to occur or could occur in the study area. Preliminary surveys in 1995 did not, during the time the surveys were conducted, locate any federally protected, state-protected, or state-rare plants within the study area. Surveys will be conducted in 1996 to look for these species. Six of the species that could occur within the study area are listed as endangered by the Service, and those that could occur in more than a migratory phase include the American burying beetle and the least tern. The Kansas Biological Survey will continue work in 1996 to identify locations of endangered, threatened, and rare plants and animals and their habitats.

Cultural Resources

Cultural resources in most of the Republican River Basin have not been systematically inventoried, so only estimates can be given for the density of these sites. From the little that has been systematically surveyed, we know that the drainage is rich in cultural history. Most of the well-known sites have been located as a result of a survey of the Federal reservoirs.

The basin has many unique and valuable paleontological resources which predate human occupation. Sites near Bartley and on Harry Strunk and Harlan County Lakes are known worldwide for their rich fossil deposits. Unique fossils such as skulls of a saber tooth cat and a shovel tooth mammoth have been recovered from Federal property on Medicine Creek.

Before written history, the valley was occupied by humans for more than 11,000 years. It may hold evidence for one of the oldest human occupations in North America at the LaSena Site on Harry Strunk Lake. Many other sites from the very early period known as PaleoIndian are in the vicinity of Bonny and Lovewell Reservoirs and Harry Strunk Lake. These date from the end of the last Ice Age and frequently include the remains of large animals that are now extinct.

The following time period, which stretches approximately from 8,000 to 2,000 years ago, is generally referred to as the Archaic Period. There are very few known sites in the western Great Plains that date to this time period. One of the best known of these is the Spring Creek Site, on Hugh Butler Lake in the Republican River Basin. It is likely that other sites will be found on reservoirs or lakes such as Bonny, Harry Strunk, Harlan County, and Swanson, which appear to have geological deposits of the right age.

The Woodland Period, which began about 2,000 years ago, is well represented in the valley. Generally, this is represented by a group known archeologically as the Keith Focus, which was defined from sites in the drainage. Woodland sites are common at Swanson, Harlan County, Hugh Butler, and Harry Strunk. There are also many sites of this age recorded on the river along and upstream from Milford Reservoir.

By far the most common sites in the basin are from a group known as the Central Plains Tradition and particularly a division of this group known as the Upper Republican Phase. These people appeared about 900 AD and are most likely ancestors of Caddoan speaking groups such as the Wichita, Pawnee, and Arikara Tribes. These were more settled agricultural people whose houses and storage pits left much richer archeological sites. These sites are common at Harlan County, Harry Strunk, and Hugh Butler Lakes. Another group, who were apparently in the area slightly later, are known as White Rock. They are likely the ancestors of Siouxan speaking groups such as the Missouri, Iowa, and Oto Tribes. White Rock sites are common around Lovewell and Harlan County Lakes, and the cultural unit was first defined at those locations. A later group, known archeologically as the Dismal River Phase, were known historically as the Apache. Well-known sites from this group are found particularly in the vicinity of Harlan County Lake.

Historically in the basin, the Pawnee had village sites such as the Hill Site in Webster County, Nebraska; the Pawnee Indian Village Museum in Republic County, Kansas; and the Bogan Site on Milford Reservoir. There is also a probable hunting camp on Swanson Lake. Many other hunting sites are no doubt present since there are many historical records of the Pawnee conducting annual hunts in the basin. Much of the Pitahawirata or Tappage Band of the Pawnee were killed in an attack by the Sioux at Massacre Canyon in Hitchcock County, Nebraska. There is also a major Pawnee sacred site, known as Guide Rock, on the Courtland Canal in Webster County, Nebraska, just east of Red Cloud. The Brule Sioux occupation in the valley is documented in the memoirs of John Young Nelson, an early trader who lived along the basin in Nebraska. Other divisions of the Sioux also hunted in the valley. The Cheyenne and Arapaho were more mobile occupants of the western end of the basin. Other mobile hunting groups such as the Kiowa and Comanche also no doubt used the basin from time to time. After the relocation of eastern tribes began in the late 1700's and early 1800's, immigrant tribes such as the Potawatomi, Delaware, Sac, and Fox also began to hunt in the basin.

In the period of written history, the valley was visited by such notable explorers as Pedro de Villasur in 1720, the Mallet brothers in 1739, Pedro Vial in 1793, Zebulon Pike and Facundo Melgares in 1806, Lieutenant John C. Fremont in 1843, Lieutenant L. C. Easton in 1849, Lieutenant Francis T. Bryan in 1856, General George Armstrong Custer in 1867, Buffalo Bill Cody in 1869, and Grand Duke Alexis in 1872. Journals survive to describe most of these explorations. Early military presence is demonstrated by sites such as the Ft. McPherson military trail up the Medicine Creek drainage and the Big Timbers military camp once located in the vicinity of the later Swanson Lake.

There are also a variety of historic sites from the later settlement period. These include World War II German prisoner of war camps at Atlanta, Indianola, and Belleville; the McCook Army Air Base; the cabin where "Kool Aid" was invented; a house designed by architect Frank Lloyd Wright in McCook; an adobe pioneer house at Keith Sebelius Lake; and the birthplace or homes of such notables as Senator George W. Norris in McCook, writer Willa Cather in Red Cloud, and actor David Janssen in Naponee.

Aesthetic Values

As noted elsewhere, prior to settlement in the mid- to late-1800's and the development of an agricultural economy, native vegetation associated with the basin consisted mainly of grasses with trees limited to narrow belts of gallery forest along stream valleys (Kellogg, 1905; Costello, 1969). Other than its dense and diverse vegetative cover, its valley bluffs, and the deeply dissected drainages, the basin was generally devoid of significant aesthetic features. Notable exceptions included the immense herds of Plains bison (*Bison bison*), their trails and wallows, Indian villages, and their trails and agricultural areas.

The Federal Government's Indian policies of the mid-19th century advocated the elimination of the Plains bison in an effort to weaken, and ultimately relocate, Plains Indian Tribes. The realization of this aspect of Indian policy ultimately removed both the Plains bison and Native Americans from the basin. As irrigation technology developed, native grassland which had supported immense herds of Plains bison, and later domesticated livestock, was broken and converted to row-crop irrigated agriculture. According to Wedel (1986), little unspoiled natural grassland remains in the basin.

Irrigated agriculture also produced changes in the landscape in ways indirectly related to row-crop agriculture. The development of large Federal impoundments inundated thousands of acres of the basin adjacent to the Republican River and its tributaries. Flood plain valleys supporting riparian gallery forests were converted to flatwater reservoirs with fluctuating surfaces and variable shorelines. Operation of these impoundments resulted in wide fluctuations in surface elevations and considerable exposure of unvegetated mudflats at their headwaters and unvegetated valley slopes along their perimeters. In many cases, riparian communities common to the flood plain re-established along much of the impoundment's perimeter. The reduction in floodflows and increased consistency in flows downstream of these impoundments favored the development and maintenance of expansive riparian forests. In addition, return flows from agricultural areas were often conveyed through natural, predominantly dry drainages and allowed riparian and upland vegetation to establish in sites which previously supported grassland communities.

However, not all modifications associated with settlement have had seemingly positive aesthetic benefits. Wedel (1986) notes that in 1982, ". . . Beaver Creek was a narrow, weed-grown ditch without water and choked with fallen trees. In place of the 'notes of many birds' (described by Fremont [1845]), one would probably hear the noisy monotone of farm tractors, the occasional snarl of the chain saw eating away at what is left of the 'dense border of wood,' and the rumble of cattle haulers and grain trucks on their way to market instead of the thunder of bison hooves."

Settlement inevitably resulted in community development and the growth of villages, towns, and cities. Because of sparse population, communities are spaced widely in the basin and tend to be concentrated within or immediately adjacent to the river valley. Communities and similar developments in the grassland landscape resemble islands of trees surrounded by a sea of grass, grain fields, and broken soils. These "islands" minimize the monotony of the generally treeless, rolling plains. On a smaller scale, shelterbelts and windrows associated with farmsteads and agricultural areas produce similar aesthetic effects.

Trends

While the basin is somewhat isolated from influences and trends experienced by other agricultural areas, a number of trends in the aesthetic quality of the basin can be identified. Areas remaining in native grass continue to decrease. However, with the success of the Conservation Reserve Program (CRP), thousands of acres of cropland have been re-planted to native and introduced grasses. With the uncertain future of the CRP, it is difficult to predict whether the acreage of grassland will continue to increase, decrease, or remain static with increases offsetting decreases. The overall trend has been a decline in the acreage of native grassland, with significant increases in the acreage of row-crop agricultural lands. This trend is predicated largely upon crop prices and government farm policy.

The acreage of native and introduced trees has increased considerably since settlement. In addition to increases along the Republican River associated with impoundment construction and operation, and that associated with irrigation return flows, the planting of native and introduced tree species is expected to continue to increase for soil conservation, wildlife habitat, energy conservation, and quality of life benefits. However, the number of new farmsteads and their associated shelterbelts and windbreaks is not expected to increase, as populations in the basin continue to experience a general decline.

Indian Trust Assets

Definition

American Indian Trust Assets are legal interests in assets held in trust by the United States for Indian tribes or individual Indians. Assets can be considered as anything that has monetary value and can include real property, physical assets, or intangible property rights. Examples of resources that could be considered to be ITAs include lands, minerals, hunting and fishing rights, water rights, and instream flows.

The United States has a trust responsibility to protect and maintain rights reserved by or granted to Indian tribes or individual Indians by treaties, statutes, and executive orders. The Secretary of the Interior (Secretary) is the trustee for the United States on behalf of the Indian tribes. All Department of the Interior agencies, including Reclamation, share the Secretary's duty to act responsibly to protect ITAs.

Policy

Reclamation established policy concerning the protection of ITAs in 1993. This policy states that Reclamation will carry out its activities in a manner which protects ITAs and avoids adverse impacts where possible. When adverse impacts cannot be avoided, Reclamation will provide appropriate mitigation or compensation.

Background

The historic distribution of Indian tribes in the Republican River Basin has been determined through relationships between Indian languages (Sturtevant, 1967). The vast majority of the upper reaches of the basin was occupied by the Arapaho and Pawnee, and the area near the confluence with the Smoky Hill River was occupied by the Kansa. The middle reaches of the basin in Nebraska and Kansas were occupied by the Pawnee at the time of contact by European and American explorers. Pawnee lifestyle was generally based upon hunting, gathering, and the cultivation of maize, beans, squash, and sunflowers (Wedel, 1986).

Upstream and downstream of lands occupied by the Pawnee were lands important to the Arapaho and Kansa, respectively. The Arapaho occupied the short-grass steppe of eastern Colorado and Wyoming and western Nebraska and were characteristic of Plains nomadic, hunter-gatherer tribes. The Kansa occupied the mid- to tall-grass prairies and forests along the lower reaches of the Republican, Solomon, Smoky Hill, and Blue Rivers and were common along the Kansas River east to its confluence with the Missouri River. Similar to the Pawnee, the Kansa favored a more sedentary, agriculturally oriented lifestyle. The Prairie Band Potawatomi were relocated from the Great Lakes area to northeastern Kansas in 1847 and 1848 pursuant to the "Treaty with the Potawatomi of 1846." This treaty recognized the Potawatomi Nation by the Federal Government and established a 30-square mile reservation.

Process

The evaluation of ITAs began with telephone consultation with the Bureau of Indian Affairs (BIA) office in Horton, Kansas. Shortly thereafter, letters were sent to tribal governments representing the Arapaho, Pawnee, Kansa, and Potawatomi Tribes. This correspondence requested the identification of ITAs known to the tribes and offered to meet to further discuss the ITA issue. To date, there has been no response from any of the tribes concerning potential ITAs in the basin. Consultation with BIA concluded that there were no trust obligations (i.e., reservations or tribal lands) in the basin. However, during consultation, BIA identified a potential ITA in the original Potawatomi reservation. The reservation included 30 miles of the Kansas River and, pursuant to the Winters Decision of 1908, held a federally reserved water right. Such a water right represents a potential ITA. BIA questioned whether the Kansas River water right legally persists following reduction in the size of the reservation and associated removal of the Kansas River from reservation boundaries (Leander, personal communication). Consultation with the Solicitor's Office concluded that a provision in the Treaty with the Potawatomi of 1861 sufficiently releases any federally reserved water right the Potawatomi Tribe may have held in the Kansas River.

A separate review of relevant treaties indicated that some tribes reserved the right to hunt on previously occupied lands. In cases relevant to the basin, the right to hunt was later relinquished through subsequent treaties.

During the investigation into potential ITAs within the basin, more than 40 treaties, executive orders, and legislative documents regarding the Kansa, Pawnee, Northern Cheyenne, Northern Arapaho, Potawatomi, Wyandot, Delaware, Chippewa, Seneca, Mixed Seneca, Shawnee, and Quapaw tribes, among others, were reviewed to determine whether potential ITAs were present or affected in the Republican River Basin. Based upon the information reviewed to date, it was determined that there are no ITAs either in, or affecting, the Republican River Basin.

Part IV—Looking Ahead

Introduction

Part IV anticipates future development and describes in greater detail possible scenarios for the management of water and related resources and the need for data that would further refine knowledge about the area and its potential.

Management Scenarios

Overview

In March 1995, public meetings were conducted to identify the needs and concerns of the public and various state agencies, as well as those of other Federal agencies in the Republican River Basin. Based on the information gathered at these meetings and through mailed comments, a list of management scenarios was developed, as described in an earlier section of this RMA. The scenarios were divided into groups of equal interest and then refined by individualized computer analysis using specific criteria. Based on this information, an initial set of separate scenarios was developed.

The management scenarios are to gauge the way in which changes in future water management could affect various beneficial water uses in the basin. The scenarios describe the outcome if water is managed to emphasize historic irrigation, fisheries, or recreation, for example. The initial management scenarios represent a full range of possibilities, some of them beyond Reclamation's existing authority to implement and others with possible unacceptable environmental impacts. The scenarios were screened at two levels of criteria, as described below.

The management scenarios are the first step in developing alternatives to be examined in detail in the subsequent draft environmental impact statement, as required under NEPA. With additional public input, Reclamation will develop a range of reasonable alternatives and provide a comparison of the social, economic, and environmental effects of the alternatives.

The target year 2025 was used to depict the impacts of flows under the various scenarios on resources within the basin.

Management Scenarios

A detailed analysis of the scenarios and their derivation is provided in attachment F and in attachment B, part IV. The initial management scenarios are:

Scenario 1 (Historic Operations)

This scenario represents the historic operation of the basin, assuming 1993 level-of-development flows. The study simulates hydrologic conditions for the period 1931 through 1993. It is based on historic irrigated acreage by irrigation district. Historic reservoir operations (same target elevations and irrigated acres as in the past) are based on the authorized project purposes such as flood control and irrigation.

Scenario Group 2 (Irrigation)

The major water management goal for all group 2 scenarios is to continue present operations and attempt to provide water to irrigate the acres that have been developed.

Scenario 2

This scenario would meet the major water management goal with the period of record for each ditch computed for full irrigable acres. Water uses other than irrigation would have secondary priority.

Scenario 2a

This scenario would attempt to meet the major water management goal while satisfying minimum reservoir elevations to increase the probability of refilling the reservoirs to provide noxious weed control.

Scenario 2b

This scenario would attempt to meet the major water management goal with reservoir elevations that would not exceed the top of the riprap during April and May. This would prevent shoreline erosion and provide sediment control.

Scenario 2c

This scenario would attempt to meet the major water management goal by modeling integrated reservoir management in the basin (operating reservoirs in coordination with each other as one unit instead of individually). This means water would be moved from upstream impoundments to offset shortages in impoundments at the lower end of the basin to benefit irrigation.

Scenario 2d

This scenario would emphasize water management through increased water delivery efficiencies. By improving canal delivery efficiencies, irrigation shortages to the irrigation districts would be reduced. Increases in onfarm and lateral and canal efficiencies of 5 percent, 10 percent, and 20 percent would be modeled (a monthly simulation of reservoir operations in the basin under specific inflow conditions).

Scenario 2e

This scenario would attempt to provide water to irrigate authorized acres (total number of acres according to authorizing legislation).

Scenario Group 3 (Reservoir Fisheries)

The major water management goal for all group 3 scenarios is to emphasize reservoir fisheries while considering various levels of irrigation.

Scenario 3

This scenario would attempt to meet the major water management goal through selecting maximum pool elevations during March and April and minimum pool elevations during July and August. Irrigation water would be provided only for historical irrigated acres (the annual project acres that have been irrigated since project irrigation service began).

Scenario 3a

This scenario would attempt to meet the major water management goal in the same way as scenario 3, except that it would attempt to provide irrigation water to acres that have been developed.

Scenario 3b

This scenario would attempt to meet the major water management goal in the same way as scenario 3a, except that minimum reservoir elevations would be selected for the months of March through August. This would prevent shoreline erosion and provide sediment control.

Scenario 3c

This scenario would attempt to meet the major water management goal while attempting to provide water to irrigate acres that have been developed. It would also emphasize integrated reservoir management in the basin. In the model, water is moved from upstream impoundments to offset shortages in impoundments in the lower end of the basin.

Scenario 3d

This scenario would attempt to meet the major water management goal but would not provide irrigation releases. Maximum reservoir elevations would be selected for March and April and July and August. Maximum releases would be selected to avoid downstream flooding. Target elevations (reservoir elevations which provide specific operational benefits) would be reached during June, July, and August to accommodate shoreline seeding.

Scenario Group 4 (Reservoir Recreation)

The major water management goal for all group 4 scenarios is to emphasize reservoir recreation with various levels of irrigation.

Scenarios 4, 4a, and 4b attempt to achieve the group's major water management goal by selecting minimum reservoir elevations for May through September.

Scenario 4

Scenario 4 emphasizes reservoir recreation while providing water to historical irrigated acres.

Scenario 4a

Scenario 4a emphasizes reservoir recreation while attempting to provide water to irrigate the acres that have been developed.

Scenario 4b

Scenario 4b emphasizes reservoir recreation with no irrigation releases in order to prevent shoreline erosion and provide sediment control.

Scenario 4c

This scenario emphasizes reservoir recreation while attempting to provide water to irrigate the acres that have been developed. It also emphasizes integrated reservoir management within the basin. This means water would be moved from upstream impoundments to offset shortages in impoundments in the lower end of the basin for the benefit of recreation.

Scenario 5 (Future Depletions)

Components of this scenario include modifying 1993 flows in the basin to reflect future flow depletions to the year 2025. This scenario attempts to provide water to irrigate the acres that have been developed. Scenario 1 results would be compared to incorporate increases in the depletions.

Scenario Group 6 (Natural Hydrologic Regime)

The major water management goal for all group 6 scenarios is to maintain instream flows by passing all inflows as outflows.

Scenario 6

This scenario attempts to achieve the goal by selecting minimum operating pools at all reservoirs in the basin. Flood constraints (the limit of water that can be stored in a reservoir or the amount of water that can be safely released into a stream channel without causing downstream damage to adjacent lands) would apply. Flood storage would be evacuated as soon as possible to reach minimum pools.

Scenario 6a

Scenario 6a attempts to achieve the goal by assuming natural conditions until reservoirs and projects were developed. It models historical reservoir operations after reservoirs were constructed and provides water to irrigate historical acres.

Scenario 6b

Scenario 6b attempts to achieve the goal by assuming natural conditions until reservoirs were constructed, but no irrigation water would be released. Reservoirs would pass peak flood flows above the top of active conservation storage. This model accounts for losses due to evaporation and seepage.

Scenario 6c

Scenario 6c attempts to achieve the goal by assuming natural conditions until the reservoirs were constructed and assessing the impact of total developed irrigated acres. Reservoirs would pass peak flood flows above the top of the active conservation storage. This model accounts for losses due to evaporation and seepage.

Scenario 6d

Scenario 6d attempts to achieve the goal by assuming natural conditions with no reservoirs being built at any time during the study period while assessing the impact of total developed irrigated acres.

Scenario Group 7 (Riparian)

The major water management goal for all group 7 scenarios is to sustain and enhance the riparian zone along the shoreline in Reclamation impoundments by fluctuating water levels. Overall target elevations would be 3 feet below the top of conservation pools. In addition, reservoir drawdown would begin in the first week of June, and target elevations are reached by the end of the second week in June.

Scenario 7

This scenario attempts to achieve the group's major goal while making no irrigation releases during the first 2 weeks of June.

Scenario 7a

This scenario attempts to achieve the group's major goal while not making any irrigation releases at any time during the year.

Scenario Group 8 (Republican River Fisheries)

The main water management goal for all group 8 scenarios is to emphasize river fisheries in designated reaches of the Republican River.

Scenarios 8, 8a, and 8b are to sustain and enhance the river fisheries in the mainstem Republican River below the Cambridge Diversion Dam to the upper end of Harlan County Lake and below Harlan County Dam to Superior-Courtland Diversion Dam. Flows in these reaches would be maintained for breeding, reproduction, and overall habitat maintenance from April through September. Minimum flow criteria have been developed for periods of drought. All three scenarios assume Harlan County Lake is at elevation 1944 from April 1 to July 1. These scenarios were developed to explore potential impacts various riverflows for fisheries might have on the basin's hydrology.

Scenario 8

Scenario 8 attempts to accomplish the major goal while providing water to historical irrigated acres.

Scenario 8a

Scenario 8a attempts to accomplish the major goal while attempting to provide water to irrigated the acres that have been developed.

Scenario 8b

Scenario 8b would accomplish the major goal while providing no water for irrigation.

Scenarios 8c through 8e share the same major goal of sustaining and enhancing the river fisheries in the Republican River, but the designated reaches are from below the Superior-Courtland Diversion Dam to the upper end of Milford Reservoir. Under all three scenarios, flows in this reach of the river would be maintained for breeding, reproduction, and overall habitat maintenance from January through December. Like the other group 8 scenarios, these were developed to explore potential impacts that various riverflows for fisheries might have on the basin's hydrology.

Scenario 8c

Scenario 8c attempts to accomplish the major goal while providing irrigation water to historical acres.

Scenario 8d

Scenario 8d attempts to accomplish the major goal while attempting to provide irrigation water to the acres that have been developed.

Scenario 8e

Scenario 8e would accomplish the major goal while providing no water for irrigation.

Scenarios 8f through 8h also share the major water management goal of sustaining and enhancing the river fisheries in the Republican River, but the designated reach is below the Cambridge Diversion Dam to the upper end of Milford Reservoir. In addition, the scenarios attempt to provide minimum desirable streamflows in this reach for water quality purposes. Flows in this reach would also be maintained for breeding, reproduction, and overall habitat maintenance from January through December.

Scenario 8f

Scenario 8f attempts to accomplish the major goal while providing water for irrigating historical acres.

Scenario 8g

Scenario 8g attempts to accomplish the major goal while attempting to provide irrigation water to the acres that have been developed.

Scenario 8h

Scenario 8h would accomplish the major goal while providing no water for irrigation.

Screening Process

The preliminary management scenarios were initially screened by threshold criteria designed by an interdisciplinary team to drop out those scenarios that could not withstand real-world tests of feasibility.

The threshold criteria eliminated management scenarios likely to be summarily and universally rejected as being illogical, unacceptable, or unrealistically difficult to implement. Those screening criteria were:

- Can this scenario be implemented with surface water physically available within the Republican River Basin?
- Does this scenario significantly and adversely impact economic activity within the basin?
- Does this scenario include some maintenance of irrigated agriculture?
- Does this scenario result in an adverse effect to threatened and/or endangered species or species proposed for listing?
- Does this scenario require major construction or removal of facilities or features within the basin?
- Does this scenario significantly and adversely increase the risk of flooding?
- Does this scenario result in significant and adverse water quality degradation?

The initial management scenarios were reduced by about half in the initial screening conducted in April 1996. Those eliminated were screened out primarily for their significant and adverse effect on economic activity in the basin, specifically irrigated agriculture or recreation.

Once the initial screening process was completed and those scenarios not meeting the requirements were eliminated, a second set of screening criteria was used to further eliminate duplicative scenario results. These criteria included:

- Whether the results from the computer analyses were the same
- Eliminate scenarios in which there were less than 2-foot differences in elevations in end-of-month reservoir contents during the month of July
- Eliminate scenarios in which there was a 1-foot difference in end-of-month contents

- Eliminate scenarios in which the increased rate for more than one reservoir's reaching inactive pool in July exceeded 20 percent

- Eliminate scenarios that reduce the available water supply to irrigators by greater than 26 percent

Using computer analysis and the screening criteria, additional scenarios were dropped from further consideration.

The scenarios dropped from consideration during these screening processes were:

2c	Total developed acres with integrated system management
3	Maximize fisheries benefits with historical irrigated acres
3d	Maximize fisheries benefits with no irrigated acres
4	Maximize recreation benefits with historical irrigated acres
4b	Maximize recreation benefits with no irrigated acres
4c	Maximize recreation benefits with integrated system management
6	Natural hydrology regime with no reservoirs and no irrigated acres
6a	Natural hydrology regime with no reservoirs and historical irrigated acres
6b	Natural hydrology regime with reservoirs as they were built and no irrigated acres
6c	Natural hydrology regime with reservoirs as they were built and total developed acres
6d	Natural hydrology regime with reservoirs and total developed acres
7a	Maximize riparian benefits with no irrigated acres
8	Instream flow analysis—Cambridge and Guide Rock with historical acres
8b	Instream flow analysis—Cambridge and Guide Rock with no irrigated acres
8c	Instream flow analysis—Guide Rock and Clay Center with historical acres

8e	Instream flow analysis—Guide Rock and Clay Center with no irrigated acres
8f	Instream flow analysis—Cambridge, Guide Rock, and Clay Center with historical acres
8h	Instream flow analysis—Cambridge, Guide Rock, and Clay Center with no acres
9	Harlan County Lake special studies, 1993 level flows with historical irrigated acres
9b	Harlan County Lake special studies, 1993 level flows with no irrigated acres
10	Harlan County Lake special studies, 2025 level flows with historical irrigated acres
10b	Harlan County Lake special studies, 2025 level flows with no irrigated acres

It should be noted that although these management scenarios have been eliminated from further consideration, specific portions of them may be included in the alternatives developed for and presented in the draft EIS.

Data Needs

In preparing the RMA, information gaps were identified. Attempts will be made to fill these gaps prior to EIS preparation.

Selenium

In order to better understand the scope and magnitude of the environmental effects associated with the selenium issue, bottom sediments and biota within the study area should be collected. Biota samples would provide critical information necessary to determine the processes of plant uptake and bioconcentration and bioaccumulation of selenium within the study area. The case may exist that geochemical conditions render the selenium in the drain water environmentally inert. However, selenium effects on biota cannot be determined until a biological assessment of drain water can be conducted. Effects of irrigation of seleniferous soils on groundwater should also be investigated. If elevated concentrations of selenium are detected in biota samples, then sampling of soils within the watershed would be the next step in the investigation.

Threatened and Endangered Species

There is a need to identify which threatened and endangered species could be impacted by potential changes associated with contract renewal. Aquatic and riparian studies are being conducted by the NGPC and the Kansas Department of Wildlife and Parks. Information concerning aquatic and terrestrial threatened and endangered species is being collected. Results of these studies may identify additional data needs that would require further study.

Cultural Resources

Only a very small percentage of lands in the Republican River drainage have been inventoried for cultural resources. Most of the resources that have been recorded lie on Federal land adjacent to reservoirs. Yet, of the reservoirs in the part of the Republican River Basin covered in this study, none has had a comprehensive cultural resources inventory. Inventories underway at Harry Strunk Lake and Lovewell Reservoir should be completed by the end of 1996. More than 300 cultural resource sites have been recorded at Harry Strunk Lake, while about 45 have been recorded at Lovewell. Cooperative agreements are in place, with five area universities to complete inventories of all Reclamation reservoirs in the drainage by the end of the year 2005.

Other

- Acreages of wetlands and riparian areas associated with surface water and reservoirs within the basin
- State Fish and Game Department recommendations for end-of-month pool elevations and instream flows
- References on the relationship between wildlife habitat on irrigated versus dryland farms
- Pool elevations at all reservoirs that render each boat ramp, dock, and beach inaccessible
- Monthly visitation at each boat ramp, dock, and beach for all reservoirs
- Concurrence from state and Federal natural resource agencies on the impact of pool fluctuation on reservoir delta wetlands

- Recommendations from state, Federal, and university authorities on the river operations that would favor native fishes

- Economic comparison of water value to irrigation versus recreation

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Attachments

Attachment A—Wildlife

Part I	Wildlife Occurring Near Republican River Reservoirs
	Habitat Characteristics
	Game Species at Reservoirs
	Fishkill Data
Part II	Endangered Species
Part III	Summary of Aquatic/Riparian Studies

Attachment B—Hydrology

Part I	Irrigation Return Flow, Subsurface Drains
Part II	Surface and Groundwater Quality Data
Part III	Area Reservoir Inflow Data and Historic Versus 1993 Level-of-Basin Development Inflow Comparisons
Part IV	Water Supply Evaluation Computer Analysis
Part V	Groundwater Research Management Assessment, Republican River Basin Water Supply Study Nebraska, Kansas, and Colorado
Part VI	Hydrology Assessment for the Republican River Basin

Attachment C—Coordination

Part I	MOU Between the Bureau of Reclamation and the Cooperating Agencies
Part II	Corps of Engineers Letter to Bureau of Reclamation

Attachment D—Socioeconomic/Agricultural

Attachment E—Administration

Part I	Republican River Compact
Part II	Water Rights—General
Part III	Republican Basin Water Rights
Part IV	Operating Agreement
Part V	Lease Agreements

Attachment F—Management Scenarios

Attachment A—Wildlife

Part I Wildlife Occurring Near Republican River Reservoirs

Habitat Characteristics

Game Species at Reservoirs

Fishkill Data

Part II Endangered Species

Part III Summary of Aquatic/Riparian Studies

Part I

Wildlife Occurring Near Republican River Reservoirs

Habitat Characteristics

Game Species at Reservoirs

Fishkill Data

Table A-1.—Wildlife occurring near Republican River reservoirs

	Common birds	Common waterfowl	Common reptiles and amphibians	Common mammals
Bonny Reservoir	Golden eagle (*Aquila chrysaetos*)	Mallard (*Anas platyrhynchos*)	Toad (*Bufo americanus*)	Mule deer (*Odocoileus hemionus*)
	Prairie falcon (*Falco mexicanus*)	Teal (*Anas discors*)	Grass snake (*Opheodrys vernalis*)	White-tailed deer (*Odocoilius virginianus*)
	Rough-legged hawk (*Buteo lagapus*)	Pintail (*Anas acuta*)	Bull snake (*Pituophis melanoleucus*)	Fox squirrel (*Sciurus niger*)
	Marsh hawk (*Circus cyaneus*)	Shoveler (*Spattula clypeata*)	Rattlesnake (*Crotalus viridus*)	Cottontail (*Sylvilagus audoboni*)
	Swainson' hawk (*Buteo swainsoni*)	Gadwall (*Anas strepera*)	Turtles (*Terrapene ornata*)	Jackrabbit (*Lepus californicus*)
	Great-horned owl (*Bubo virginianus*)	Widgeon (*Mereca americana*)	Bullfrog (*Rana catesbeiana*)	Black-tailed prairie dog (*Cyomys ludovicianus*)
	Rail (*Rallus limicola*)	Canada goose (*Branta canadensis*)		Beaver (*Castor canadensis*)
	Pheasant (*Phasianus colchicus*)			Muskrat (*Ondatra zibethica*)
	Quail (*Colinus virginianus*)			Mink (*Mutola vison*)
	Mourning dove (*Zenaidura macroura*)			Weasel (*Mustela frenata*)
	Bittern (*Botaurus lentiginosus*)			Opposum (*Didelphis marsupialis*)
	Grebe (*Aechmophorus occidentalis*)			Raccoon (*Procyon lotor*)
	Egret (*Casmerodius albus*)			Skunk (*Mephitis mephitis*)
	Heron (*Ardea herodias*)			Badger (*Taxidea taxus*)
	Phalarope (*Steganopus tricolor*)			Coyote (*Canis latrans*)
	Sandpiper (*Actitus macularia*)			Bobcat (*Lynx refus*)
	Curlew (*Numenius americanus*)			Red fox (*Vulpes fulva*)
	Dowitcher (*Limnoaromus scolopaceus*)			Kit fox (*Vulpes macrotis*)
	Warbler (*Dendroica sp.*)			
Wildlife common to southwestern Nebraska	Golden eagle (*Aquila chrysaetos*)	Mallard (*Anas platyrhynchos*)	Tiger salamander (*Ambystoma tigrinum*)	Opossum (*Didelphis marsupialis*)
	Bald eagle (*Haliaeetus leucocephalus*)	Teal (*Anas discors*)	American toad (*Bufo americanus*)	Least shrew (*Cryptotis parva*)
Enders Reservoir	Turkey vulture (*Cathartes aura*)	Pintail (*Anas acuta*)	Woodhouse's toad (*Bufo woodhousei*)	Shorttail shrew (*Blarina brevicauda*)
Swanson Lake	Ferruginous hawk (*Buteo regalis*)	Shoveler (*Spatula clypeata*)	Great plains toad (*Bufo cognatus*)	Eastern mole (*Scalopus aquaticus*)
Hugh Butler Lake	Red-tailed hawk (*Buteo jamaicensis*)	Western grebe (*Aechmophorus occidentalis*)	Northern chorus frog (*Pseudacris triseriata*)	Small-footed myotis (*Myotis subulatus*)
Harry Strunk Lake	Marsh hawk (*Circus cyaneus*)	Eared grebe (*podiceps caspicus*)	Northern cricket frog (*Acris crepitans*)	Red bat (*Lasiurus borealis*)
Harlan County Lake	Swainson's hawk (*Buteo swainsoni*)	Pied-billed grebe (*Podilymbus podiceps*)	Plains spadefoot (*Scaphiopus bombifrons*)	Silver-haired bat (*Lasionycteris noctivagans*)
	American kestrel (*Falco sparverius*)	Double-crested cormorant (*Phalacrocorax auritus*)	Northern leopard frog (*Rana pipiens*)	Hoary bat (*Lasiurus cinereus*)
	Great-horned owl (*Bubo virginianus*)	American coot (*Fulica americana*)	Bullfrog (*Rana catesbeiana*)	Raccoon (*Procyon lotor*)
	Burrowing owl (*Speotyto cunicularia*)		Snapping turtle (*Chelydra serpentina*)	Longtail weasel (*Mustela frenata*)
	Short-eared owl (*Asio flammeus*)		Painted turtle (*Chrysemys picta*)	Mink (*Mustela vison*)
	Barn owl (*Tyto alba*)		Blanding's turtle (*Emys blandingii*)	Badger (*Taxidea taxus*)
	Screech owl (*Otus asio*)		Western box turtle (*Terrapene ornata*)	Spotted skunk (*Spilogale putorius*)

Table A-1.—Wildlife occurring near Republican River reservoirs—continued

	Common birds	Common waterfowl	Common reptiles and amphibians	Common mammals
Wildlife common to southwestern Nebraska—continued	Virginia rail (*Rallus limicola*)		Lesser earless lizard (*Holbrookia maculata*)	Striped skunk (*Mephitis mephitis*)
	Ring-necked pheasant (*Phasianus colchicus*)		Short-horned lizard (*Phrynosoma douglassi*)	Coyote (*Canis latrans*)
	Quail (*Colinus virginianus*)		Eastern fence lizard (*Sceloporus undulatus*)	Black-tail prairie dog (*Cynomys ludovicianus*)
Enders Reservoir Swanson Lake Hugh Butler Lake Harry Strunk Lake Harlan County Lake	Mourning dove (*Zenaidura macroura*)		Six-lined racerunner (*Cnemidophorus sexlineatus*)	Thirteen-lined ground squirrel (*Citellus tridecemlineautus*)
	Bittern (*Botaurus lentiginosus*)		Many-lined skink (*Eumeces multivirgatus*)	Franklin's ground squirrel (*Citellus franklini*)
	Great blue heron (*Ardea herodias*)		Great plains skink (*Eumeces obsoletus*)	Spotted ground squirred (*Citellus spilosoma*)
	Phalarope (*Steganopus tricolor*)		Common water snake (*Natrix sipedon*)	Eastern fox squirrel (*Sciurus niger*)
	Sandpiper (*Actitis macularia*)		Northwestern garter snake (*Thamnophis ordinoides*)	Plains pocket gopher (*Geomys bursarius*)
	Green heron (*Butorides virescens*)		Plains garter snake (*Thamnophis radix*)	Plains pocket mouse (*Perognathus flavescens*)
	Turkey (*Meleagris gallopavo*)		Common garter snake (*Thamnophis sirtalis*)	Silky pocket mouse (*Perognathus flavus*)
	Sora (*Porzana carolina*)		Eastern hognose snake (*Heterodon platyrhinos*)	Hispid pocket mouse (*Perognathus hispidus*)
	Killdeer (*Charadrius vociferus*)		Western hognose snake (*Heterodon nasicus*)	Ord kangaroo rat (*Dipodomys ordi*)
	Upland plover (*Bartramia longicauda*)		Eastern ring-neck snake (*Diadophis punctatus*)	Beaver (*Castor canadensis*)
	American avocet (*Recurvirostra americana*)		Smooth green snake (*Opheodrys vernalis*)	Plains harvest mouse (*Reithrodontomys montanus*)
	Rock dove (*Columba livia*)		North American racer (*Coluber constrictor*)	Western harvest mouse (*Reithrodontomys megalotis*)
	Yellow-billed cuckoo (*Coccyzus americanus*)			Deer mouse (*Peromyscus maniculatus*)
	Black-billed cuckoo (*Coccyzus erythropthalmus*)			Northern grasshopper mouse (*Onychomys leucogaster*)
	Poor-will (*Phalaenoptilus nuttallii*)			Eastern woodrat (*Neotoma floridana*)
	Common nighthawk (*Chordeiles minor*)			Prairie vole (*Microtus ochrogaster*)
	Chimney swift (*Chaetura pelagica*)			Muskrat (*Ondatra zibethica*)
	Belted kingfisher (*Megaceryle alcyon*)			House mouse (*Mus musculus*)
	Common flicker (*Colaptes auratus*)			Meadow jumping mouse (*Zapus hudsonius*)
	Red-bellied woodpecker (*Centurus carolinus*)			Porcupine (*Erethizon dorsatum*)
	Red-headed woodpecker (*Melanerpes erythrocephalus*)			Blacktail jackrabbit (*Lepus californicus*)
	Eastern kingbird (*Tyrannus tyrannus*)			Desert Cottontail (*Sylvilagus audubonii*)
	Western kingbird (*Tyrannus verticalis*)			Eastern cottontail (*Sylvilagus floridanus*)
	Great crested flycatcher (*Myiarchus crinitus*)			Mule deer (*Odocoileus hemionus*)
	Eastern phoebe (*Sayornis phoebe*)			Whitetail deer (*Odocoileus virginianus*)
	Say's phoebe (*Sayornis saya*)			
	Eastern wood pewee (*Contopus virens*)			
	Western wood pewee (*Contopus sordidulus*)			
	Horned lark (*Eremophila alpestris*)			

material becomes coarser or less cemented in the lower part (McGovern and Coffin, 1963). Also present are beds of soft limestone, bentonite, and volcanic ash. The top of the formation consists of a few feet of a dense, sandy limestone known as the "Algal limestone." Maximum thickness is about 500 feet in the northern Medicine Creek subbasin in Nebraska. Depth to the top of the formation varies from 0 to 200 feet, averaging less than 100 feet. The surface of the Ogallala slopes to the east with an average gradient of 12 feet/mile.

Pleistocene loess deposits (wind deposited silt and clay) are present throughout the upland areas and valley walls. These deposits, varying in thickness from 0 to 200 feet, lie above the water table and yield little water.

Sand deposited by the wind during the Pleistocene and Holocene epochs is present in the northwest section of the upper basin with a maximum thickness of 170 feet. These deposits are an important element of the aquifer system because of their high permeability, which allows rapid recharge to the underlying Ogallala Formation.

The next most important sources of ground water are alluvium and terrace deposits of Holocene age. They are found in the valleys and under the flood plains of the larger streams and are comprised of varying mixtures of clay, silt, sand, and gravel. Thickness of these deposits varies from 0 to 90 feet.

Lower Republican Basin

The principal aquifer system in the lower basin is composed of alluvium and terrace deposits and the Ogallala, Grand Island, and Dakota Formations. The base of the aquifer system consists of Pierre Shale, the Niobrara and Wellington Formations, and the Chase Group.

The alluvium and terrace deposits of recent and Pleistocene age are a major source of municipal and irrigation water. They are made up of unconsolidated clay, silt, sand, and gravel that have been deposited in the valleys and flood plains of the major streams. The deposits generally become more coarse with depth. Thickness of the alluvium ranges up to 130 feet. The terrace deposit thickness ranges up to 125 feet.

Covering the uplands of the lower basin are undifferentiated deposits, consisting of loess, volcanic ash, and gravels formed locally by weathering or stream action. Where saturated, these deposits will provide small to moderate amounts of water for domestic and stock wells. Thickness ranges up to 100 feet.

The Grand Island Formation is a major source of irrigation water in northeastern Jewell and northwestern Republic Counties, Kansas. It consists of coarse sand and medium-to-coarse gravel Interbedded with silty clay deposited during the Pleistocene age in a former channel of the Republican River (Dunlap, 1982). Thickness ranges up to 120 feet.

Draft (sections only) Site Characterization and Water Quality Section Republican River Study

Geology

Upper Republican Basin

The major geologic formations are the Ogallala Formation, alluvium, and eolian deposits that make up the aquifer system. The base for the aquifer system is composed of the Niobrara Formation, Pierre Shale, and White River Group.

The Niobrara Formation and the Pierre Shale of late Cretaceous age, and the White River Group of Tertiary age are relatively impermeable consolidated deposits, which restrict the downward movement of water from the overlying aquifer system. The Niobrara and Pierre Shale are of marine origin. The Niobrara Formation (the aquifer base in the eastern part of the upper basin) consists of massive chalk beds, chalky shales and limestones, and thin beds of bentonite. The Niobrara Formation has a thickness of approximately 650 feet in Phillips County, Kansas. The Pierre Shale (the aquifer base in the western part of the upper basin) lies conformably on the Niobrara Formation. It is a thinly bedded shale with thin beds of bentonite and numerous concretionary zones. The Pierre Shale in the Frenchman Creek area is more than 2,000 feet thick. The Niobrara Formation and Pierre Shale slope to the east with an average gradient of 14.7 feet/mile. The White River Group (Brule and Chadron Formations) of Oligocene age, lies unconformably on the Pierre Shale in the northwestern portion of the upper basin. It appears to be of fluviatile origin and consists of siltstone, clay, and localized channel deposits of sand and gravel that may or may not be cemented. Although the deposit is considered impermeable, minor amounts of water could be obtained from unconsolidated sand and gravel deposits within the formation. It has a maximum thickness of +/- 450 feet.

The semiconsolidated Ogallala Formation of Pliocene age is the major source of ground water due to its areal extent, accessibility, and extent of saturation. The formation is present throughout the upper basin, except where major streams have eroded through it to the bedrock. The Ogallala is believed to have been formed by eastward flowing streams whose sediment filled pre-existing valleys in the bedrock. Eventually, lateral constraints were eliminated, and the streams coalesced to form a broad alluvial plain. The formation consists of a poorly sorted mixture of clay, silt, sand, and gravel that is loosely cemented; the

Part II

Surface and Groundwater Quality Data

REPUBLICAN RIVER BASIN IRF

(Irrigation Return Flow)

Subsurface Drains

Report of Water Analysis

Soil and Water Laboratory
U. S. Bureau of Reclamation
Bismarck, ND 58501

Site ID Date Collected	UNITS	FC-1 09/08/94	FC-1 06/06/95	FC-2 09/07/94	FC-2 06/06/95	FC-3 09/08/94	FC-3 06/07/95	FC-4 09/08/94	FC-4 06/07/95	FC-5 09/08/94	FC-5 06/07/95
Major Cations:											
Calcium	(mg/L)	95	93	107	100	95	93	103	101	88	90
Magnesium	(mg/L)	29	31	42	40	26	27	24	24	21	24
Potassium	(mg/L)	30.8	30.6	22.8	19.7	18.0	16.4	14.6	14.0	16.0	14.9
Sodium	(mg/L)	83	92	67	58	42	43	39	39	42	58
Major Anions:											
Alkalinity (as $CaCO_3$ mg/L)		299.9	325.1	335.6	313.4	318.4	321.5	312.7	314.0	307.7	335.1
Chloride	(mg/L)	37.6	40.1	41.6	43.1	33.7	33.4	45.0	43.0	20.7	22.8
Sulfate	(mg/L)	156.4	148.7	173.8	148.0	70.0	73.6	79.2	74.8	66.5	93.1
Dissolved Nutrients:											
Ammonia (NH_3-N)	(mg/L)	0.10	0.18	0.13	0.18	0.13	0.16	0.13	0.24	0.09	0.16
Nitrate (NO_3-N)	(mg/L)	16.98	18.91	13.84	13.38	7.88	8.66	2.52	2.37	3.97	7.50
Nitrite (NO_2-N)	(mg/L)	<0.02	--	<0.02	–	<0.02	–	<0.02	–	<0.02	–
Ortho-Phosphate (P)	(mg/L)	0.11	0.11	0.07	0.07	0.08	0.06	0.08	0.08	0.16	0.14
Calculated Values:											
TDS	(mg/L)	629.1	649.5	669.5	610.6	484.2	488.5	495.0	487.0	442.9	511.1
SAR		1.91	2.11	1.39	1.24	0.98	1.01	0.90	0.90	1.05	1.41
Hardness as $CaCO_3$	(mg/L)	357.5	359.9	439.7	415.2	345.9	344.6	355.6	351.9	305.8	321.9
Cations/Anion Balance	(%)	0.1	-0.3	-0.8	-0.8	-0.7	-1.8	-0.9	-0.6	-0.3	-2.4
Dissolved Trace Metals											
Arsenic	(ug/L)	12.1	12.8	8.2	6.40	8.9	8.80	8.7	8.40	15.4	13.8
Boron	(ug/L)	<100	850.	<100	720.	<100	740.	<100	460.	<100	500.
Cadmium	(ug/L)	<.2	0.35	<.2	<0.2	.34	0.49	<.2	3.11	.30	1.52
Chromium	(ug/L)	<2.0	<1.0	<2.0	<1.0	<2.0	<1.0	<2.0	<1.0	<2.0	<1.0
Copper	(ug/L)	11.4	<2.0	1.7	<2.0	3.1	2.20	<1.0	2.20	2.9	<2.0
Iron	(ug/L)	<20.0	<50.0	<20.0	66.00	<20.0	<50.0	79.0	87.00	<20.0	62.00
Lead	(ug/L)	6.2	1.50	6.7	2.30	12.9	1.30	3.7	12.50	19.0	4.10
Manganese	(ug/L)	15.0	<50.0	10.0	<50.0	10.0	<50.0	375.0	412.0	<10.0	<50.0
Mercury	(ug/L)	<.2	0.20	<.2	<0.2	<.2	0.23	<.2	<0.2	<.2	0.29
Nickel	(ug/L)	2.0	<40.	<2.0	<40.	3.0	<40.	5.0	<40.	2.0	<40.
Selenium	(ug/L)	10.0	10.30	14.0	13.80	8.0	7.50	5.0	4.20	3.0	4.20
Zinc	(ug/L)	34.4	<50.0	49.6	<50.0	235.8	<50.0	62.9	<50.0	75.8	<50.0
Aluminum	(ug/L)	32.0	260.	41.0	180.	59.0	130.	20.0	111.	83.0	111.
Beryllium	(ug/L)	<0.2	<10.	<0.2	<10.	<0.2	<10.	<0.2	<10.	<0.2	<10.

KS001433

REPUBLICAN RIVER BASIN IRF

(Irrigation Return Flow)

Subsurface Drains

Report of Water Analysis
Soil and Water Laboratory
U. S. Bureau of Reclamation
Bismarck, ND 58501

Site ID Date Collected	UNITS	NB-1 09/08/94	NB-1 06/07/95	NB-2 09/07/94	NB-2 06/07/95	NB-3 09/07/94	NB-3 06/08/95	KB-4 09/07/94	KB-4 06/08/95	KB-5 09/09/94	KB-5 06/08/95
Major Cations:											
Calcium	(mg/L)	120	124	139	131	97	114	311	352	399	361
Magnesium	(mg/L)	22	26	16	15	21	24	47	52	40	33
Potassium	(mg/L)	13.3	13.5	9.4	9.1	15.7	12.9	19.4	18.6	10.3	10.7
Sodium	(mg/L)	65	65	69	67	46	50	217	235	192	215
Major Anions:											
Alkalinity (as $CaCO_3$, mg/L)		318.5	345.2	358.2	361.4	270.5	317.0	362.7	370.0	308.0	338.7
Chloride	(mg/L)	45.6	47.0	40.2	38.6	29.5	33.9	94.8	93.1	73.6	77.4
Sulfate	(mg/L)	148.1	148.7	151.1	126.3	129.9	131.7	978.6	923.9	1182.1	886.0
Dissolved Nutrients:											
Ammonia (NH_3-N)	(mg/L)	0.21	0.23	0.13	0.20	0.15	0.17	0.24	0.29	0.33	0.26
Nitrate (NO_3-N)	(mg/L)	6.13	6.64	5.31	5.11	1.76	5.46	11.78	16.08	16.12	15.76
Nitrite (NO_2-N)	(mg/L)	<0.02	–	<0.02	–	<0.02	–	<0.02	–	<0.02	–
Ortho-Phosphate (P)	(mg/L)	0.28	.21	0.12	0.11	0.20	0.17	0.36	0.32	0.21	0.19
Calculated Values:											
TDS	(mg/L)	610.1	638.2	645.5	608.9	503.0	562.1	1897.8	1907.7	2098.6	1802.2
SAR		1.43	1.39	1.48	1.48	1.11	1.11	3.03	3.11	2.45	2.91
Hardness as $CaCO_3$	(mg/L)	386.9	416.7	414.2	388.1	326.6	382.3	969.7	1079.4	1161.8	1036.9
Cations/Anion Balance	(%)	-1.3	-1.2	-1.3	-1.7	-0.7	-1.3	-3.0	3.0	-3.3	3.1
Disolved Trace Metals											
Arsenic	(ug/L)	12.5	10.1	8.8	8.50	4.6	4.40	11.2	8.80	3.8	3.60
Boron	(ug/L)	<100	440.	<100	410.	<100		<100	740.	<100	520.
Cadmium	(ug/L)	<.2	1.24	<.2	1.60	<.2	0.29	<.2	0.58	<.2	0.57
Chromium	(ug/L)	<2.0	<1.0	<2.0	<1.0	<2.0	<1.0	<2.0	<1.0	<2.0	<1.0
Copper	(ug/L)	<1.0	3.8	1.4	95.00	4.0	<2.0	2.0	<2.0	3.6	<2.0
Iron	(ug/L)	81.0	<50.0	20.0	255.0	<20.0	135.0	64.0	107.0	76.0	177.0
Lead	(ug/L)	4.7	3.80	3.9	17.50	4.0	2.60	2.2	4.40	3.2	6.00
Manganese	(ug/L)	63.0	<50.0	40.0	57.00	30.0	<50.0	20.0	<50.0	10.0	67.00
Mercury	(ug/L)	<.2	<0.2	<.2	0.24	<.2	<0.2	<.2	<0.2	<.2	<0.2
Nickel	(ug/L)	<2.0	<40.	<2.0	<40.	2.0	<40.	4.0	<40.	3.0	<40.
Selenium	(ug/L)	5.0	5.20	9.0	6.30	<2.0	<2.00	25.0	25.60	22.0	40.10
Zinc	(ug/L)	19.6	<50.0	<10.0	<50.0	95.2	<50.0	277.8	<50.0	30.1	<50.0
Aluminum	(ug/L)	109.1	130.	70.0	<100.	30.0	120.	41.0	250.	30.0	160.
Beryllium	(ug/L)	<0.2	< 10.	<0.2	<10.	<0.2	<10.	<0.2	<10.	<0.2	<10.

KS001434

REPUBLICAN RIVER BASIN
(Irrigation Return Flow)
Subsurface Drains

Report of Water Analysis
Soil and Water Laboratory
U. S. Bureau of Reclamation
Bismarck, ND 58501

Site ID Date Collected		NB-3 09/07/94		KB-4 09/07/94		KB-5 09/07/94	
PESTICIDES 8080	UNITS	Concentration	Quantitation Limit	Concentration	Quantitation Limit	Concentration	Quantitation Limit
Alachlor	(ug/L)	ND	0.05	ND	0.05	ND*	0.05
Aldrin	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Benefin	(ug/L)	ND	0.05	ND	0.05	ND	0.05
α-BHC	(ug/L)	ND	0.06	ND	0.06	ND	0.06
β-BHC	(ug/L)	ND	0.05	ND	0.05	ND	0.05
δ-BHC	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Captan	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Carbophenothion	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Chlordane	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Dicofol	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Dieldrin	(ug/L)	ND	0.06	ND	0.06	ND	0.06
DMPA	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Endosulfan I	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Endosulfan II	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Endosulfan sulfate	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Endrin	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Endrin aldehyde	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Endrin ketone	(ug/L)	ND	0.06	ND	0.06	ND	0.06
Heptachlor	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Heptachlor epoxide	(ug/L)	ND	0.05	ND	0.05	ND	0.05
2,4' - DDT	(ug/L)	ND	0.05	ND	0.05	ND	0.05
2,4' - TDE/DDD	(ug/L)	ND	0.06	ND	0.05	ND	0.05
4,4' - DDE	(ug/L)	ND	0.05	ND	0.05	ND	0.05
4,4' - DDT	(ug/L)	ND	0.05	ND	0.05	ND	0.05
4,4' - TDE/DDD	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Methoxychlor	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Nitrofen	(ug/L)	ND	0.05	ND	0.05	ND	0.05
PCNB	(ug/L)	ND	0.05	ND	0.05	ND	0.05
Toxaphene	(ug/L)	ND	1.0	ND	1.0	ND	1.0
CARBAMATES 8321							
Aminocarb	(ug/L)	ND	1	ND	1	ND*	1
Aldicqarb	(ug/L)	ND	1	ND	1	ND	1
Barban	(ug/L)	ND	1	ND	1	ND	1
Benomyl (Carbendazim)	(ug/L)	ND	1	ND	1	ND	1
Bromacil	(ug/L)	ND	1	ND	1	ND	1
Carbaryl	(ug/L)	ND	1	ND	1	ND	1
Carbofuran	(ug/L)	ND	1	ND	1	ND	1
Chloropropham	(ug/L)	ND	5	ND	5	ND	5
Chloroxuron	(ug/L)	ND	1	ND	1	ND	1
Diuron	(ug/L)	0.4 J	1	ND	1	ND	1
Fenuron	(ug/L)	ND	1	ND	1	ND	1
Fluometuron	(ug/L)	ND	1	ND	1	ND	1
Linuron	(ug/L)	ND	1	ND	1	ND	1
Fluometuron	(ug/L)	ND	1	ND	1	ND	1
Methomyl	(ug/L)	ND	1	ND	1	ND	1
Methiocarb	(ug/L)	ND	1	ND	1	ND	1
Mexacarbate	(ug/L)	ND	5	ND	5	ND	5
Monuron	(ug/L)	ND	1	0.3 J	1	ND	1
Neburon	(ug/L)	ND	1	ND	1	ND	1
Oxamyl	(ug/L)	ND	1	ND	1	ND	1
Propachlor	(ug/L)	ND	5	ND	5	ND	5
Propham	(ug/L)	ND	6	ND	6	ND	6
Propoxur	(ug/L)	ND	1	ND	1	ND	1
Siduron	(ug/L)	ND	1	ND	1	ND	1
Tebuthiuron	(ug/L)	ND	1	ND	1	ND	1
TRIAZINE 619							
Ametryn	(ug/L)	ND*	0.5	ND*	0.5	ND*	0.5
Atraton	(ug/L)	ND	0.5	ND	0.5	ND	0.5
Atrazine	(ug/L)	ND	0.5	ND	0.5	ND	0.5
Prometon	(ug/L)	ND	0.5	ND	0.5	ND	0.5
Prometryn	(ug/L)	ND	0.5	ND	0.5	ND	0.5
Propazine	(ug/L)	ND	0.5	ND	0.5	ND	0.5
Simetryn	(ug/L)	ND	0.5	ND	0.5	ND	0.5
Simazine	(ug/L)	ND	0.5	ND	0.5	ND	0.5
Terbuthylazine	(ug/L)	ND	0.5	ND	0.5	ND	0.5
Terbutryn	(ug/L)	ND	0.5	ND	0.5	ND	0.5

J = ESTIMATED VALUE, BELOW DETECTION LIMIT.
* ND = NONE DETECTED

REPUBLICAN RIVER BASIN

(IRRIGATION RETURN FLOW)

Subsurface Drains

Report of Water Analysis

Soil and Water Laboratory

U. S. Bureau of Reclamation

Bismarck, ND 58501

Site ID / Date Collected		FC-5 09/16/94		FC-7 09/09/94		NB-1 09/08/94		NB-2 09/07/94	
	UNITS	Concentration	Quantitation Limit	Concentration	Quantitation Limit	Concentration	Quantitation Limit	Concentration	Quantitation Limit
PESTICIDES 8080									
Alachlor	(ug/L)	ND*	0.05	ND*	0.05	ND	0.05	ND	0.05
Aldrin	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Benefin	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
a-BHC	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
B-BHC	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
G-BHC	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Captan	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Carbophenothion	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Chlordane	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Dicofol	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Dieldrin	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
DMPA	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Endosulfan I	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Endosulfan II	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Endosulfan sulfate	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Endrin	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Endrin aldehyde	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Endrin ketone	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Heptachlor	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Heptachlor epoxide	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
2,4' - DDT	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
2,4' - TDE/DDD	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
4,4' - DDE	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
4,4' - DDT	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
4,4' - TDE/DDD	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Methoxychlor	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Nitrofen	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
PCNB	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Toxaphene	(ug/L)	ND	1.0	ND	1.0	ND	1.0	ND	1.0
CARBAMATES 8321									
Aminocarb	(ug/L)	ND*	1	–	–	ND	1	ND	1
Aldicqarb	(ug/L)	ND	1	–	–	ND	1	ND	1
Barban	(ug/L)	ND	1	–	–	ND	1	ND	1
Benomyl (Carbendazim)	(ug/L)	ND	1	–	–	ND	1	ND	1
Bromacil	(ug/L)	ND	1	–	–	ND	1	ND	1
Carbaryl	(ug/L)	ND	1	–	–	ND	1	ND	1
Carbofuran	(ug/L)	ND	1	–	–	ND	1	ND	1
Chloropropham	(ug/L)	ND	5	–	–	ND	5	ND	5
Chloroxuron	(ug/L)	ND	1	–	–	ND	1	ND	1
Diuron	(ug/L)	ND	1	–	–	ND	1	ND	1
Fenuron	(ug/L)	ND	1	–	–	ND	1	ND	1
Fluometuron	(ug/L)	ND	1	–	–	ND	1	ND	1
Linuron	(ug/L)	ND	1	–	–	ND	1	ND	1
Fluometuron	(ug/L)	ND	1	–	–	ND	1	ND	1
Methomyl	(ug/L)	ND	1	–	–	ND	1	ND	1
Methiocarb	(ug/L)	ND	1	–	–	ND	1	ND	1
Mexacarbate	(ug/L)	ND	5	–	–	ND	5	ND	5
Monuron	(ug/L)	ND	1	–	–	ND	1	ND	1
Neburon	(ug/L)	ND	1	–	–	ND	1	ND	1
Oxamyl	(ug/L)	ND	1	–	–	ND	1	ND	1
Propachlor	(ug/L)	ND	5	–	–	ND	5	ND	5
Propham	(ug/L)	ND	5	–	–	ND	5	ND	5
Propoxur	(ug/L)	ND	1	–	–	ND	1	ND	1
Siduron	(ug/L)	ND	1	–	–	ND	1	ND	1
Tebuthiuron	(ug/L)	ND	1	–	–	ND	1	ND	1
TRIAZINE 619									
Ametryn	(ug/L)	ND*	0.5	ND*	0.5	ND*	0.5	ND*	0.5
Atraton	(ug/L)	ND	0.5	ND	0.5	ND	0.5	ND	0.5
Atrazine	(ug/L)	ND	0.5	ND	0.5	0.6	0.5	ND	0.5
Prometon	(ug/L)	ND	0.5	ND	0.5	ND	0.5	ND	0.5
Prometryn	(ug/L)	ND	0.5	ND	0.5	ND	0.5	ND	0.5
Propazine	(ug/L)	ND	0.5	ND	0.5	ND	0.5	ND	0.5
Simetryn	(ug/L)	ND	0.5	ND	0.5	ND	0.5	ND	0.5
Simazine	(ug/L)	ND	0.5	ND	0.5	ND	0.5	ND	0.5
Terbuthylazine	(ug/L)	ND	0.5	ND	0.5	ND	0.5	ND	0.5
Terbutryn	(ug/L)	ND	0.5	ND	0.5	ND	0.5	ND	0.5

J = ESTIMATED VALUE, BELOW DETECTION LIMIT.

* ND = NONE DETECTED

REPUBLICAN RIVER BASIN
(Irrigation Return Flow)
Subsurface Drains

Report of Water Analysis
Soil and Water Laboratory
U. S. Bureau of Reclamation
Bismarck, ND 58501

Site ID Date Collected		FC-1 09/09/94		FC-2 09/09/94		FC-3 09/08/94		FC-4 09/08/94	
	UNITS	Concentration	Quantitation Limit	Concentration	Quantitation Limit	Concentration	Quantitation Limit	Concentration	Quantitation Limit
PESTICIDES 8080									
Alachlor	(ug/L)	ND*	0.05	ND*	0.05	ND*	0.05	ND*	0.05
Aldrin	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0 05
Benefin	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
a-BHC	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
B-BHC	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
O-BHC	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Captan	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Carbophenothion	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Chlordane	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Dicofol	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.06
Dieldrin	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
DMPA	(ug/L)	ND	0.06	ND	0.06	ND	0.06	ND	0.05
Endosulfan I	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Endosulfan II .	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Endosulfan sulfate	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Endrin	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Endrin aldehyde	(ug/L)	ND	0.06	ND	0.06	ND	0.06	ND	0.05
Endrin ketone	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Heptachlor	(ug/L)	ND	0.05	ND	0 05	ND	0.05	ND	0.05
Heptachlor epoxide	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0 05
2,4' – DDT	(ug/L)	ND	0.05	ND	0 05	ND	0.05	ND	0 05
2,4' – TDE/DDD	(ug/L)	ND	0.06	ND	0.06	ND	0.05	ND	0 05
4,4' – DDE	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
4,4' – DDT	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.06
4,4' – TDE/DDD	(ug/L)	ND	0.05	ND	0.05	ND	0 05	ND	0.05
Methoxychlor	(ug/L)	ND	0 05	ND	0.05	ND	0.05	ND	0 05
Nitrofen	(ug/L)	ND	0 05	ND	0 05	ND	0.05	ND	0 05
PCNB	(ug/L)	ND	0.05	ND	0.05	ND	0.05	ND	0.05
Toxaphene	(ug/L)	ND	1.0	ND	1.0	ND	1.0	ND	1.0
CARBAMATES 8321									
Aminocarb	(ug/L)	ND*	1	ND*	1	ND*	1	ND*	1
Aldicqarb	(ug/L)	ND	1	ND	1	ND	1	ND	1
Barban	(ug/L)	ND	1	ND	1	ND	1	ND	1
Benomyl (Carbendazim)	(ug/L)	ND	1	ND	1	ND	1	ND	1
Bromacil	(ug/L)	ND	1	ND	1	ND	1	ND	1
Carbaryl	(ug/L)	ND	1	ND	1	ND	1	ND	1
Carbofuran	(ug/L)	ND	1	ND	1	ND	1	ND	1
Chloroprepham	(ug/L)	ND	5	ND	5	ND	5	ND	5
Chloroxuron	(ug/L)	ND	1	ND	1	ND	1	ND	1
Diuron	(ug/L)	ND	1	0.2 J	1	ND	1	1	1
Fenuron	(ug/L)	ND	1	ND	1	ND	1	ND	1
Fluometuron	(ug/L)	ND	1	ND	1	ND	1	ND	1
Linuron	(ug/L)	ND	1	ND	1	ND	1	ND	1
Fluometuron	(ug/L)	ND	1	ND	1	ND	1	ND	1
Methomyl	(ug/L)	ND	1	ND	1	ND	1	ND	1
Methiocarb	(ug/L)	ND	1	ND	1	ND	1	ND	1
Mexacarbate	(ug/L)	ND	6	ND	6	ND	6	ND	6
Monuron	(ug/L)	ND	1	0.3 J	1	ND	1	0.3 J	1
Neburon	(ug/L)	ND	1	ND	1	ND	1	ND	1
Oxamyl	(ug/L)	ND	1	ND	1	ND	1	ND	1
Propachlor	(ug/L)	ND	5	ND	5	ND	5	ND	5
Propham	(ug/L)	ND	5	ND	6	ND	6	ND	6
Propoxur	(ug/L)	ND	1	ND	1	ND	1	ND	1
Siduron	(ug/L)	ND	1	ND	1	ND	1	ND	1
Tebuthiuron	(ug/L)	ND	1	ND	1	ND	1	ND	1
TRIAZINE 619									
Ametryn	(ug/L)	ND*	0.5	ND*	0.5	ND*	0.5	ND*	0 5
Atraton	(ug/L)	ND	0 5	ND	0 5	ND	0.5	ND	0 5
Atrazine	(ug/L)	ND	0 5	ND	0 5	ND	0.5	ND	0 5
Prometon	(ug/L)	ND	0.5	ND	0.5	ND	0.5	ND	0.5
Prometryn	(ug/L)	ND	0.6	ND	0.5	ND	0.5	ND	0.5
Propazine	(ug/L)	ND	0.5	ND	0.5	ND	0.5	ND	0.5
Simetryn	(ug/L)	ND	0 5	ND	0 5	ND	0.5	ND	0 5
Simazine	(ug/L)	ND	0 5	ND	0 5	ND	0.5	ND	0 5
Terbuthylazine	(ug/L)	ND	0 5	ND	0 5	ND	0.5	ND	0 5
Terbutryn	(ug/L)	ND	0.5	ND	0.5	ND	0.5	ND	0.5

J ESTIMATED VALUE, BELOW DETECTION LIMIT

* ND = NONDETECTED

Part I

Irrigation Return Flow, Subsurface Drains

Attachment B—Hydrology

Part I Irrigation Return Flow, Subsurface Drains

Part II Surface and Groundwater Quality Data

Part III Area Reservoir Inflow Data and Historic Versus 1993 Level-of-Basin-Development Inflow Comparisons

Part IV Water Supply Evaluation Computer Analysis

Part V Groundwater Research Management Assessment. Republican River Basin Water Supply Study Nebraska, Kansas, and Colorado

Part VI Hydrology Assessment for the Republican River Basin

Angler Use and Fish Community Dynamics in Five Southwest Nebraska Reservoirs and the Adjoining Republican River

1995 Field Sampling Synopsis

December 7, 1995

The 1995 field season was the first of a two year project designed to document angler use and fish community dynamics in the Republican River within Nebraska and its five mainstem reservoirs. Field sampling collected data on five specific objectives during 1995 including fish community dynamics along the Republican River, availability of potential spawning habitats for selected game fish, angler use of the Republican River between the Cambridge and Guide Rock Diversion dams, angler use of the mainstem reservoirs, and fish community dynamics in the mainstem reservoirs. Prior to beginning field work in April, sampling sites along the river were selected based on input from local resource managers and conservation officers, and logistically verified by site visits.

Fish community surveys on the Republican River were conducted during four periods in 1995 to document seasonal trends: April-May, June-July, August-September and October-November. A total of 16 permanent sampling sites were established and surveyed each periods as river conditions allowed. Habitat parameters measured at each sites during each period included discharge, mean depth, mean velocity, mean width and substrate composition. A combination of seining, cheese-baited hoop nets, and electroshocking were used to quantify fish community composition and relative abundance. All fish collected were measured and hard bony structures were taken for age and growth analyses. Approximately 40 species of fish were collected from the river in 1995.

Potential riverine spawning habitat for walleye, white bass, channel catfish and flathead catfish was assessed at nine stations along the Republican River between the Cambridge Diversion Dam and Harlan County Reservoir during the summer of 1995. Stations were selected as representative of larger river stretches. Maps were constructed documenting total area occupied by different potential spawning habitat types within each station. Examples of habitat types measured included log jams, undercut banks, gravel bars, bedrock, burrows, car bodies, revetment and rip rap hardpoints.

The angler use survey on the Republican River was stratified into two river stretches: Cambridge Diversion Dam downstream to Harlan County Reservoir and the Harlan County Reservoir stilling basin downstream to the Guide Rock Diversion Dam. Eighteen access points along these stretches were used for angler creels and interviews. Angler creels on each river stretch were performed ten times per month from April through October.

Angler use surveys on each of the mainstem reservoirs were performed ten times per month from April through October. Instantaneous counts of anglers were taken over a 60 minutes period during each count day. Angler interviews were conducted primarily at access points around the reservoirs to collect effort and catch data.

Fish community surveys on the mainstem reservoirs were conducted between August and October 1995. A combination of seining, gill nets and frame nets were used to quantify fish community composition and relative abundance. All fish collected were measured and hard bony structures were taken for age and growth analyses. Approximately 26 species of fish were collected in the reservoirs during 1995.

Inventory for Endangered, Threatened, and Rare
Plant and Animal Species Within the Floodplain Corridor
of the Republican River Basin

1995 Field Survey Synopsis

December 5, 1995

The 1995 field season was the first of a three year project to conduct field survey work within the floodplain corridor of the Republican River for plant and animal species identified by the Nebraska Natural Heritage Program as endangered, threatened, or rare. To date, field survey work has been conducted for three species associations; plants, terestrial animals, and aquatic animals. The animals include six species groups; birds, herptiles, mammals, insects, fish, and unionid mollusks. Prior to beginning field work, survey sites were selected using color infrared photographs of the basin. Survey sites encompassed all plant community types present in the study area including: wetlands, grasslands, riparian areas and streams. Sites selected from the photos were marked on U.S.G.S. 7.5' topographic maps for use in the field.

Survey work for the plants began in June and was continued throughout the growing season. Seventy-two sites were surveyed resulting in three occurrence records of species on the Heritage list. These were: two records of cardinal flower (*Lobelia cardinalis*), and one record of Fremont's clematis (*Clematis fremontii*). Approximately fifteen specimens remain to be identified and some of these may be Heritage list species.

Survey work for the terrestrial animals was initiated in May and continued through August. A total of thirty-seven sites were surveyed. Only three occurrences records were observed. Two are confirmed breeding records for Cooper's hawks (*Accipiter cooperii*), and one is for the coachwhip snake (*Masticophis flagellum*).

Field work for the aquatic species was conducted during October and November. Fourteen sites were surveyed resulting in nine occurrence records. Seven of the records are for orangethroat darters (*Etheosoma spectabilis*). The remaining two records are of the plains topminnow (*Fundulus sciadicus*). Additionally, the plains minnow (*Hybognathus placitus*) was recorded in the north fork of the Republican River near Benkelman.

Considering the large number of sites surveyed, the overall total of only fifteen records is relatively small. While an in-depth evaluation of potential and historic species for the study area has not been done, the initial cause for the low number of rare species in the area is probably due to the lack of unique and high quality habitats in the area. This is most likely the result of large scale conversion of native habitats to agricultural use, long term modification of the basin hydrology, and a high level of degradation of the remaining habitat.

The three year survey for bald eagle use in the basin will begin in late December, 1995 and continue in 1996, and 1997. For 1996 the approach taken with survey work will be modified from that in 1995. Field work in 1995 focused on surveying all community types present in the basin. The focus of field work in 1996 will be to verify known occurrence records of Heritage species known from the area prior to 1995 and on habitat types capable of supporting species known or of possible occurrence in the study area. In addition, survey work for the aquatic species will begin in early spring and continue through the summer to cover spawning, stream flows, and time periods not surveyed in 1995.

A Systematic Survey for Protected and Rare Animals and Plants and the Identification of Riparian Natural Communities along the Republican River in North-central Kansas

This document summarizes the work by the Kansas Biological Survey in its study of protected and rare species and riparian natural communities along the Republican River in north-central Kansas. Initiation of field work was delayed until mid-1995 because not all authorizing paperwork was processed until then and because of flooding in north-central Kansas during the spring of 1995. Activities are arranged according to the major objectives identified in the Survey's proposal to the Bureau of Reclamation.

Objective 1. Identify specific locations of outstanding natural areas.

1. Element occurrence records, managed area basic records, and other pertinent information in the Kansas Natural Heritage Inventory's database were transferred to 1:24,000 scale topo maps for field use. A total of 29 element occurrences and managed areas were identified in the study area.

2. Potential natural areas (PNAs) were identified on field topo maps using Heritage data and the information on the maps. We will supplement this information with data from aerial photographs this winter. Roughly a dozen PNAs were identified during two field reconnaissance trips to the study area in 1995. Detailed assessment of the quality of these areas will be completed during the 1996 field season.

3. Plat maps were acquired for the counties included in the study area. These maps will be used to aid in contacting land owners as field surveys progress.

Objective 2. Identify specific locations of protected and rare animals and plants.

1. A survey schedule for protected and rare species known or believed to occur in the study area was developed using life history information for each species. Field surveys for rare plants began in 1995 and will be completed in 1996. Field surveys for rare animals will begin in 1996 and will be completed by early 1997. No protected or state-rare species were discovered in 1995.

Objective 3. Map historical and current riparian vegetation.

1. Historical and current riparian vegetation in the study area will be mapped in 1996. The only work carried out specifically for this objective was the purchase of NAPP photos, which we have received.

Objective 4. Compile baseline information for vascular plants and vertebrates occurring in the floodplain.

1. Existing information about the flora and fauna of the study area is being compiled from published and unpublished literature sources, the Vertebrate Characterization Abstract (maintained by the Kansas Natural Heritage Inventory), the Kansas Biota Database (maintained by the Kansas Biological Survey), and the Collection Information Management System (maintained by the R.L. McGregor Herbarium).

2. Roughly 400 plant vouchers were collected in the study area during 1995 and deposited in the R.L. McGregor Herbarium (KANU) at the University of Kansas. Specimen label data for all vouchers have been computerized in the Collection Information Management System.

Initial Observations from the Stream Assessment of the Republican River Basin

Department of Biological Sciences, Fort Hays State University, Hays, Kansas 67601

5 December 1995

After completing the first year of data collection at sites on the Republican River, White Rock Creek, and Prairie Dog Creek, we can offer some initial observations. A better analysis should be possible after compilation of the second year's data. High flows in the spring of 1995, which prevented us from entering the Republican River during the April-May sample period, certainly had an impact on the fish communities and habitat, and additional collections in 1996 will be beneficial.

The fish communities of the two small creeks were sampled at two sites apiece, which were located downstream from either Sebelius Reservoir or Lovewell Reservoir. The fish community in Prairie Dog Creek is typical of most small streams in northwestern Kansas. It is comprised of few species (mostly Fathead Minnows and Central Stonerollers) that are tolerant of the conditions associated with low, intermittent flows. White Rock Creek has a more diverse community. Most of the additional species are those associated with reservoirs (e.g., Walleye, Crappie); however, we also have specimens of noteworthy native species (e.g., Plains Minnow) in our museum collection that were captured in 1987. The more diverse fish community of this reach of White Rock Creek can be attributed to the fact that it is a short stretch of stream situated between Lovewell Reservoir and the Republican River, two very different habitats that supply components of each of their fish communities to the community in the creek. The species of fishes present in White Rock Creek probably will vary from year to year with the flow conditions in the creek and in the Republican River, which influence the movements of the fish.

Relatively little work has been done previously in the Republican River in Kansas. Although the river ecosystem has undergone changes, the fish community still includes some noteworthy species, as documented by our samples. Speckled Chubs are disappearing from most of the broad, sandy streams they once occupied in Kansas. However, they were one of the most abundant species in the October 1995 sample at our site in Republic County near the Nebraska state line, and they were present at all five of our Republican River sample sites. Similarly, Plains Minnows were once among the most abundant species in these same wide, sandy streams, but they have been virtually extirpated from the Kansas River system. The Republican River between Harlan County Reservoir and Milford Reservoir is one of the last places they can still be captured with any certainty in this basin, although they have declined greatly in abundance. These species and others native to this river were adapted to relatively shallow flows over a broad bed of shifting sand. Following the high flows in 1993 and early 1995, we found the bed to be composed of loose, shifting sand. This condition has all but disappeared in similar streams in northern Kansas (e.g., Smoky Hill River, Kansas River), and it is probably one of the principal reasons why native species, such as the Speckled Chub and Plains Minnow, are disappearing.

Overall, the fish community in the Republican River appeared to be reasonably diverse. Of the species occurring in the lower Republican River, as mapped by Cross (1967. Handbook of fishes in Kansas. Univ. Kansas Mus. Nat. Hist., Misc. Publ. No. 45:1-357) and Metcalf (1966. Fishes of the Kansas River system in relation to zoogeography of the Great Plains. Univ. Kansas Publ., Mus. Nat. Hist. 17(3):23-189), only two have not been captured recently (Sturgeon Chub and Flathead Chub), although, as mentioned above, the decline in the Plains Minnow is of concern statewide. The fish community in our study area is now influenced by the movement of fishes out of reservoirs, which have added species to the native fauna. Perhaps the most abundant of these is the Gizzard Shad. It is also likely that the reservoirs enhance the sportfish community in the river, which consists largely of Channel Catfish, Flathead Catfish, and White Bass.

With regard to physical/chemical habitat variables, the only apparent change of note was a dramatic decrease in chloride concentrations in the August and October samples compared with values obtained in the earlier samples. We are not certain whether this was related to irrigation activities or a decrease in natural inflows caused by the summer drought. Other chemical measurements showed no dramatic increases or decreases during 1995.

Part III

Summary of Aquatic/Riparian Studies

roosting areas. Mid-winter bald eagle counts have been conducted in conjunction with the National Wildlife Federation. The Service has noted that all of the criteria for essential eagle wintering habitat are found at Harlan County Lake.

Black-Footed Ferret

The last confirmed record of a live black-footed ferret in Kansas was in Sheridan County in 1957. The last confirmed sighting in Nebraska was in the late 1940's; however, numerous probable and unconfirmed reports of ferret sightings have been made since that time in southwestern Nebraska.

Eskimo Curlew

The Eskimo curlew historically occurred in Nebraska as a very common migrant. The last known Nebraska confirmed sighting was in 1926.

Swift Fox

Past observations, records of occurrence, and analysis of existing potential habitat indicate that the swift fox's present range in Nebraska includes the southwestern region and the western half of the panhandle. The decline of the swift fox can be directly associated with changes in land use such as plowing native prairie and extensive use of poison in the coyote control program.

Topeka Shiner

A shiner listed on the Kansas species in need of conservation list, the Topeka shiner (*Notropis topeka*), was collected from Cherry Creek in the upper Republican River Basin in 1947.

American Burying Beetle

This large carrion beetle is documented from Douglas, Doniphan, Pottawatomie, Riley, and Saline Counties within the basin, but no records exist since the late 1920's. Recent survey efforts by several agencies have failed to locate this insect, and its current status is unknown. Populations are known to exist in Arkansas, Oklahoma, and Nebraska.

Peregrine Falcon

Peregrine falcon are known to infrequently migrate through the basin and are normally found in association with shorebird and waterfowl concentrations. The peregrine falcon feeds almost exclusively on smaller birds, hunting primarily in open areas such as crop fields and grasslands, rivers, and water bodies. Most recent peregrine reports from within this basin are from the eastern half of the State, but they should be expected as uncommon migrants throughout the basin and Kansas. The Service did not indicate any confirmed sightings of peregrine falcons at Harlan County Lake. There is little suitable habitat at Enders, Swanson, Harry Strunk, or Hugh Butler Lakes. Bonny Reservoir provides suitable stopover habitat.

Whooping Crane

Whooping cranes have been sighted on their migration through the area. This tall wading bird is a regular spring and fall migrant, primarily through the central third of Kansas. They have been reported, however, from as far east as Jefferson County. During March-April and October-November they use resting habitats in the State, including shallow wetlands, river islands and bars, and crop fields. The whooping crane occurs in Nebraska only as a spring and fall migrant. It is most commonly observed in the central portion of the State, usually near the Platte River. Whooping cranes use shallow, sparsely vegetated streams and wetlands with good horizontal visibility during migration for roosting and feeding sites. Two whooping crane sightings have been confirmed by the Service at or in the vicinity of Harlan County Lake, and sightings have been confirmed at Hugh Butler Lake.

Bald Eagle

Bald eagles may be expected to occur along any river or at any reservoir in Kansas during winter, as evidenced by sighting records of the Kansas Department of Wildlife and Parks. Bald eagles use as perch and roost sites large trees in proximity to open water, a combination which provides ready access to foraging sites. Active bald eagle nests are also increasing in Kansas and could occur in any of these same habitats. Bald eagles are common migrants, and Nebraska is within the traditional wintering range. Small numbers of bald eagles have been observed at Enders, Swanson, Hugh Butler, and Harry Strunk Lakes. Harlan County Lake and the Republican River downstream from the dam are important wintering areas for bald eagles. Midwinter eagle counts during the 11-year period between 1982 and 1992 averaged 83 bald eagles between Alma, Nebraska, and Naponee, Nebraska, including Harlan County Lake. A peak of 272 eagles was counted in the area during the 1992 survey. A communal night roost is located immediately below the dam. Approximately 5 to 15 bald eagles use Bonny Reservoir in Colorado every year.

Wintering waterfowl are the main food source for the wintering bald eagles, while riparian habitat downstream from the Harlan County Dam provides

Table A-10.—Species in need of conservation

State	Common name	Scientific name
Kansas	Black tern	*Chlidonias niger*
Kansas	Bobolink	*Dolichonyx oryzivorus*
Kansas	Brassy minnow	*Hybognathus hankinsoni*
Kansas	Chihuahuan raven	*Corvus cryptoleucus*
Kansas	Cylindrical papershell mussel	*Anadontoides ferussacianus*
Kansas	Ferruginous hawk	*Buteo regalis*
Kansas	Franklin's ground squirrel	*Spermophilus franklinii*
Kansas	Glossy snake	*Arizona elegans*
Kansas	Golden eagle	*Aquila chrysaetos*
Kansas	Long-billed curlew	*Numenius americanus*
Kansas	Mountain plover	*Charadrius montanus*
Kansas	Plains minnow	*Hybognathus placitus*
Kansas	River shiner	*Notropis blennius*
Kansas	Short-eared owl	*Asio flammeus*
Kansas	Southern bog lemming	*Synaptomys cooperi*
Kansas	Western hognose snake	*Heterodon nasicus*
Kansas	Topeka shiner	*Notropis topeka*

Trends

Piping Plover and Least Tern

These aquatic bird species presently occur only as spring and fall migrants in the Kansas River Basin. Both species are associated with unvegetated shorelines, sandbars, and mudflats of wetlands and rivers. Piping plovers feed primarily on aquatic invertebrates, and least terns feed primarily on minnows. The piping plover has been reported from the Kansas, Smoky Hill, and Saline Rivers. The least tern has been observed on the Kansas River at Lawrence and Manhattan and doubtless occurs fairly regularly during migration at several locations within the basin. Although no nesting activity has been confirmed in Harlan County, the birds may occur as migrants. There are no confirmed nesting records on the Republican River.

Table A-8.—Federally listed species in Nebraska

Status	Common name	Scientific name
Endangered	Black-footed ferret	*Mustela nigripes*
Endangered	Peregrine falcon	*Falco peregrinus*
Endangered	Eskimo curlew	*Numenius borealis*
Endangered	Interior least tern	*Sterna antillarum*
Endangered	Whooping crane	*Grus americana*
Endangered	American burying beetle	*Nicrophorus americanus*
Threatened	Bald eagle	*Haliaeetus leucocephalus*
Candidate[1]	Mountain plover	*Charadrius montanus*
Candidate	Topeka shiner	*Notropis topeka*
Candidate	Swift fox	Vulpes velox

[1] Candidate species are those plant and animal species for which the U.S. Fish and Wildlife Service has sufficient information on their biological status and threatens to propose them as endangered or threatened under the Endangered Species Act.

Table A-9.—State-listed species

Status	State	Common name	Scientific name
Endangered	Colorado	Greater prairie chicken	*Tympanochos cupido pinnatus*
Endangered	Colorado	Prairie sharp-tailed grouse	*Pedioecetes phasianellus jamesi*
Threatened	Colorado	White pelican	*Pelecanus erythrorhynchos*
Threatened	Colorado	Plains orangethroat darter	*Ethoestoma spectabile pulchellum*
Threatened	Kansas	Snowy plover	*Charadrius alexandrinus*
	Kansas	White-faced ibis	*Plegadis chihi*
	Nebraska	Wolf spikerush	*Eleocharis wolfii*
	Nebraska	Yellow mud turtle	*Kinostemon flavescens flavescens*
	Nebraska	Plains topminnow	*Fundulus sciadicus*
	Nebraska	Southern bog lemming	*Synaptomys cooperi*
Endangered	Nebraska	Swift fox	*Vulpes velox*
	Nebraska	Sturgeon chub	*Machrybopsis gelida*
	Nebraska	Ferruginous hawk	*Buteo regalis*
	Nebraska	Hall's bullrush	*Scirpus hallii*

Endangered Species

Federally Listed and Proposed and Candidate Species

The Service identified the following threatened, endangered, or candidate (proposed for listing as endangered species) species which occur, or may occur in the Republican River Basin in Colorado (table A-6), Kansas (table A-7), and Nebraska (table A-8).

Table A-6.—Federally listed species in Colorado (Yuma County)

Status	Common name	Scientific name
Endangered	Black-footed ferret	*Mustela negripes*
Threatened	Bald eagle	*Haliaeetus leucocephalus*
Candidate[1]	Swift fox	*Vulpes velox*

[1] Candidate species are those plant and animal species for which the U.S. Fish and Wildlife Service has sufficient information on their biological status and threatens to propose them as endangered or threatened under the Endangered Species Act.

Table A-7.—Federally listed species in Kansas

Status	Common name	Scientific name
Endangered	Piping plover	*Charadrius melodus*
Endangered	Least tem	*Stema antillarum*
Endangered	Peregrine falcon	*Falco peregrinus*
Endangered	Whooping crane	*Grus americana*
Threatened	Bald eagle	*Haliaeetus leucocephalus*

Federal Critical Habitat

No critical habitat has been designated for endangered species in Kansas. There is a known population of regal fritillary butterfly occurring at Bonny Reservoir.

State Special Status Species

State special status species are shown in table A-9. In addition to the threatened and endangered species listed by Kansas, there is a "watch" list designated "Species in Need of Conservation" (table A-10).

Part II

Endangered Species

Table A-6.—Documented fish kills in the Republican River since 1980—continued

Date	Location of fish kill	Reason for fish kill	Number and types of fish killed
June 29, 1990	Republican River in Republic County, Kansas	Animal waste	5,345 fish: flathead catfish, shovelnose sturgeon, river carpsucker, longnose gar, carp, channel catfish, and goldeye
August 3, 1990	1 mile south of Republican City	Dewatering of Republican River below Harlan County Dam	>6,000 fish: juvenile white bass, walleye, and catfish and others
September 10-14, 1990	McCook to Harlan County Dam	Zero flows	Large numbers
July 15, 1991	Norton	Disease or parasites	275 fish: walleye, wiper, and channel catfish
July 19, 1991	Republican River from Rope Creek to wet of Orleans Bridge	Dewatering of a 6- to 8-mile segment of the river	Hundreds of minnows and other species
August 3, 1991	Buffalo Creek	Oxygen demand	2,016 fish: river carpsucker, channel catfish, flathead catfish, and carp
August 12-13, 1991	Republican River 1.5 miles east of Alma, Highway 183 bridge (upper end of Harlan County Reservoir)	Rapid water rise stimulated upstream migration followed by rapidly receding water levels which stranded fish	4,700 fish: quillback, carp, channel catfish, flathead catfish, and drum
August 13, 1991	Republican River to Harlan County Reservoir—west end of lake	Heavy rainfall encouraged flathead catfish and carp to move upstream—after the heavy rains ended, the water receded quickly, leaving the fish stranded; a contributing factor is allowing reservoir levels to drop too low	4,500 catfish and carp
August 29, 1991	Republican River—Alma Bridge to Arapahoe	Zero flow	Around 13,000 fish: quillback, carp, channel catfish, flathead catfish, drum, and minnows
November 21, 1991	Marsh Creek	Oxygen demand	>5,000 fish: carp, bigmouth buffalo, drum, river carpsucker, longnose gar, and channel catfish
December 1993	Republican River below Harlan County Dam	Possible that fish were being pulled through the deep release at Harlan	Possibly 1,000 white bass
July 20, 1995	Cambridge Canal in Furnas and Harlan Counties	Possibly a Magnacide H application	>5,000 fish: channel catfish, river carpsucker, common carp, gizzard shad, and green sunfish

Table A-1.—Wildlife occurring near Republican River reservoirs—continued

	Common birds	Common waterfowl	Common reptiles and amphibians	Common mammals
Wildlife common to southwestern Nebraska—continued	Barn swallow *(Hirundo rustica)*			
	Cliff swallow *(Petrochelidon pyrrhonota)*			
	Bank swallow *(Riparia riparia)*			
	Rough-winged swallow *(Stelgidopteryx ruficollis)*			
Enders Reservoir Swanson Lake Hugh Butler Lake Harry Strunk Lake Harlan County Lake	Blue jay *(Cyanocitta cristata*			
	Black-billed magpie *(Pica pica)*			
	Common crow (Corvus *brachyrhynchos)*			
	Black-capped chickadee *(Parus atricapillus)*			
	House wren *(Troglodytes aedon)*			
	Rock wren *(Salpinctes obsoletus)*			
	Mockingbird *(Mimus polyglottos)*			
	Gray catbird *(Dumetella carolinensis)*			
	American robin *(Turdus migratorius)*			
	Eastern bluebird *(Sialia sialis)*			
	Loggerhead shrike *(Lanius ludovicianus)*			
	Starling *(Sturnus vulgaris)*			
	Bell's vireo *(Vireo bellii)*			
	Red-eyed vireo *(Vireo olivaceus)*			
	gilvus)			
	Warbling vireo *(Vireo gilvus)*			
	Common yellowthroat *(Geothlypis trichas)*			
	Yellow-breasted chat *(Icteria virens)*			
	House sparrow *(Passer domesticus)*			
	Bobolink *(Dolichonyx oryzivorus)*			
	Western meadowlark *(Sturnella neglecta)*			
	Yellow-headed blackbird *(Xanthocephalus xanthocephalus)*			
	Red-winged blackbird *(Agelaius phoeniceus)*			
	Orchard oriole *(Icterus spurius)*			
	Northern oriole *(Icterus galbula)*			
	Common grackle *(Quiscalus quiscula*			
	Brown-headed cowbird *(Molothrus ater)*			
	Cardinal *(Richmondena cardinalis)*			

Table A-1.—Wildlife occurring near Republican River reservoirs—continued

	Common birds	Common waterfowl	Common reptiles and amphibians	Common mammals
Wildlife common to southwestern Nebraska—continued Enders Reservoir Swanson Lake Hugh Butler Lake Harry Strunk Lake Harlan County Lake	Black-headed grosbeak *(Pheucticus melanocephalus)* Blue grosbeak *(Guiraca caerulea)* Dickcissel *(Spiza americana)* American goldfinch *(Spinus tristis)* Grasshopper sparrow *(Ammodramus savannarum)* Vesper sparrow *(Pooecetes gramineus)* Lark sparrow *(Chondestes grammacus)* Cassin's sparrow *(Aimophila cassinii)* Chipping sparrow *(Spizella passerina)* Field sparrow *(Spizella pusilla)* McCown'a longspur *(Rhynchophanes mccownii)*			
Wildlife common to Norton County, Kansas Keith Sebelius Lake	Great blue heron *(Ardea herodias)* Northern green heron *(Butorides virescens)* Sharp-shinned hawk *(Accipiter striatus)* Red-tailed hawk *(Buteo jamaicensis)* Swainson's hawk *(Buteo swainsoni)* Rough-legged hawk *(Buteo lagopus)* Ferruginous hawk *(Buteo regalis)* Golden eagle *(Aquila chrysaetos)* Bald eagle *(Haliaeetus leucocephalus)* Marsh hawk *(Circus cyaneus hudonius)* Osprey *(Pandion haliaetus)* Prairie falcon *(Falco mexicanus)* American kestrel *(Falco sparverius)* Bobwhite quail *(Colinus virginianus)* Ring-necked pheasant *(Phaseanus colchicus)* Turkey *(Meleagris gallopavo)* Greater sandhill crane *(Grus canadensis tabida)* Killdeer upland plover *(Charadrius vociferus)*	Eared grebe *(Podiceps nigricallis)* Pie-billed grebe *(Podilymbus podiceps* White pelican *(Pelecanus erythrogynchos)* Double-crested cormorant *(Phalacrocrax auritus)* Canada goose *(Branta candensis)* White fronted goose *(Anser albifrons)* Snow goose *(Chen hyperborea)* Mallard *(Anas platyrhynchos)* Gadwall *(Anas strepera)* Northern pintail *(Anas acuta)* Green-winged teal *(anas crecca)* Blue-winged teal *(Anas discors)* American wegeon *(Anas americana)* Northern shoveler *(Anas clypeata)* Wood duck *(Aix sponsa)* Redhead *(Aythya americana)* Canvasback *(Aythya valisineria)*	Eastern tiger salamander *(Ambystoma t. tigrinum)* Plains spadefoot *(Scaphiopus bombifrons)* Great plains toad *(Bufo cognatus)* Rocky mountain toad *(Bufo woodhousei woodhousei)* Blanchard's cricket frog *(Acris crepitans blanchardi)* Western chorus frog *(Pseudacris triseriata triseriata)* Bullfrog *(Rana catesberana)* Plains leopard frog *(Rana pipiens)* Northern snapping turtle *(Chelydra serpentina serpentina)* Eastern ornate box turtle *(Terrapene ornata ornata)* Western painted turtle *(Chrysemys picta belli)* Great plains skink *(Eumeces obsouetus)*	Oppossum *(Didelphis marsupialis)* Short-tailed shrew *(Blarina brevicauda)* Eastern mole *(Scalopus aquaticus)* Small-footed myotis *(Myotis subulatus)* Big brown bat *(Eptesicus fuscus)* Silver-haired bat (migrant) *(Larsionycteris noctivagans)* Red bat *(Lasiurus borealis)* Eastern cottontail *(Sylvilagus floridanus)* White-tailed jackrabbit *(Lepus townsendii)* Black-tailed jackrabbit *(Lepus californicus)* Fox squirrel *(Sciurus niger)* Black-tailed prairie dog *(Cynomys ludovicianus)* Plains-pocket gopher *(Geomys bursarius)* Plains-pocket mouse *(Perognathus flavescens)* Silky-pocket mouse *(Perognathus flavus)* Ord's kangaroo rat *(Dipodomys ordii)*

Table A-1.—Wildlife occurring near Republican River reservoirs—continued

	Common birds	Common waterfowl	Common reptiles and amphibians	Common mammals
Wildlife common to Norton County, Kansas—continued Keith Sebelius Lake	Spotted sandpiper *(Bartramia longicauda)*	Lesser scaup *(Aythya affinis)*	Prairie lined racerunner *(Cnemidophours sexlineatus viridis)*	Beaver *(Castor canadensis)*
	Pectoral sandpiper *(Erolia melanotos)*	Bufflehead *(Bucephala albeola)*	Prairie ringneck snake *(Diadpohis punctatus arnysi)*	Northern grasshopper mouse *(Onychomys leucogaster)*
	American avocet *(Recurvirosta americana)*	Ruddy duck *(Oxyura jamaicensis)*	Western hognose snake *(Heterodon nasicus)*	Western harvest mouse *(Reithrodontomys megalotis)*
	Ring-billed gull *(Larus delawarensis)*	Common merganser *(Mergus merganser)*	Eastern yellow-bellied racer *(Coluber constrictor flaviventris)*	Plains harvest mouse *(Reithrodontomys montanus)*
	Franklin's gull *(Larus pipixcan)*	American coot *(Fulica americana)*	Bullsnake *(Pituophis melanolecus sayi)*	White-footed deer mouse *(Peromyscus maniculatus)*
	Forster's tern *(Sterna forseri)*		Prairie kingsnake *(Lampropeltis calligaster callitagaster)*	Woods mouse *(Peromyscus leucopus)*
	Black tern *(Chlidonias niger)*		Western milk snake *(Lampropeltis triangulum gentilius)*	Wood rat *(Neotoma floridana)*
	Rock dove *(Columba livia)*		Western plains garter snake *(Thamnophis radix haydeni)*	Muskrat *(Ondatra zibethicus)*
	Mourning dove *(Zenaida macroura)*		Red-sided garter snake *(Thamnophis sirtalis praietalis)*	Prairie mole *(Microtus ochrogaster)*
	Barn owl *(Tyoto alba)*			Norway rat *(Rattus norvegicus)*
	Great horned owl *(Bubo virginianus)*			House mouse *(Mus musculus)*
	Burrowing owl *(Athene cunicularia)*			Coyote *(Canis latrans)*
	Short-eared owl *(Asio Flammeus)*			Raccoon *(Procyon lotor)*
	Common nighthawk *(Chordeiles minor)*			White-tailed deer *(Odocoileus virginianus)*
	Chimney swift *(Chaetura pelagica)*			
	Belted kingfisher *(Megaceryle alcyon)*			
	Common flicker *(Colaptes auratus)*			
	Red-bellied woodpecker *(Melanerpes carolinus)*			
	Red-headed woodpecker *(Melanerpes erythrocephalus)*			
	Eastern kingbird *(Tyrannus tyrannus)*			
	Western kingbird *(Tyrannus verticalis)*			
	Great crested flycatcher *(Myiarchus crinitus)*			
	Say's phoebe *(Sayornis saya)*			
	Least flycatcher *(Empidonax minimus)*			
	Horned lark *(Eremophila alpestris)*			
	Rough-winged swallow *(Stelgidopteryx ruficollis)*			
	Barn swallow *(Hirundo rustica)*			
	Cliff swallow *(Petrochelidon pyrrhonota)*			
	Blue jay *(Cyanocitta cristata)*			
	Black-billed magpie *(Pica pica)*			
	Common crow *(Corvus brachyrhynchos)*			
	Black-capped chickadee *(Parus atricapillus)*			

Table A-1.—Wildlife occurring near Republican River reservoirs—continued

	Common birds	Common waterfowl	Common reptiles and amphibians	Common mammals
Wildlife common to Norton County, Kansas—continued	Brown creeper *(Certhia familiaris)*			
	House wren *(Troglodytes aedon)*			
	Winter wren *(Troglodytes troglodytes)*			
	North mockingbird *(Mimus polyglottos)*			
Keith Sebelius Lake	Gray catbird *(Dumetella carolinensis)*			
	American robin *(Turdus migratorius)*			
	Loggerhead shrike *(Lanius ludovicianus)*			
	Starling *(Sturnus vulgaris)*			
	Bell's vireo *(Vireo bellii)*			
	Warbling vireo *(Vireo gilvus)*			
	Yellow warbler *(Dendroica petechia)*			
	Common yellowthroat *(Geothlypis trichas)*			
	Yellow-breasted chat *(Icteria virens)*			
	House sparrow *(Passer domesticus)*			
	Western meadowlark *(Sturnella neglecta)*			
	Yellow-headed blackbird *(Xanthocephalus xanthocephalus)*			
	Red-winged blackbird *(Agelaisu phoeniceus)*			
	Orchard oriole *(Icterus spurius)*			
	Northern oriole *(Icterus galbula)*			
	Brewer's blackbird *(Euphagus cyanocephalus)*			
	Common grackle *(Quiscalus quiscalus)*			
	Brown-headed cowbird *(Molothrus ater)*			
	Cardinal *(Cardinalis cardinalis)*			
	Black-headed grosbeak *(Pheucticus melanocephalus)*			
	Indigo bunting *(Passerina cyanea)*			
	Dickcissel *(Spiza americana)*			
	American goldfinch *(Carduelis tristis)*			
	Lark bunting *(Calamospiza melanocorys)*			
	Grasshopper sparrow *(Ammodramus savannarum)*			

Table A-1.—Wildlife occurring near Republican River reservoirs—continued

	Common birds	Common waterfowl	Common reptiles and amphibians	Common mammals
Wildlife common to Norton County, Kansas—continued Keith Sebelius Lake	Lark sparrow *(Chondestes grammacus)* Dark-eyed junco *(Junco hyemalis)* Tree sparrow *(Spizella arborea)* Harris sparrow *(Zonotrichia guerula)* Song sparrow *(Melospiza melodia)* Lapland longspur *(Calcarius lapponicus)*			
Wildlife common to north-central Kansas Lovewell Reservoir	Great blue heron *(Ardea herodias)* Northern green heron *(Butorides virescens)* Cattle egret *(Bubulcus ibis)* Great egret *(Casmerodius albus)* Black crowned nigh heron *(Nycticorax nycticorax)* American bittern *(Botaurus lentigenosus)* Turkey vulture *(Cathartes aura)* Swainson's hawk *(Buteo swainsoni)* Harris' hawk *(Parabuteo unicinctus)* Golden eagle *(Aquila chrysaetos)* Bald eagle *(Haliaeetus leucocephalus)* Marsh hawk *(Circus cyaneus hudonius)* Prairie falcon *(Falco mexicanus)* Greater prairie chicken *(Tympanuchus cupido)* Bobwhite quail *(Colinus virginianus)* Ring-necked pheasant *(Phaseanus colchicus)* Whooping crane *(Grus american)* Killdeer *(Charadrius vociferus)* Upland sandpiper *(Bartramia longicauda)* Spotted sandpiper *(Actitis macularia)* Greater yellowlegs *(Totanus melanoleucus)* Lesser yellowlegs *(Totanus flavipes)* White-rumped sandpiper *(Erolia fuscicollis)* Dunlin *(Erolia alpina)* Semipalmated sandpiper *(Ereuneter pusillus)*	White pelican *(Pelecanus erythrogynchos)* Double-crested cormorant *(Phalacrocrax auritus)* Canada goose *(Branta candensis)* Snow goose *(Chen hyperborea)* Mallard *(Anas platyrhynchos)* Gadwall *(Anas strepera)* Northern pintail *(Anas acuta)* Green-winged teal *(anas crecca)* Blue-winged teal *(Anas discors)* American wegeon *(Anas americana)* Northern shoveler *(Anas clypeata)* Wood duck *(Aix sponsa)* Redhead *(Aythya americana)* Canvasback *(Aythya valisineria)* Lesser scaup *(Aythya affinis)* Common goldeneye *(Bucephala clangula)* Bufflehead *(Bucephala albeola)* Common merganser *(Mergus merganser)* American coot *(Fulica americana)*	Eastern tiger salamander *(Ambystoma t. tigrinum)* Great plains toad *(Bufo cognatus)* Rocky mountain toad *(Bufo woodhousei woodhousei)* Blanchard's cricket frog *(Acris crepitans blanchardi)* Western chorus frog *(Pseudacris triseriata triseriata)* Bullfrog *(Rana catesberana)* Plains leopard frog *(Rana pipiens)* Northern snapping turtle *(Chelydra serpentina serpentina)* Eastern ornate box turtle *(Terrapene ornata ornata)* Western painted turtle *(Chrysemys picta belli)* Great plains skink *(Eumeces obsouelus)* Prairie lined racerunner *(Cnemidophours sexlineatus viridis)* Prairie ringneck snake *(Diadpohis punctatus amysi)* Western hognose snake *(Heterodon nasicus)* Eastern yellow-bellied racer *(Coluber constrictor flaviventris)* Bullsnake *(Pituophis melanolecus sayi)*	Oppossum *(Didelphis marsupialis)* Short-tailed shrew *(Blarina brevicauda)* Little short-tailed shrew *(Cryptotis parva)* Keen's myotis *(Myotis keeni)* Silver-haired bat (migrant) *(Larsionycteris noctivagans)* Hoary bat *(Lasiurus cinereus)* Red bat *(Lasiurus borealis)* Eastern cottontail *(Silvilagus floridanus)* Black-tailed jackrabbit *(Lepus californicus)* Fox squirrel *(Sciurus niger)* Black-tailed prairie dog *(Cynomys ludovicianus)* Thirteen-lined ground squirrel *(Spermophilus tridecemlineatus)* Plains-pocket gopher *(Geomys bursarius)* Plains-pocket mouse *(Perognathus flavescens)* Silky-pocket mouse *(Perognathus flavus)* Hispid pocket mouse *(Perognathus hispidus)* Ord's kangaroo rat *(Dipodomys ordii)* Beaver *(Castor canadensis)* Northern grasshopper mouse *(Onychomys leucogaster)* Western harvest mouse *(Reithrodontomys megalotis)*

Table A-1.—Wildlife occurring near Republican River reservoirs—continued

	Common birds	Common waterfowl	Common reptiles and amphibians	Common mammals
Wildlife common to north-central Kansas—continued Lovewell Reservoir	Western sandpiper *(Ereuneter mauri)* Long-billed dowitcher *(Limnodromus scolopaceus)* Wilson's phalarope *(Steganopus tricolor)* Ring-billed gull *(Larus delawarensis)* Franklin's gull *(Larus pipixcan)* Forster's tern *(Sterna forseri)* Black tern *(Childonias niger)* Rock dove *(Columba livia)* Mourning dove *(Zenaida macroura)* Yellow-billed cuckoo *(Coccyzua americanus)* Black-billed cuckoo *(Coccyzus erythropthalmus)* Roadrunner *(Gercoccyx californianus)* Barn owl *(Tyoto alba)* Great horned owl *(Bubo virginianus)* Snowy owl *(Nyctea scandiaca)* Poor-will *(Phalaenoptilus nuttallii)* Common nighthawk *(Chordeiles minor)* Chimney swift *(Chaetura pelagica)* Belted kingfisher *(Megaceryle alcyon)* Common flicker *(Colaples auratus)* Red-bellied woodpecker *(Melanerpes carolinus)* Red-headed woodpecker *(Melanerpes erythrocephalus)* Downy woodpecker *(Picoides pubescens)* Eastern kingbird *(Tyrannus tyrannus)* Western kingbird *(Tyrannus verticalis)* Scissor-tailed flycatcher *(Muscivora forticata)* Great crested flycatcher *(Myiarchus crinitus)* Eastern phoebe *(Sayornis phoebe)* Eastern wood phoebe *(Contopus virnes)* Horned lark *(Eremophila alpestris)* Rough-winged swallow *(Stelgidopteryx ruficollis)*		Prairie kingsnake *(Lampropeltis calligaster calligaster)* Western milk snake *(Lampropeltis triangulum gentilus)* Western plains garter snake *(Thamnophis radix haydeni)* Red-sided garter snake *(Thamnophis sirtalis praietalis)*	Plains harvest mouse *(Reithrodontomys montanus)* Deer mouse *(Peromyscus maniculatus)* White-footed deer mouse *(Peromyscus leucopus)* Hispid cotton rat *(Sigmodon hispidus)* Wood rat *(Neotoma floridana)* Muskrat *(Ondatra zibethicus)* Prairie mole *(Microtus ochrogaster)* Norway rat *(Rattus norvegicus)* House mouse *(Mus musculus)* Porcupine *(Erithezon dorsatum)* Coyote *(Canis latrans)* Red fox *(Vulpes vulpes)* Raccoon *(Procyon lotor)* Mink *(Mustels vison)* Long-tailed weasel *(Mustela frenata)* Badger *(Taxidea taxus)* Striped skunk *(Mephitis mephitis)* White tailed deer *(Odocolleus virginianus)*

Table A-1.—Wildlife occurring near Republican River reservoirs—continued

	Common birds	Common waterfowl	Common reptiles and amphibians	Common mammals
Wildlife common to north-central Kansas—continued	Barn swallow *(Hirundo rustica)*			
	Cliff swallow *(Petrochelidon pyrrhonota)*			
	Purple martin *(Progne subis)*			
	Blue jay *(Cyanocitta cristata)*			
Lovewell Reservoir	Black-billed magpie *(Pica pica)*			
	Common crow *(Corvus brachyrhynchos)*			
	Pinon jay *(Gymnorhinus cyanocephala)*			
	White breasted nuthatch *(Sitta carolinensis)*			
	House wren *(Troglodytes aedon)*			
	North mockingbird *(Mimus polyglottos)*			
	Gray catbird *(Dumetella carolinensis)*			
	Brown thrasher *(Toxostoma rufum)*			
	American robin *(Turdus migratorius)*			
	Eastern bluebird *(Sialia sialis)*			
	Cedar waxwing *(Bombycilla cedrorum)*			
	Loggerhead shrike *(Lanius ludovicianus)*			
	Starling *(Sturnus vulgaris)*			
	Bell's vireo *(Vireo bellii)*			
	Warbling vireo *(Vireo gilvus)*			
	Yellow warbler *(Dendroica petechia)*			
	Common yellowthroat *(Geothlypis trichas)*			
	House sparrow *(Passer domesticus)*			
	Eastern meadowlark *(Sturnella magna)*			
	Western meadowlark *(Sturnella neglecta)*			
	Yellow-headed blackbird *(Xanthocephalus xanthocephalus)*			
	Red-winged blackbird *(Agelaisu phoeniceus)*			
	Orchard oriole *(Icterus spurius)*			
	Northern oriole *(Icterus galbula)*			
	Brewer's blackbird *(Euphagus cyanocephalus)*			
	Great-tailed grackle *(Quiscalus mexicanus)*			
	Common grackle *(Quiscalus quiscalus)*			

Table A-1.—Wildlife occurring near Republican River reservoirs—continued

	Common birds	Common waterfowl	Common reptiles and amphibians	Common mammals
Wildlife common to north-central Kansas—continued	Brown-headed cowbird *(Molothrus ater)*			
	Cardinal *(Cardinalis cardinalis)*			
	Rose-breasted grosbeak *(Pheucticus ludivicianus)*			
Lovewell Reservoir	Blue grosbeak *(Guiraca caerulea)*			
	Indigo bunting *(Passerina cyanea)*			
	Dickcissel *(Spiza americana)*			
	American goldfinch *(Carduelis tristis)*			
	Lark bunting *(Calamospiza melanocorys)*			
	Grasshopper sparrow *(Ammodramus savannarum)*			
	Lark sparrow *(Chondestes grammacus)*			
	Lincoln's sparrow *(Melospiza lincolnii)*			

Table A-2.—Acres of cover types in Nebraska in 1972

County	Cropland	Grassland	Woodland	Unused	Developed	Water
Chase	221,000	290,000	1,400	7,266	10,447	2,183
	(42%)	(54%)	(<1%)	(1%)	(2%)	(<1%)
Dundy	148,000	384,000	5,200	4,783	8,998	462
	(27%)	(70%)	(1%)	(1%)	(2%)	(1%)
Frontier	243,000	328,000	1,300	7,574	13,100	3,570
	(41%)	(55%)	(<1%)	(1%)	(2%)	(1%)
Gosper	114,000	139,000	1,650	4,682	6,500	97
	(43%)	(52%)	(1%)	(2%)	(2%)	(<1%)
Hayes	167,000	255,000	2,000	5,326	5,486	792
	(38%)	(59%)	(<1%)	(1%)	(1%)	(<1%)
Hitchcock	212,000	203,000	5,600	5,929	7,900	5,643
	(48%)	(46%)	(1%)	(1%)	(2%)	(1%)
Red Willow	230,000	178,000	7,000	6,559	11,520	2,687
	(53%)	(41%)	(2%)	(2%)	(3%)	(1%)
Franklin	190,000	160,900	5,200	4,700	8,300	1,546
	(51%)	(43%)	(1%)	(1%)	(2%)	(<1%)
Furnas	259,900	175,800	8,300	5,600	11,500	5,596
	(56%)	(38%)	(2%)	(1%)	(2%)	(1%)
Harlan	205,300	117,700	8,600	4,900	12,800	14,785
	(56%)	(32%)	(32%)	(1%)	(4%)	(<4%)
Nuckolls	211,320	127,393	10,596	12,218	7,689	1,259
	(57%)	(34%)	(3%)	(3%)	(2%)	(<1%)
Webster	183,325	163,016	3,733	9,590	5,552	2,699
	(50%)	(44%)	(1%)	(3%)	(2%)	(1%)

Table A-3.—Habitats within public use areas

	Upland (acres)	Wetland (acres)	Water (acres)
Colorado	14,000		2,000
Kansas	25,000	1,250	20,000
Nebraska	43,000	3,500	19,000

Table A-4.—Habitat descriptions at Republican River reservoirs

Reservoir	Upland	Riparian	Wetland
Bonny	Grassland: interspersed grass and forb species including blue grama grass, buffalo grass, little bluestem, Indiangrass, sand reedgrass, sunflower, yucca, sagebrush and prickly pear Trees: Russian olive, locust, chokecherry, plum, and silverberry Crops:	Cottonwood, box elder, ash, and willow species	Extensive marsh complex at the upper end of the reservoir—can include grasses, rushes, spikerush, and sedges, bulrushes, cattail, common reed, and smartweed
Enders, Swanson, Harry Strunk, Hugh Butler Harlan County	Grassland: native short grass and mixed grass prairie communities occur in some areas Trees and thickets: wildrose, hawthorne, snowberry, silverberry, wild plum, chokecherry Shelterbelt species: cottonwood, green ash, elm, ponderosa pine, Russian olive, eastern red cedar Crops: wheat, grain sorghum, forage sorghum, hay, corn, sugar beets, and beans	Cottonwood, elm, boxelder, black willow, green ash, black and honey locust, black walnut, and hackberry	Some marshy areas with bullrushes and cattails at Harry Strunk
Keith Sebelius and Lovewell	Grassland: side-oats, bluestem species, and blue grama are the dominant upland native grass species Crops: alfalfa and corn Trees and shrubs: buckbrush, sumac, wild plum, kochia, nettle species, ragweed, hemp, black sampson, lambsquarter, prairie clover, common milkweed, and sunflower Shelterbelt species: cottonwood, green ash, elm, ponderosa pine, Russian olive, and eastern red cedar		

Table A-5.—Most important game species at Republican River reservoirs

Reservoir	Most sought-after game species
Bonny	Pheasant/quail
	Ducks/geese
	Deer
	Dove
	Rabbit/squirrel
Enders	Deer
	Waterfowl
	Pheasant
	Turkey
Swanson	Deer
	Waterfowl
	Pheasant
	Quail
	Other small game
Hugh Butler	Pheasant
	Deer
	Waterfowl
	Other small game
Harry Strunk	Pheasant
	Deer
	Quail
	Waterfowl
	Other small game
Keith Sebelius	Pheasant
	Turkey
	Deer
	Ducks
	Geese
Harlan County	Pheasant
	Quail
	Deer
	Turkey
Lovewell	Pheasant
	Quail
	Deer
	Turkey

Table A-6.—Documented fish kills in the Republican River since 1980

Date	Location of fish kill	Reason for fish kill	Number and types of fish killed
June 25, 1980	Republican River—first 5 miles above Swanson Reservoir	Insufficient water quantity; rapid decrease in flows; high temperatures	98 percent river carpsucker; 1,655 fish
June 9, 1981	White Rock Creek	Animal waste	57,400 fish: gizzard shad, minnows, goldeye, sunfish, drum, river carpsucker, catfish, and carp
June 11, 1981	Arikaree River to Republican River	Possible pesticide or other	>1,000 fish
June 30, 1981	North and South Fork Republican River	Low river flows combined with high temperatures	Mainly adult river carpsucker
March 1, 1983	Below Harlan County Dam	Pressure change; after a period of zero release from the reservoir, a deep-water release evidently sucked lethargic fish through to a surface pressure. Water level dropped suddenly as bottom release was changed to surface release which stranded fish on banks and snags.	About 7,000 fish, including white bass, drum, walleye, crappie, and gizzard shad
August 6, 1984	Garr Creek, Washington County, Kansas	Animal waste	45 fish-walleye, flathead catfish, carp, drum, gizzard shad, crappie, and largemouth bass
May 1, 1986	Sebelius Reservoir		>132,000 fish: gizzard shad, largemouth bass, crappie, walleye, carp, wiper, bluegill, and channel catfish
May 30, 1989	Mouth of Frenchman at Culbertson past McCook	Possible toxic material; also, low oxygen and high temperatures	>62,000 fish: channel catfish, flathead catfish, bluegill, green sunfish, carp, quillback, sucker, and minnows
June 24, 1989	Furnas-Harlan County—about 20 miles	Low water flows and high temperatures	About 3,000 fish, including quillback and river carpsucker, gizzard shad, carp, white bass, channel catfish, and flathead catfish
August 15, 1989	Driftwood-Meeker Canal below Swanson Reservoir	Likely herbicide	81 percent drum, also gizzard shad and flathead catfish; 50,400 fish
June 18-19, 1990	1 mile south of Alma	Feedlot runoff, low dissolved oxygen	Several hundred adult fish of various species

The Ogallala Formation is found in the Nebraska portion of the lower basin. It is composed of sandstone and siltstone interbedded with sand, gravel, and clay and has various degrees of cementation by calcium carbonate and silica. Thickness ranges over 100 feet and thins in an easterly direction. The base of the formation slopes to the southeast with an average gradient of 7 feet/mile.

Underlying the Ogallala and forming a relatively impermeable base are the Pierre Shale and Niobrara Formation. These formations were deposited in a marine environment during the late Cretaceous age. The Pierre is a dark-gray fissile shale, and the Niobrara consists of chalky shale and limestone. The Niobrara has a thickness of about 400 feet in Harlan County, Nebraska, and thins in an easterly direction.

Underlying the Niobrara Formation in the northern part of the lower basin, in descending stratigraphic order, are the Carlile Shale, Greenhorn Limestone, and Graneros Shale. They crop out at the surface in the central portion of the lower basin. Of these formations, the Greenhorn Limestone has the most potential for yielding small quantities of water for domestic purposes. Maximum total thickness of these deposits is about 430 feet.

The Dakota Formation is one of the principal aquifers in the vicinity of Cloud and Clay Counties (Kansas) for supplying municipal, domestic, and stock wells. Thickness ranges up to 350 feet. The quality of water varies from good to bad with a better quality generally obtained where the formation crops out or is near the surface. Water obtained from the Dakota Formation in most of northwestern Cloud County, Kansas contains high chloride concentrations, 250 ppm (parts per million) or higher (Fader 1968, pg 14). Walters and Bayne (1959) reported that samples obtained from the Dakota Formation in Clay County, Kansas show chloride concentrations below 250 ppm.

The Wellington Formation and Chase Group underlie the Dakota Formation to the north and crop out at the surface in Clay County, Kansas. Total thickness of these deposits ranges up to 480 feet. Small to moderate amounts of water for domestic and stock use may be obtained from several formations within the Chase Group. Better quality water can be obtained where the formations are not deeply buried.

Water Supply and Uses

The surface water supply for the Republican River Basin originates as rainfall, accumulates as surface water runoff, and runs downstream to the confluence of the tributaries. Base flow from the alluvial aquifers and return flows from surface irrigation are other surface water sources.

Since the mid to late 1960's, significant decreases in instream flow have occurred. This has reduced the water supply for irrigation or other demands.

Surface Water Irrigation

Surface water supply for irrigation is affected by the amounts of water available for diversion to the canals and laterals that comprise the irrigation districts in the Republican River Basin. Significant changes have occurred in the watershed runoff characteristics during the past 3 decades. Several factors that are affecting surface water supply in the basin are: development and addition of soil and water conservation practices, changes in base flow due to increased ground-water pumping for irrigation, and cyclical variations in the precipitation regime.

Recharge from surface water irrigation practices has contributed a significant amount of water to the ground-water system in several areas of the basin. Deep percolation from applied surface water and seepage from canals and reservoirs in the Platte River Basin have caused water level rises up to 50 feet along the northern edge of the study area in Nebraska. In Kansas, water level rises due to surface water irrigation have occurred in the Grand Island Formation east of Lovewell Reservoir and in Pleistocene and Cretaceous deposits to the southwest. Small areas of rising water tables have also occurred near several reservoirs in the basin as a result of seepage.

Return flows from surface water have also increased the base flows in several of the major streams. Streams showing large increases in base flow include Driftwood and Blackwood Creeks, and the Republican River reach from Hardy, Nebraska, to Concordia, Kansas.

The estimated average annual recharge from surface water irrigation in the Republican River Basin (including seepage from the Platte River Basin) for the historic period is 211,300 acre-ft.

Metals and Chlorinated Hydrocarbons in Sediments and Fish

Background

In the fall of 1989 and 1990, Region VI of the U.S. Fish and Wildlife Service sampled sediments at 29 locations and fish at 30 locations on the Republican River and tributaries to assess background concentrations of metals and long-lived organochlorine compounds in aquatic habitats in the Republican River basin. Sampling was completed in October 1990 and study results were presented in the 1993 report, "Background Contaminants Evaluation of the Republican River Drainage, Colorado, Kansas, and Nebraska." Findings from this report are summarized below.

Results

Metals in Sediments

- Except for very high arsenic concentrations at the upper end of Lovewell Reservoir and White Rock Creek below the reservoir, arsenic and mercury concentrations were comparable to those for western U.S. soils and sediments in all locations.
- Virtually all selenium concentrations in sediment samples collected were very low.
- Neither thallium nor silver was detected in any sediment sample.
- Concentrations of aluminum, barium, boron, chromium, iron, magnesium, and molybdenum were within the ranges of normal U.S. and north-central U.S. soil concentrations.
- Beryllium concentrations did not indicate a problem.
- Copper and nickel concentrations in White Rock Creek, upper Lovewell Reservoir, and Norton Reservoir were well above the means for western U.S. and northern Great Plains soils.
- Lead concentrations from the upper end of Lovewell Reservoir were much higher than the means from U.S. soil studies.
- The only locations where manganese concentrations were higher than U.S. norms were found at the upper end of Lovewell Reservoir.
- Strontium concentrations were high only at the upper end of Lovewell Reservoir.
- The concentration at the one location where tin was found - the upper end of Harlan county Reservoir - was very high compared to means for western U.S. soils. The reported value, however, is viewed with suspicion.

- No problems appeared related to vanadium concentrations.
- Zinc concentrations in many locations were well above the mean concentrations in western U.S. and northern Great Plains soils.

Metals in Fish

- Arsenic concentrations did not warrant concern.
- No mercury concentrations in Republican River study fish composites exceeded the 1984 National Contaminant Biomonitoring Program (NCBP) mean.
- Nearly every fish sample analyzed by atomic absorption for this study contained a selenium concentration greater than the NCBP means.
- Beryllium, lead, silver, and thallium were not detected in any fish analyzed by ICP.
- Aluminum concentrations were comparable to and as highly variable as those in fish composites collected for studies in Kansas and Nebraska.
- Barium concentrations were higher than those from other studies in Kansas rivers. Effects (if any) of observed levels of concentration could not be estimated due to very limited information on this subject.
- Boron concentrations for the fish collected in this study were judged not a cause for concern.
- Cadmium was not believed to represent a serious contamination problem in the drainage.
- Fish composites at 10 locations were contaminated with chromium. Assessment of the concentrations was considered difficult due to lack of information regarding a source of chromium at some locations.
- Copper concentrations in 11 fish composites exceeded the 1978-1979 1.1 ug/g NCBP 85th percentile concentration.

- Iron and magnesium concentrations were normal.
- Manganese concentrations at several locations were high. A review of the sources of the manganese may be necessary at numerous locations.
- Most of the molybdenum concentrations found were judged not to warrant concern.
- Nickel was detected in a variety of species, but the source and effects of the metal were not known.
- Strontium was detected in almost every fish composite analyzed, but means to assess the body burdens observed in Republican drainage fish composites was not available.
- Tin concentrations were detected in two samples. The effects of these concentrations were not known.
- Vanadium concentrations found in fish were suspected of being normal.
- Zinc concentrations observed during the study were judged not to constitute a problem.

Chlorinated Hydrocarbons in Sediments

- Organochorine concentrations in sediments in the Republican River basin are low. The only organchlorine residue detected was p,p—DDE (at Swanson Reservoir, Enders Reservoir, and on Thompson Creek).

Chlorinated Hydrocarbons in Fish

- Hexachlorobenzene, benzene hexachloride, and endrin were not detected in any fish composite.
- The cyclodiene concentration (chlordane compounds, heptachlor, aldrin, endrin, dieldrin, and endosulfan) in a composite species from Junction City, Kansas, was the only fish sample that exceeded the 0.1 ug/g whole body wet weight concentration recommended by the National Academy of Science and National Academy of Engineering to protect aquatic life.

- Toxaphene concentrations were observed in fish from Lovewell Reservoir and from the Republican River at Scandia in 1989. They were not detected, however, in fish from these locations analyzed in 1990.

- Mirex was detected in a composite sample taken from the head of the Bartley diversion canal in 1989. It is conjectured that mirex may have been recently used in the vicinity although banned for all uses in 1978.

- PCBs were not detected in most fish composites collected. Arochlor 1254 was found in fish from Harlan County Reservoir and from Lovewell Reservoir at concentrations judged not likely to present a serious problem.

- DDT compounds do not present a problem for biota in the locations sampled.

SUBBASIN 1 (Surface Water)
AREA 1

PARAMETER	UNITS	MEDIUM	REMARK	NUMBER	MEAN	MAXIMUM	MINIMUM
ENDRIN			U	1	0	0	0
AVERAGE ENDRIN, TOTAL	UG/L	WATER	TOTAL	104	0.1519	0.3	0
HEPTCHLR				9	0	0	0
HEPTCHLR			K	62	0.5258	1	0.02
HEPTCHLR			U	1	0	0	0
AVERAGE HEPTCHLR, TOTAL	UG/L	WATER	TOTAL	72	0.4528	1	0
METLCHLR DISS			K	3	0.05	0.05	0.05
AVERAGE METLCHLR DISS	UG/L	WATER	TOTAL	3	0.05	0.05	0.05
2,4-D SMPL	UG/L	WATER		11	0.2927	2.1	0
2,4-D SMPL			K	60	0.62	2	0.4
AVERAGE 2,4-D	UG/L	WATER	TOTAL	71	0.5693	2.1	0
ALACHLOR DISS	UG/L	WATER	K	3	0.05	0.05	0.05
AVERAGE ALACHLOR DISS	UG/L	WATER	TOTAL	3	0.05	0.05	0.05
MERCURY HG, DISS	UG/L	WATER		33	1.003	12	0
MERCURY HG, DISS			K	1	0.1	0.1	0.1
MERCURY HG, DISS			U	1	0.5	0.5	0.5
AVERAGE MERCURY HG, DISS	UG/L	WATER	TOTAL	35	0.9629	12	0
MERCURY HG. TOT	UG/L	WATER		22	0.6364	6	0
MERCURY HG. TOT			K	77	0.4987	0.5	0.4
MERCURY HG. TOT			U	1	0.4	0.4	0.4
AVERAGE MERCURY HG. TOT	UG/L	WATER	TOTAL	100	0.528	6	0
ALACHLOR TOT	UG/L	WATER	K	62	0.2331	0.25	0.1
ALACHLOR TOT			U	1	0	0	0
AVERAGE ALACHLOR TOT	UG/L	WATER	TOTAL	63	0.2294	0.25	0
MTRBUZIN TOT	UG/L	WATER	K	61	0.1	0.1	0.1
AVERAGE MTRBUZIN, TOT	UG/L	WATER	TOTAL	61	0.1	0.1	0.1
MTRBUZIN DISS	UG/L	WATER	K	3	0.05	0.05	0.05
AVERAGE MTRBUZIN DISS	UG/L	WATER	TOTAL	3	0.05	0.05	0.05

FILE: BRALL.WD

A = VALUE REPORTED IS THE MEAN OF TWO OR MORE DETERMINATIONS
K = ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN
U = INDICATES MATERIAL WAS ANALYZED FOR BUT NOT DETECTED.
CASE OF SPECIES, U INDICATES UNDETERMINDED SEX.

SUBBASIN 2 (Surface Water)
AREA 2

PARAMETER	UNITS	MEDIUM	REMARK	NUMBER	MEAN	MAXIMUM	MINIMUM
MGNSIUM MG, DISS	UG/L	WATER		109	16.374	23	10
MGNSIUM MG, DISS			A	2	17.5	19.2	15.8
AVERAGE MGNSIUM MG, DISS	UG/L	WATER	TOTAL	111	16.395	23	10
ARSENIC AS, DISS	UG/L	WATER		10	8.564	11	6
AVERAGE ARSENIC AS, DISS	UG/L	WATER	TOTAL	10	8.564	11	6
BARIUM BA, DISS	UG/L	WATER		2	0	0	0
AVERAGE BARIUM BA, DISS	UG/L	WATER	TOTAL	2	0	0	0
BERYLIUM BE, DISS	UG/L	WATER		2	0	0	0
AVERAGE BERYLIUM BE, DISS	UG/L	WATER	TOTAL	2	0	0	0
BORON B, DISS	UG/L	WATER		21	121.48	800	60
BORON B, DISS			K	3	100	100	100
AVERAGE BORON B, DISS	UG/L	WATER	TOTAL	24	118.79	800	60
CADMIUM CD, DISS	UG/L	WATER		2	0	0	0
CADMIUM CD, DISS			K	1	0.35	0.4	0.4
CADMIUM CD, DISS			U	7	11.479	15	0.4
AVERAGE CADMIUM CD, DISS	UG/L	WATER	TOTAL	10	8.07	15	0
CHROMIUM CR, DISS	UG/L	WATER		2	5	10	0
CHROMIUM CR, DISS			K	1	11.1	11	11
CHROMIUM CR, DISS			U	6	10.183	11	10
AVERAGE CHROMIUM CR, DISS	UG/L	WATER	TOTAL	9	9.1333	11	0
CHROMIUM CR, TOT	UG/L	WATER		2	0	0	0
AVERAGE CHROMIUM CR, TOT	UG/L	WATER	TOTAL	2	0	0	0
COPPER CU, DISS	UG/L	WATER		2	8.5	17	0
COPPER CU, DISS			K	5	8.346	10	5
COPPER CU, DISS			U	3	8.2433	10	5
AVERAGE COPPER CU, DISS	UG/L	WATER	TOTAL	10	8.346	17	0
IRON FE, TOT	UG/L	WATER		15	3880	22900	200
IRON FE, TOT			K	1	100	100	100
AVERAGE IRON FE, TOT	UG/L	WATER	TOTAL	16	3643.8	22900	100
IRON FE, DISS	UG/L	WATER		3	26.67	40	0.01
IRON FE, DISS			K	3	22.733	30	19
IRON FE, DISS			U	4	26.25	30	15
AVERAGE IRON FE, DISS	UG/L	WATER	TOTAL	10	25.321	40	0.01
LEAD PB, DISS	UG/L	WATER		2	0	0	[illegible]
LEAD PB, DISS			K	1	2.13	2	[illegible]
LEAD PB, DISS			U	7	15.957	20	2
AVERAGE LEAD PB, DISS	UG/L	WATER	TOTAL	10	11.383	20	0
MANGNESE MN, DISS	UG/L	WATER		4	8.5	24	0
MANGNESE MN, DISS			K	3	10	10	10
MANGNESE MN, DISS			U	4	7.48	10	6.5
AVERAGE MANGNESE MN, DISS	UG/L	WATER	TOTAL	11	8.5382	24	0
MOLY MO, DISS	UG/L	WATER		2	2.5	3	2
AVERAGE MOLY MO, DISS	UG/L	WATER	TOTAL	2	2.5	3	2

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U = INDICATES MATERIAL WAS ANALYZED FOR BUT NOT DETECTED.
CASE OF SPECIES, U INDICATES UNDETERMINDED SEX.

SUBBASIN 2 (Surface Water) AREA 2							
PARAMETER	UNITS	MEDIUM	REMARK	NUMBER	MEAN	MAXIMUM	MINIMUM
NICKEL NI, DISS	UG/L	WATER		3	7.6667	23	0
NICKEL NI, DISS			K	2	19.45	20	19
NICKEL NI, DISS			U	5	19.78	20	19
AVERAGE NICKEL NI, DISS	UG/L	WATER	TOTAL	10	16.08	23	0
SILVER AG, DISS				2	0	0	0
AVERAGE SILVER AG, DISS	UG/L	WATER	TOTAL	2	0	0	0
STRONTUM SR, DISS				2	560	610	510
AVERAGE STRONTUM SR, DISS	UG/L	WATER	TOTAL	2	560	610	510
VANADIUM V, DISS				2	16.35	27	6
TOTAL VANADIUM V, DISS	UG/L	WATER	TOTAL	2	16.35	27	6
ZINC ZN, DISS	UG/L	WATER		4	34.75	62	5
ZINC ZN, DISS			K	3	25.9	30	18
ZINC ZN, DISS			U	3	25.667	30	17
AVERAGE ZINC ZN, DISS	UG/L	WATER	TOTAL	10	29.37	62	5
ZINC ZN, TOT	UG/L	WATER		12	85.833	550	0
ZINC ZN, TOT			K	4	55	100	10
AVERAGE ZINC ZN, TOT	UG/L	WATER	TOTAL	16	78.125	550	0
SELENIUM SE, DISS	UG/L	WATER		3	6.1333	8	5
SELENIUM SE, DISS			K	5	2.236	3	2
SELENIUM SE, DISS			U	1	1.2	1	1
AVERAGE SELENIUM SE, DISS	UG/L	WATER	TOTAL	9	3.42	8	1
CYANZINE DISS	UG/L	WATER	K	6	0.05	0.05	0.05
AVERAGE CYANZINE DISS	UG/L	WATER	TOTAL	6	0.05	0.05	0.05
PROPACLR	UG/L	WATER	U	2	0	0	0
AVERAGE PROPACLR TOT	UG/L	WATER	TOTAL	2	0	0	0
PROPZINE, DISS	UG/L	WATER	K	6	0.05	0.05	0.05
AVERAGE PROPZINE, DISS	UG/L	WATER	TOTAL	6	0.05	0.05	0.05
PRPAZINE TOT	UG/L	WATER	U	1	0	0	0
AVERAGE PRPAZINE TOT	UG/L	WATER	TOTAL	1	0	0	0
CHLORPY- RIFOS	UG/L	WATER	U	5	0	0	0
AVERAGE CHLORPY- RIFOS TOT	UG/L	WATER	TOTAL	5	0	0	0
SIMAZINE	UG/L	WATER	U	2	0	0	0
AVERAGE SIMAZINE TOT	UG/L	WATER	TOTAL	2	0	0	0
PROMETON	UG/L	WATER	U	1	0	0	0
AVERAGE PROMETON TOT	UG/L	WATER	TOTAL	1	0	0	0
ALDRIN	UG/L	WATER	U	5	0	0	0
AVERAGE ALDRIN TOT	UG/L	WATER	TOTAL	5	0	0	0
CHLRDANE	UG/L	WATER	U	5	0	0	0
AVERAGE CHLRDANE TOT	UG/L	WATER	TOTAL	5	0	0	0
METOCLR (DUAL)	UG/L	WATER	U	2	0	0	0
AVERAGE METOCLR (DUAL) TOT	UG/L	WATER	TOTAL	2	0	0	0
DIELDRIN	UG/L	WATER	U	5	0	0	0
AVERAGE DIELDRIN TOT	UG/L	WATER	TOTAL	5	0	0	0

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CASE OF SPECIES, U INDICATES UNDETERMINDED SEX.

SUBBASIN 2 (Surface Water)
AREA 2

PARAMETER	UNITS	MEDIUM	REMARK	NUMBER	MEAN	MAXIMUM	MINIMUM
ENDRIN	UG/L	WATER	U	5	0	0	0
AVERAGE ENDRIN TOT	UG/L	WATER	TOTAL	5	0	0	0
HEPTCHLR	UG/L	WATER	U	5	0	0	0
AVERAGE HEPTCHLR TOT	UG/L	WATER	TOTAL	5	0	0	0
METLCHLR DISS	UG/L	WATER	K	6	0.05	0.05	0.05
AVERAGE METLCHLR DISS	UG/L	WATER	TOTAL	6	0.05	0.05	0.05
ALACHLOR DISS	UG/L	WATER	K	6	0.05	0.05	0.05
AVERAGE ALACHLOR DISS	UG/L	WATER	TOTAL	6	0.05	0.05	0.05
MERCURY HG, DISS	UG/L	WATER		2	0.05	0.1	0
MERCURY HG, DISS			K	3	0.4	0.4	0.4
MERCURY HG, DISS			U	5	0.5	0.5	0.5
AVERAGE MERCURY HG, DISS	UG/L	WATER	TOTAL	10	0.38	0.5	0
ALACHLOR TOT	UG/L	WATER	U	7	0	0	0
AVERAGE ALACHLOR TOT	UG/L	WATER	TOTAL	7	0	0	0
CRBFURAN TOT	UG/L	WATER	U	1	0	0	0
AVERAGE CRBFURAN TOT	UG/L	WATER	TOTAL	1	0	0	0
MTRBUZIN TOT	UG/L	WATER	U	2	0	0	0
AVERAGE MTRBUZIN TOT	UG/L	WATER	TOTAL	2	0	0	0
BUTYLATE TOT	UG/L	WATER	U	1	0	0	0
AVERAGE BUTYLATE TOT	UG/L	WATER	TOTAL	1	0	C	0
CYANAZIN	UG/L	WATER	U	2	0	0	0
AVERAGE CYANAZIN TOT	UG/L	WATER	TOTAL	2	0	0	0
EPTC	UG/L	WATER	U	1	0	0	0
AVERAGE EPTC TOT	UG/L	WATER	TOTAL	1	0	0	0
CYPRAZIN TOT	UG/L	WATER	U	1	0	0	0
AVERAGE CYPRAZIN TOT	UG/L	WATER	TOTAL	1	0	0	0
MTRBUZIN DISS	UG/L	WATER	K	6	0.05	0.05	0.05
AVERAGE MTRBUZIN DISS	UG/L	WATER	TOTAL	6	0.05	0.05	0.05

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CASE OF SPECIES, U INDICATES UNDETERMINDED SEX.

SUBBASIN 3 (Surface Water)
AREA 3

PARAMETER	UNITS	MEDIUM	REMARK	NUMBER	MEAN	MAXIMUM	MINIMUM
MERCURY HG, TOTAL	UG/L	WATER	K	30	0.5	0.5	0.5
AVERAGE MERCURY HG, TOT	UG/L	WATER	TOTAL	69	0.3203	6.1	0
ALACHLOR TOTAL	UG/L	WATER	K	36	0.225	0.25	0.1
AVERAGE ALACHLOR TOT	UG/L	WATER	TOTAL	36	0.225	0.25	0.1
MTRBUZIN TOTAL	UG/L	WATER	K	36	0.1	0.1	0.1
AVERAGE MTRBUZIN TOT	UG/L	WATER	TOTAL	36	0.1	0.1	0.1

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SUBBASIN 4 (Surface Water)
AREA 4

PARAMETER	UNITS	MEDIUM	REMARK	NUMBER	MEAN	MAXIMUM	MINIMUM
SELENIUM SE, TOT	UG/L	WATER	A	1	2.63	3	3
SELENIUM SE, TOT			K	6	3.3333	8	2
SELENIUM SE, TOT			U	5	10	10	10
AVERAGE SELENIUM SE, TOT	UG/L	WATER	TOTAL	39	4.5921	13	1
CYANZINE DISS	UG/L	WATER	K	3	0.05	0.05	0.05
AVERAGE CYANZINE DISS TOT	UG/L	WATER	TOTAL	3	0.05	0.05	0.05
PROPZINE	UG/L	WATER	K	3	0.05	0.05	0.05
AVERAGE PROPZINE TOT	UG/L	WATER	TOTAL	3	0.05	0.05	0.05
CHLORPY- RIFOS	UG/L	WATER	U	1	0	0	0
AVERAGE CHLORPY- RIFOS TOT	UG/L	WATER	TOTAL	1	0	0	0
ALDRIN	UG/L	WATER	U	1	0	0	0
AVERAGE ALDRIN TOT	UG/L	WATER	TOTAL	1	0	0	0
CHLRDANE	UG/L	WATER	U	1	0	0	0
AVERAGE CHLRDANE TOT	UG/L	WATER	TOTAL	1	0	0	0
DIELDRIN	UG/L	WATER	U	1	0	0	0
AVERAGE DIELDRIN TOT	UG/L	WATER	TOTAL	1	0	0	0
ENDRIN	UG/L	WATER	U	1	0	0	0
AVERAGE ENDRIN TOT	UG/L	WATER	TOTAL	1	0	0	0
HEPTCHLR	UG/L	WATER	U	1	0	0	0
AVERAGE HEPTCHLR TOT	UG/L	WATER	TOTAL	1	0	0	0
METLCHLR DISS	UG/L	WATER	K	3	0.05	0.05	0.05
AVERAGE METLCHLR DISS	UG/L	WATER	TOTAL	3	0.05	0.05	0.05
ALACHLOR WTR DISS	UG/L	WATER	K	3	0.05	0.05	0.05
AVERAGE ALACHLOR DISS	UG/L	WATER	TOTAL	3	0.05	0.05	0.05
MERCURY HG, DISS	UG/L	WATER		10	0.85	3.8	0
MERCURY HG,DISS			K	10	0.3	0.5	0.1
AVERAGE MERCURY HG, DISS	UG/L	WATER	TOTAL	20	0.575	3.8	0
MERCURY HG, TOT	UG/L	WATER		23	0.5217	3.4	0
MERCURY HG, TOT			K	27	0.2259	0.5	0.1
MERCURY HG, TOT			K	10	0.73	1	0.4
AVERAGE MERCURY HG, TOT	UG/L	WATER	TOTAL	60	0.4233	3.4	0
ALACHLOR TOTAL	UG/L	WATER	U	1	0	0	0
AVERAGE ALACHLOR TOT	UG/L	WATER	TOTAL	1	0	0	0
MTRBUZIN DISS	UG/L	WATER	K	3	0.05	0.05	0.05
AVERAGE MTRBUZIN DISS	UG/L	WATER	TOTAL	3	0.05	0.05	0.05

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SUBBASIN 5 (Surface Water)
AREA 5

PARAMETER	UNITS	MEDIUM	REMARK	NUMBER	MEAN	MAXIMUM	MINIMUM
CYANAZIN		WATER	K	6	0.1	0.1	0.1
AVERAGE CYANAZIN TOT	UG/L	WATER	TOTAL	11	0.1	0.1	0.1
MTRBUZIN DISS		WATER	K	16	0.05	0.05	0.05
AVERAGE MTRBUZIN DISS	UG/L	WATER	TOTAL	16	0.05	0.05	0.05

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SUBBASIN 6 (Surface Water)
AREA 6

PARAMETER	UNITS	MEDIUM	REMARK	NUMBER	MEAN	MAXIMUM	MINIMUM
SILVER AG, TOT	UG/L	WATER		49	5.4694	10	0
AVERAGE SILVER AG, TOT	UG/L	WATER	TOTAL	49	5.4694	10	0
VANADIUM V, TOT	UG/L	WATER		26	10.462	30	3
VANADIUM V, TOT			K	8	3.75	5	3
AVERAGE VANADIUM V, TOT	UG/L	WATER	TOTAL	34	8.8824	30	3
ZINC ZN, DISS	UG/L	WATER		18	6.6667	20	0
AVERAGE ZINC ZN, DISS	UG/L	WATER	TOTAL	18	6.6667	20	0
ZINC ZN, TOT	UG/L	WATER		69	61.855	700	0
ZINC ZN, TOT			K	2	105	110	100
AVERAGE ZINC ZN, TOT	UG/L	WATER	TOTAL	71	63.07	700	0
ALUMINUM AL, TOT	UG/L	WATER		36	2884.3	22780	80
AVERAGE ALUMINUM AL, TOT	UG/L	WATER	TOTAL	36	2884.3	22780	80
SELENIUM SE, DISS	UG/L	WATER		5	3.6	6	2
AVERAGE SELENIUM SE, DISS	UG/L	WATER	TOTAL	5	3.6	6	2
SELENIUM SE, TOT	UG/L	WATER		31	2.9678	8	0
SELENIUM SE, TOT			K	19	10.99	50	1
AVERAGE SELENIUM SE, TOT	UG/L	WATER	TOTAL	50	6.016	50	0
ALDRIN	UG/L	WATER	K	46	0.1591	0.5	0.02
ALDRIN			U	2	0	0	0
AVERAGE ALDRIN TOT	UG/L	WATER	TOTAL	48	0.1525	0.5	0
CHLRDANE	UG/L	WATER	K	46	0.4285	1	0.12
CHLRDANE			U	2	0	0	0
AVERAGE CHLRDANE TOT	UG/L	WATER	TOTAL	48	0.4106	1	0
METOCLR (DUAL)	UG/L	WATER		3	0.5433	0.63	0.38
METOCLR (DUAL)			K	26	0.25	0.25	0.25
METOCLR (DUAL) TOT	UG/L	WATER	TOTAL	29	0.2804	0.63	0.25
DDT	UG/L	WATER	K	11	10	10	10
AVERAGE DDT TOT	UG/L	WATER	TOTAL	11	10	10	10
DIELDRIN	UG/L	WATER	K	46	0.1767	0.5	0.03
DIELDRIN			U	2	0	0	0
AVERAGE DIELDRIN TOT	UG/L	WATER	TOTAL	48	0.1694	0.5	0
ENDRIN	UG/L	WATER	K	46	0.1576	0.3	0.05
ENDRIN			U	2	0	0	0
AVERAGE ENDRIN TOT	UG/L	WATER	TOTAL	48	0.151	0.3	0
HEPTCHLR	UG/L	WATER	K	35	0.384	1	0.02
AVERAGE HEPTCHLR TOT	UG/L	WATER	TOTAL	35	0.384	1	0.02
ATRAZINE	UG/L	WATER	U	2	0	0	0
AVERAGE ATRAZINE TOT	UG/L	WATER	TOTAL	2	0	0	0
HCB	UG/L	WATER	K	1	10	10	10
AVERAGE HCB TOTAL	UG/L	WATER	TOTAL	1	10	10	10
2,4-D	UG/L	WATER	K	32	0.65	0.8	0.4
2,4-D			U	2	0	0	0
AVERAGE 2,4-D TOT	UG/L	WATER	TOTAL	34	0.6118	0.8	0

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SUBBASIN 6 (Surface Water)
AREA 6

PARAMETER	UNITS	MEDIUM	REMARK	NUMBER	MEAN	MAXIMUM	MINIMUM
MERCURY HG, DISS	UG/L	WATER					
AVERAGE MERCURY HG, DISS	UG/L	WATER	TOTAL	13	0.0385	0.5	0
MERCURY HG, TOTAL	UG/L	WATER		18	0	0	0
MERCURY HG, TOTAL			K	27	0.5	0.5	0.5
AVERAGE MERCURY HG, TOT	UG/L	WATER	TOTAL	45	0.3	0.5	0
ALACHLOR TOTAL	UG/L	WATER	K	32	0.2078	0.25	0.1
AVERAGE ALACHLOR TOT	UG/L	WATER	TOTAL	32	0.2078	0.25	0.1
MTRBUZIN TOTAL	UG/L	WATER	K	32	0.1	0.1	0.1
AVERAGE MTRBUZIN TOT	UG/L	WATER	TOTAL	32	0.1	0.1	0.1

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SUBBASIN 1A (Groundwater)
AREA 1A

ELEMENTS	UNITS	MEDIUM	REMARKS	NUMBER	MEAN	MAXIMUM	MINIMUM
SELENIUM SE,DISS	UG/L	WATER	K	2	1.000000	1	1
AVERAGE SELENIUM SE,DISS	UG/L	WATER	TOTAL	15	6.266700	26	1
MERCURY HG,DISS	UG/L	WATER	K	5	0.340000	1	0
AVERAGE MERCURY HG,DISS	UG/L	WATER	TOTAL	5	0.340000	1	0

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FILE: RR1A.WK3
Diskette 1

SUBBASIN 2A (Groundwater)
AREA 2A

PARAMETER	MEDIUM	REMARKS	NUMBER	MEAN	MAXIMUM	MINIMUM
MGNSIUM MG.DISS MG/L	WATER		109		23	10
MGNSIUM MG.DISS MG/L		A	2		19	16
AVERAGE MGNSIUM MG, DISS	WATER	TOTAL	111		23	10
ARSENIC AS,DISS UG/L	WATER		10	8.564000	11	6
AVERAGE ARSENIC AS, DISS	WATER	TOTAL	10	8.564000	11	6
BARIUM BA,DISS UG/L	WATER		2	0.000000	0	0
AVERAGE BARIUM BA, DISS	WATER	TOTAL	2	0.000000	0	0
BERYLIUM BE,DISS UG/L	WATER		2	0.000000	0	0
AVERAGE BERYLIUM BE, DISS	WATER	TOTAL	2	0.000000	0	0
BORON B,DISS UG/L	WATER		21		800	60
BORON B,DISS UG/L		K	3		100	100
AVERAGE BORON B, DISS	WATER	TOTAL	24		800	60
CADMIUM CD,DISS UG/L	WATER		2	0.000000	0	0
CADMIUM CD,DISS UG/L		K	1	0.350000	0	0
CADMIUM CD,DISS UG/L		U	7		15	0
AVERAGE CADMIUM CD, DISS	WATER	TOTAL	10	8.070000	15	0
CHROMIUM CR.DISS UG/L	WATER		2	5.000000	10	0
CHROMIUM CR.DISS UG/L		K	1		11	11
CHROMIUM CR.DISS UG/L		U	6		11	10
CHROMIUM CR, DISS	WATER	TOTAL	9	9.133300	11	0
CHROMIUM CR.TOT UG/L	WATER		2	0.000000	0	0
AVERAGE CHROMIUM CR, TOT	WATER	TOTAL	2	0.000000	0	0
COPPER CU.DISS UG/L	WATER		2	8.500000	17	0
COPPER CU.DISS UG/L		K	5	8.346000	10	5
COPPER CU,DISS UG/L		U	3	8.243300	10	5
AVERAGE COPPER CU, DISS	WATER	TOTAL	10	8.346000	17	0
IRON FE,TOT UG/L	WATER		15		22900	200
IRON FE,TOT UG/L		K	1		100	100
AVERAGE IRON FE, TOT	WATER	TOTAL	16		22900	100
IRON FE,DISS UG/L	WATER		3		40	0
IRON FE,DISS UG/L		K	3		30	19
IRON FE,DISS UG/L		U	4		30	15
AVERAGE IRON FE, DISS	WATER	TOTAL	10		40	0
LEAD PB,DISS UG/L	WATER		2	0.000000	0	0
LEAD PB,DISS UG/L		K	1	2.430000	2	2
LEAD PB,DISS UG/L		U	7		20	2
AVERAGE LEAD PB, DISS	WATER	TOTAL	10		20	0
MANGNESE MN.DISS UG/L	WATER		4	8.500000	24	0
MANGNESE MN.DISS UG/L		K	3		10	10
MANGNESE MN.DISS UG/L		U	4	7.480000	10	7
AVERAGE MANGNESE MN, DISS	WATER	TOTAL	11	8.538200	24	0

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SUBBASIN 2A (Groundwater)
AREA 2A

PARAMETER	MEDIUM	REMARKS	NUMBER	MEAN	MAXIMUM	MINIMUM
MOLY MO,DISS UG/L	WATER		2	2.500000	3	2
AVERAGE MOLY MO, DISS	WATER	TOTAL	2	2.500000	3	2
NICKEL NI,DISS UG/L	WATER		3	7.666700	23	0
NICKEL NI,DISS UG/L		K	2		20	19
NICKEL NI,DISS UG/L		U	5		20	19
AVERAGE NICKEL NI, DISS	WATER	TOTAL	10		23	0
SILVER AG,DISS	WATER		2	0.000000	0	0
AVERAGE SILVER AG, DISS	WATER	TOTAL	2	0.000000	0	0
STRONTUM SR,DISS UG/L	WATER		2		610	510
AVERAGE STRONTUM SR, DISS	WATER	TOTAL	2		610	510
VANADIUM V,DISS UG/L	WATER		2		27	6
AVERAGE VANADIUM V, DISS	WATER	TOTAL	2		27	6
ZINC ZN,DISS UG/L	WATER		4		62	5
ZINC ZN,DISS UG/L		K	3		30	18
ZINC ZN,DISS UG/L		U	3		30	17
AVERAGE ZINC ZN, DISS	WATER	TOTAL	10		62	5
ZINC ZN,TOT UG/L	WATER		12		550	0
ZINC ZN,TOT UG/L		K	4		100	10
AVERAGE ZINC ZN, TOT	WATER	TOTAL	16		550	0
SELENIUM SE,DISS UG/L	WATER		3	6.133300	8	5
SELENIUM SE,DISS UG/L		K	5	2.236000	3	2
SELENIUM SE,DISS UG/L		U	1	1.200000	1	1
AVERAGE SELENIUM SE, DISS	WATER	TOTAL	9	3.420000	8	1
PROPZINE DISS, UG/L	WATER	K	6	0.050000	0	0
AVERAGE PROPZINE DISS TOT	WATER	TOTAL	6	0.050000	0	0
PRPAZINE TOTAL UG/L	WATER	U	1	0.000000	0	0
AVERAGE PRPAZINE TOT	WATER	TOTAL	1	0.000000	0	0
CHLORPY- RIFOS TOT UG/L	WATER	U	5	0.000000	0	0
AVERAGE CHLORPY- RIFOS TOT	WATER	TOTAL	5	0.000000	0	0
SIMAZINE WATER (UG/L)	WATER	U	2	0.000000	0	0
AVERAGE SIMAZINE TOT	WATER	TOTAL	2	0.000000	0	0
PROMETON WATER (UG/L)	WATER	U	1	0.000000	0	0
AVERAGE PROMETON TOT	WATER	TOTAL	1	0.000000	0	0
ALDRIN TOTAL UG/L	WATER	U	5	0.000000	0	0
AVERAGE ALDRIN TOT	WATER	TOTAL	5	0.000000	0	0

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CASE OF SPECIES, U INDICATES UNDETERMINDED SEX.

SUBBASIN 2A (Groundwater)
AREA 2A

PARAMETER	MEDIUM	REMARKS	NUMBER	MEAN	MAXIMUM	MINIMUM
CHLRDANE TOT UG/L	WATER	U	5	0.000000	0	0
AVERAGE CHLRDANE TOT	WATER	TOTAL	5	0.000000	0	0
METOCLR (DUAL) UG/L	WATER	U	2	0.000000	0	0
AVERAGE METOCLR (DUAL) TOT	WATER	TOTAL	2	0.000000	0	0
DIELDRIN TOTAL, UG/L	WATER	U	5	0.000000	0	0
AVERAGE DIELDRIN TOT	WATER	TOTAL	5	0.000000	0	0
ENDRIN TOTAL, UG/L	WATER	U	5	0.000000	0	0
AVERAGE ENDRIN TOT	WATER	TOTAL	5	0.000000	0	0
HEPTCHLR TOTAL, UG/L	WATER	U	5	0.000000	0	0
AVERAGE HEPTCHLR TOT	WATER	TOTAL	5	0.000000	0	0
METLCHLR DISS, UG/L	WATER	K	6	0.050000	0	0
AVERAGE METLCHLR DISS	WATER	TOTAL	6	0.050000	0	0
ALACHLOR DISS UG/L	WATER	K	6	0.050000	0	0
AVERAGE ALACHLOR WTR DISS	WATER	TOTAL	6	0.050000	0	0
MERCURY HG,DISS UG/L	WATER		2	0.050000	0	0
MERCURY HG,DISS UG/L		K	3	0.400000	0	0
MERCURY HG,DISS UG/L		U	5	0.500000	1	1
AVERAGE MERCURY HG,DISS	WATER	TOTAL	10	0.380000	1	0
ALACHLOR TOTAL UG/L	WATER	U	7	0.000000	0	0
AVERAGE ALACHLOR TOT	WATER	TOTAL	7	0.000000	0	0
CRBFURAN TOTAL, UG/L	WATER	U	1	0.000000	0	0
AVERAGE CRBFURAN TOT	WATER	TOTAL	1	0.000000	0	0
MTRBUZIN TOT UG/L	WATER	U	2	0.000000	0	0
AVEREAGE MTRBUZIN TOT	WATER	TOTAL	2	0.000000	0	0
BUTYLATE TOT UG/L	WATER	U	1	0.000000	0	0
AVERAGE BUTYLATE TOT	WATER	TOTAL	1	0.000000	0	0
CYANAZIN UG/L	WATER	U	2	0.000000	0	0
AVERAGE CYANAZIN TOT	WATER	TOTAL	2	0.000000	0	0
EPTC UG/L	WATER	U	1	0.000000	0	0
AVERAGE EPTC TOT	WATER	TOTAL	1	0.000000	0	0
CYPRAZIN TOTAL UG/L	WATER	U	1	0.000000	0	0
AVERAGE CYPRAZIN TOT	WATER	TOTAL	1	0.000000	0	0
MTRBUZIN WTR DISS UG/L	WATER	K	6	0.050000	0	0
AVERAGE MTRBUZIN DISS	WATER	TOTAL	6	0.050000	0	0

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CASE OF SPECIES, U INDICATES UNDETERMINDED SEX.

File: RR2.WK1
DISKETTE 1

SUBBASIN 3A (Groundwater)
AREA 3A

ELEMENTS	MEDIUM	REMARKS	NUMBER	MEAN	MAXIMUM	MINIMUM
MGNSIUM MG,DISS MG/L	WATER		95		210	11
AVERAGE MGNSIUM MG, DISS	WATER	TOTAL	95		210	11
ARSENIC AS,DISS UG/L	WATER		7	8.714300	14	5
AVERAGE ARSENIC AS, DISS	WATER	TOTAL	7	8.714300	14	5
BORON B,DISS UG/L	WATER		7		270	60
AVERAGE BORON B,DISS	WATER	TOTAL	7		270	60
CADMIUM CD,DISS UG/L	WATER	K	5	2.000000	2	2
CADMIUM CD,DISS UG/L	WATER	U	2	0.000000	0	0
AVERAGE CADMIUM CD, DISS	WATER	TOTAL	7	1.428600	2	0
CHROMIUM CR,DISS UG/L	WATER	K	1		20	20
CHROMIUM CR,DISS UG/L	WATER	U	6	0.000000	0	0
AVERAGE CHROMIUM CR, DISS	WATER	TOTAL	7	2.857200	20	0
COPPER CU,DISS UG/L	WATER		4	2.750000	5	2
COPPER CU,DISS UG/L	WATER	K	1	2.000000	2	2
COPPER CU,DISS UG/L	WATER	U	2	0.000000	0	0
AVERAGE COPPER CU, DISS	WATER	TOTAL	7	1.8572	5	0

FILE: RR3A.WK3
DISKETTE 1

A = VALUE REPORTED IS THE MEAN OF TWO OR MORE DETERMINATIONS
K = ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN.
U = INDICATES MATERIAL WAS ANALYZED FOR BUT NOT DETECTED
CASE OF SPECIES, U INDICATES UNDETERMINDED SEX.

SUBBASIN 4A (Groundwater)
AREA 4A

ELEMENTS	MEDIUM	REMARKS	NUMBER	MEAN	MEDIUM	MINIMUM
MGNSIUM MG,DISS MG/L	WATER		46		42	13
AVERAGE MGNSIUM MG, DISS	WATER	TOTAL	46		42	13
ARSENIC AS,DISS UG/L	WATER		1		14	14
AVERAGE ARSENIC AS, DISS	WATER	TOTAL	1		14	14
ARSENIC AS,TOT UG/L	WATER	U	3		10	10
AVERAGE ARSENIC AS, TOT	WATER	TOTAL	3		10	10
BARIUM BA,TOT UG/L	WATER		3		120	100
AVERAGE BARIUM BA, TOT	WATER	TOTAL	3		120	100
BERYLIUM BE,TOT UG/L	WATER	U	3		20	20
AVERAGE BERYLIUM BE, TOT	WATER	TOTAL	3		20	20
BORON B,DISS UG/L	WATER		2		210	50
AVERAGE BORON B, DISS	WATER	TOTAL	2		210	50
CADMIUM CD,DISS UG/L	WATER	U	1	0.000000	0	0
AVERAGE CADMIUM CD, DISS	WATER	TOTAL	1	0.000000	0	0
CADMIUM CD,TOT UG/L	WATER	U	3		20	20
AVERAGE CADMIUM CD, TOT	WATER	TOTAL	3		20	20
CHROMIUM CR,DISS UG/L	WATER	K	1		20	20
AVERAGE CHROMIUM CR, DISS	WATER	TOTAL	1		20	20
CHROMIUM CR,TOT UG/L	WATER	U	3		20	20
AVERAGE CHROMIUM CR, TOT	WATER	TOTAL	3		20	20
COPPER CU,DISS UG/L	WATER		1	3.000000	3	3
AVERAGE COPPER CU, DISS	WATER	TOTAL	1	3.000000	3	3
IRON FE,TOT UG/L	WATER		3		80	50
AVERAGE IRON FE, TOT	WATER	TOTAL	3		80	50
IRON FE,DISS UG/L	WATER		1		30	30
AVERAGE IRON FE, DISS	WATER	TOTAL	1		30	30
LEAD PB,DISS UG/L	WATER		1	3.000000	3	3
AVERAGE LEAD PB, DISS	WATER	TOTAL	1	3.000000	3	3

SUBBASIN 4A (Groundwater)
AREA 4A

ELEMENTS	MEDIUM	REMARKS	NUMBER	MEAN	MEDIUM	MINIMUM
AVERAGE LEAD PB,TOT	WATER	U	3		100	100
AVERAGE LEAD PB, TOT	WATER	TOTAL	3		100	100
MANGNESE MN TOT UG/L	WATER	U	3		20	20
AVERAGE MANGNESE MN, TOT	WATER	TOTAL	3		20	20
MANGNESE MN;DISS UG/L	WATER	K	1		10	10
AVERAGE MANGNESE MN, DISS	WATER	TOTAL	1		10	10
NICKEL NI,TOT UG/L	WATER	U	3		50	50
AVERAGE NICKEL NI, TOT	WATER	TOTAL	3		50	50
SILVER AG,TOT UG/L	WATER	U	3		10	10
AVERAGE SILVER AG, TOT	WATER	TOTAL	3		10	10
VANADIUM V,TOT UG/L	WATER	U	3		100	100
AVERAGE VANADIUM V, TOT	WATER	TOTAL	3		100	100
ZINC ZN,DISS UG/L	WATER	K	1		20	20
AVERAGE ZINC ZN, DISS	WATER	TOTAL	1		20	20
ZINC ZN, TOT UG/L	WATER	U	3		20	20
AVERAGE ZINC ZN, TOT	WATER	TOTAL	3		20	20
ALUMINUM AL,TOT UG/L	WATER	U	3		100	100
AVERAGE ALUMINUM AL, TOT	WATER	TOTAL	3		100	100
SELENIUM SE,DISS UG/L	WATER		1		11	11
AVERAGE SELENIUM SE, DISS	WATER	TOTAL	1		11	11
SELENIUM SE,TOT UG/L	WATER	U	3		10	10
AVERAGE SELENIUM SE, TOT	WATER	TOTAL	3		10	10
MERCURY HG,DISS UG/L	WATER	K	1	0.100000	0	0
AVERAGE MERCURY HG, DISS	WATER	TOTAL	1	0.100000	0	0
MERCURY HG,TOT UG/L	WATER	U	3	1.000000	1	1
AVERAGE MERCURY HG, TOT	WATER	TOTAL	3	1.000000	1	1

K = ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN.
U = INDICATES MATERIAL WAS ANALYSED FOR BUT NOT DETECTED.
CAS OF SPECIES, U INDICATES UNDETERMINDED SEX.

FILe: RR4A
Diskette 1

SUBBASIN 5A (Groundwater)
AREA 5A

ELEMENTS	MEDIUM	REMARKS	NUMBER	MEAN	MAXIMUM	MINIMUM
MGNSIUM MG,DISS MG/L	WATER		95		210	11
AVERAGE MGNSIUM MG, DISS TOT	WATER	TOTAL	95		210	11
ARSENIC AS,DISS UG/L	WATER		7	8.714300	14	5
AVERAGE ARSENIC AS, DISS UG/L TOT	WATER	TOTAL	7	8.714300	14	5
BORON B,DISS UG/L	WATER		7		270	60
AVERAGE BORON B, DISS UG/L TOT	WATER	TOTAL	7		270	60
CADMIUM CD,DISS UG/L	WATER	K	5	2.000000	2	2
CADMIUM CD,DISS UG/L	WATER	U	2	0.000000	0	0
AVERAGE CADMIUM CD, DISS UG/L TOT	WATER	TOTAL	7	1.428600	2	0
CHROMIUM CR,DISS UG/L	WATER	K	1		20	20
CHROMIUM CR,DISS UG/L	WATER	U	6	0.000000	0	0
AVERAGE CHROMIUM CR, DISS UG/L TOT	WATER	TOTAL	7	2.857200	20	0
COPPER CU,DISS UG/L	WATER		4	2.750000	5	2
COPPER CU,DISS UG/L	WATER	K	1	2.000000	2	2
COPPER CU,DISS UG/L	WATER	U	2	0.000000	0	0
AVERAGE COPPER CU, DISS UG/L TOT	WATER	TOTAL	7	1.857200	5	0
IRON FE,DISS UG/L	WATER		4		3200	20
IRON FE,DISS UG/L	WATER	K	3		10	10
AVERAGE IRON FE, DISS UG/L TOT	WATER	TOTAL	7		3200	10
LEAD PB,DISS UG/L	WATER		4	2.750000	4	2
LEAD PB,DISS UG/L	WATER	K	1	2.000000	2	2
LEAD PB,DISS UG/L	WATER	U	2	0.000000	0	0
AVERAGE LEAD PB, DISS UG/L TOT	WATER	TOTAL	7	1.857200	4	0
MANGNESE MN,DISS UG/L	WATER		4		800	100
MANGNESE MN,DISS UG/L	WATER	K	3		10	10
AVERAGE MANGNESE MN, DISS UG/L TOT	WATER	TOTAL	7		800	10
ZINC ZN,DISS UG/L	WATER		1		20	20
ZINC ZN,DISS UG/L	WATER	K	6		20	20
AVERAGE ZINC ZN, DISS UG/L TOT	WATER	TOTAL	7		20	20
SELENIUM SE,DISS UG/L	WATER		6	6.000000	13	1
SELENIUM SE,DISS UG/L	WATER	K	1	1.000000	1	1
AVERAGE SELENIUM SE, DISS UG/L TOT	WATER	TOTAL	7	5.285700	13	1
MERCURY HG,DISS UG/L	WATER	K	7	0.100000	0	0
AVERAGE MERCURY HG, DISS UG/L TOT	WATER	TOTAL	7	0.100000	0	0

FILE: RR5A.WK3

DISKETTE 1

K = ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN.
U = INDICATES MATERIAL WAS ANALYZED FOR BUT NOT DETECTED.
CASE OF SPECIES, U INDICATES UNDETERMINED SEX.

SUBBASIN 6A (Groundwater)
AREA 6A

PARAMETER	MEDIUM	REMARKS	NUMBER	MEAN	MAXIMUM	MINIMUM
MGNSIUM MG, DISS MG/L	WATER		44		21	7
AVERAGE MGNSIUM MG, DISS TOT	WATER	TOTAL	44		21	7
ARSENIC AS, DISS UG/L	WATER		1	4.000000	4	4
AVERAGE ARSENIC AS, DISS TOT	WATER	TOTAL	1	4.000000	4	4
BORON B, DISS UG/L	WATER		1		30	30
AVERAGE BORON B, DISS TOT	WATER	TOTAL	1		30	30
CADMIUM CD, DISS UG/L	WATER	K	1	2.000000	2	2
AVERAGE CADMIUM CD, DISS TOT	WATER	TOTAL	1	2.000000	2	2
CHROMIUM CR, DISS UG/L	WATER	K	1		20	20
AVERAGE CHROMIUM CR, DISS TOT	WATER	TOTAL	1		20	20
COPPER CU, DISS UG/L	WATER		1		19	19
AVERAGE COPPER CU, DISS TOT	WATER	TOTAL	1		19	19
IRON FE, DISS UG/L	WATER		1		20	20
AVEREAGE IRON FE, DISS TOT	WATER	TOTAL	1		20	20
LEAD PB, DISS UG/L	WATER		1		12	12
AVERAGE LEAD PB, DISS TOT	WATER	TOTAL	1		12	12
MANGNESE MN, DISS UG/L	WATER	K	1		10	10
AVERAGE MANGNESE MN, DISS TOT	WATER	TOTAL	1		10	10
ZINC ZN, DISS UG/L	WATER		1		80	80
AVERAGE ZINC ZN, DISS TOT	WATER	TOTAL	1		80	80
SELENIUM SE, DISS UG/L	WATER		1	1.000000	1	1
AVERAGE SELENIUM SE, DISS TOT	WATER	TOTAL	1	1.000000	1	1
AMETRYN DISS UG/L	WATER	U	5	0.000000	0	0
AVERAGE AMETRYN DISS, TOT	WATER	TOTAL	5	0.000000	0	0
PROPCHLR (RAMROD) DISS. UG/L	WATER	U	5	0.000000	0	0
AVERAGE PROPCHLR (RAMROD) DISS, TOT	WATER	TOTAL	5	0.000000	0	0
PROPZINE DISS, UG/L	WATER	U	5	0.000000	0	0
AVERAGE PROPZINE DISS, TOT	WATER	TOTAL	5	0.000000	0	0
TRIFLRLN TREFLAN DISS, UG/L	WATER	U	5	0.000000	0	0
AVERAGE TRIFLRLN TREFLAN DISS	WATER	TOTAL	5	0.000000	0	0
CHLORPY- RIFOS TOT, UG/L	WATER	U	5	0.000000	0	0
AVERAGE CHLORPY- RIFOS, TOT	WATER	TOTAL	5	0.000000	0	0
SIMAZINE WATER (UG/L)	WATER	U	5	0.000000	0	0
AVERAGE SIMAZINE TOT	WATER	TOTAL	5	0.000000	0	0
PROMETON WATER (UG/L)	WATER	U	5	0.000000	0	0
AVERAGE PROMETON WATER TOT	WATER	TOTAL	5	0.000000	0	0
METOCLR (DUAL) UG/L	WATER	U	5	0.000000	0	0
AVERAGE METOCLR (DUAL) TOT	WATER	TOTAL	5	0.000000	0	0

SUBBASIN 6A (Groundwater)
AREA 6A

PARAMETER	MEDIUM	REMARKS	NUMBER	MEAN	MAXIMUM	MINIMUM
2,4-D UG/L	WATER	U	5	0.000000	0	0
AVERAGE 2,4-D TOT	WATER	TOTAL	5	0.000000	0	0
MERCURY HG, DISS UG/L	WATER		1	0.200000	0	0
AVERAGE MERCURY HG, DISS TOT	WATER	TOTAL	1	0.200000	0	0
ALACHLOR TOT UG/L	WATER	U	5	0.000000	0	0
AVERAGE ALACHLOR TOT	WATER	TOTAL	5	0.000000	0	0
CRBFURAN TOT UG/L	WATER	U	5	0.000000	0	0
AVERAGE CRBFURAN TOT	WATER	TOTAL	5	0.000000	0	0
MTRBUZIN TOT UG/L	WATER	U	5	0.000000	0	0
AVERAGE MTRBUZIN TOT	WATER	TOTAL	5	0.000000	0	0
BUTYLATE TOT UG/L	WATER	U	5	0.000000	0	0
AVERAGE BUTYLATE TOT	WATER	TOTAL	5	0.000000	0	0
CYANAZIN UG/L	WATER	U	5	0.000000	0	0
AVERAGECYANAZIN TOT	WATER	TOTAL	5	0.000000	0	0
EPTC UG/L	WATER	U	5	0.000000	0	0
AVERAGE EPTC TOT	WATER	TOTAL	5	0.000000	0	0
TERBUFOS TOT UG/L	WATER	U	5	0.000000	0	0
AVERAGE TERBUFOS TOT	WATER	TOTAL	5	0.000000	0	0

FILE:RR6A.WK1
DISKETTE 1

K = ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN.
U = INDICATES MATERIAL WAS ANALYZED FOR BUT NOT DETECTED.
CASE OF SPECIES, U INDICATES UNDETERMINDED SEX.

Part III

Area Reservoir Inflow Data and Historic Versus 1993 Level-of-Basin-Development Inflow Comparisons

Figure 1

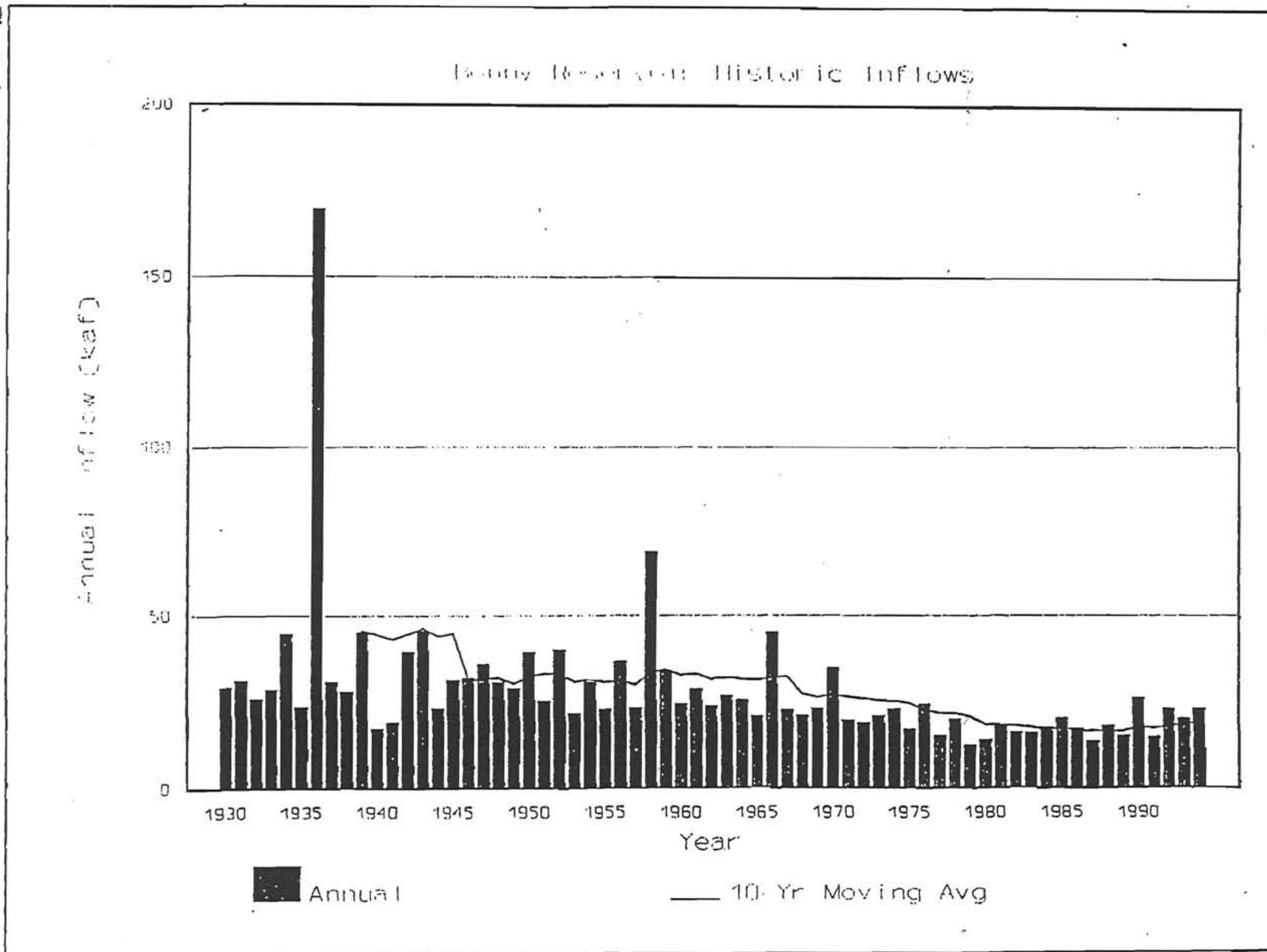
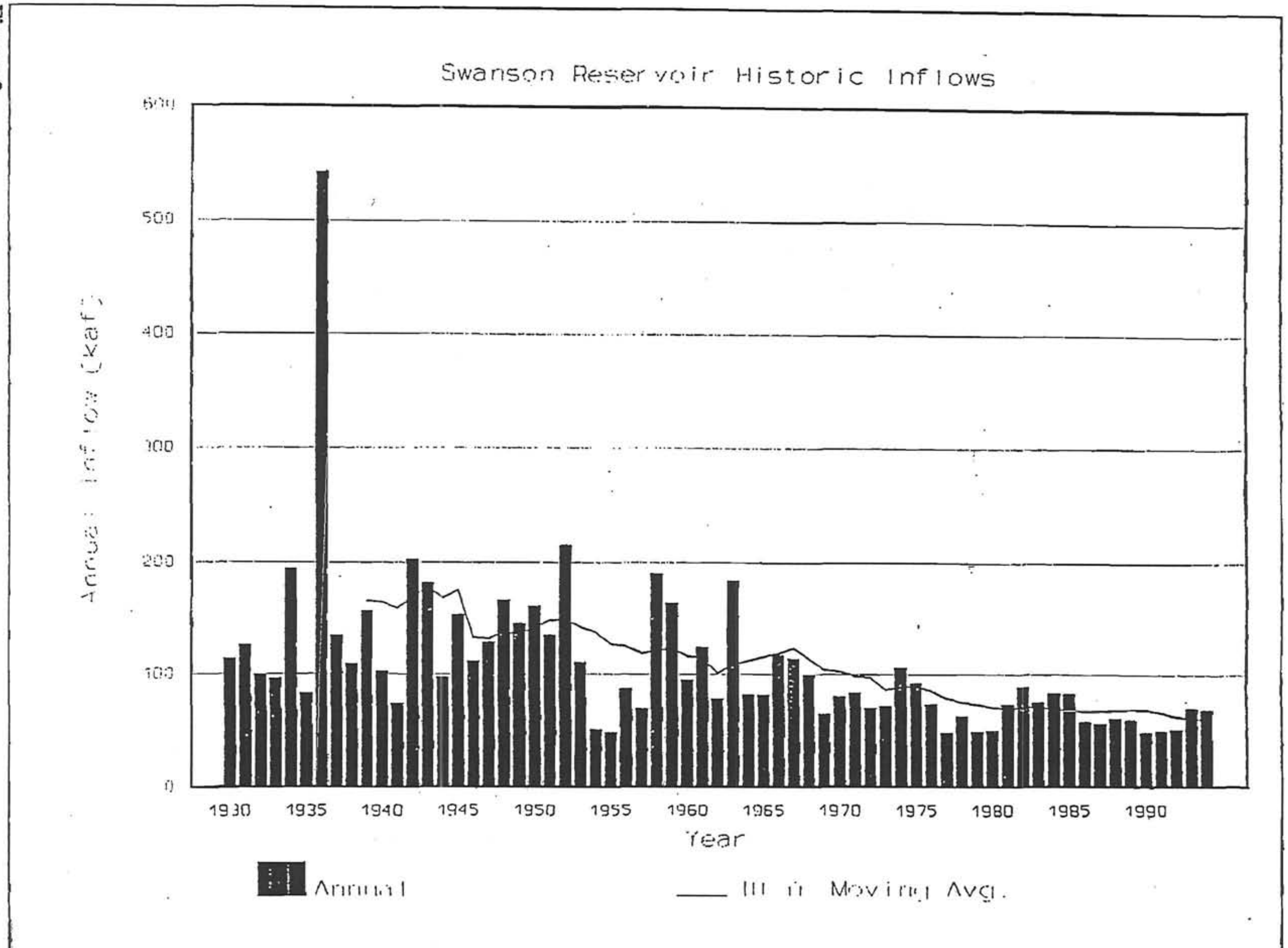

Historic Inflows
200
150
100
50
0
(kaf)
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
Year
Annual
10 Yr Moving Avg

Figure 2



KS001499

Figure 3

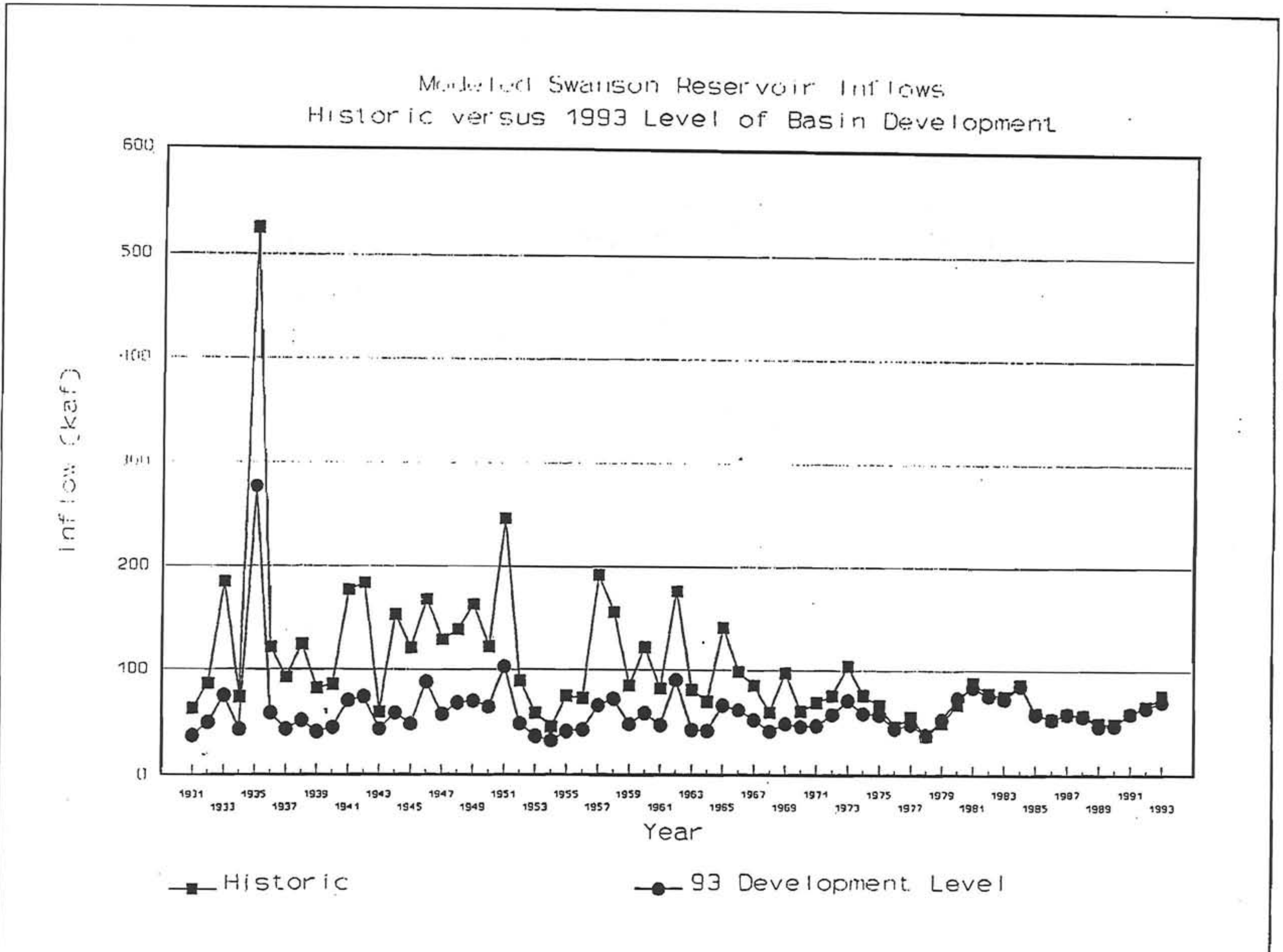
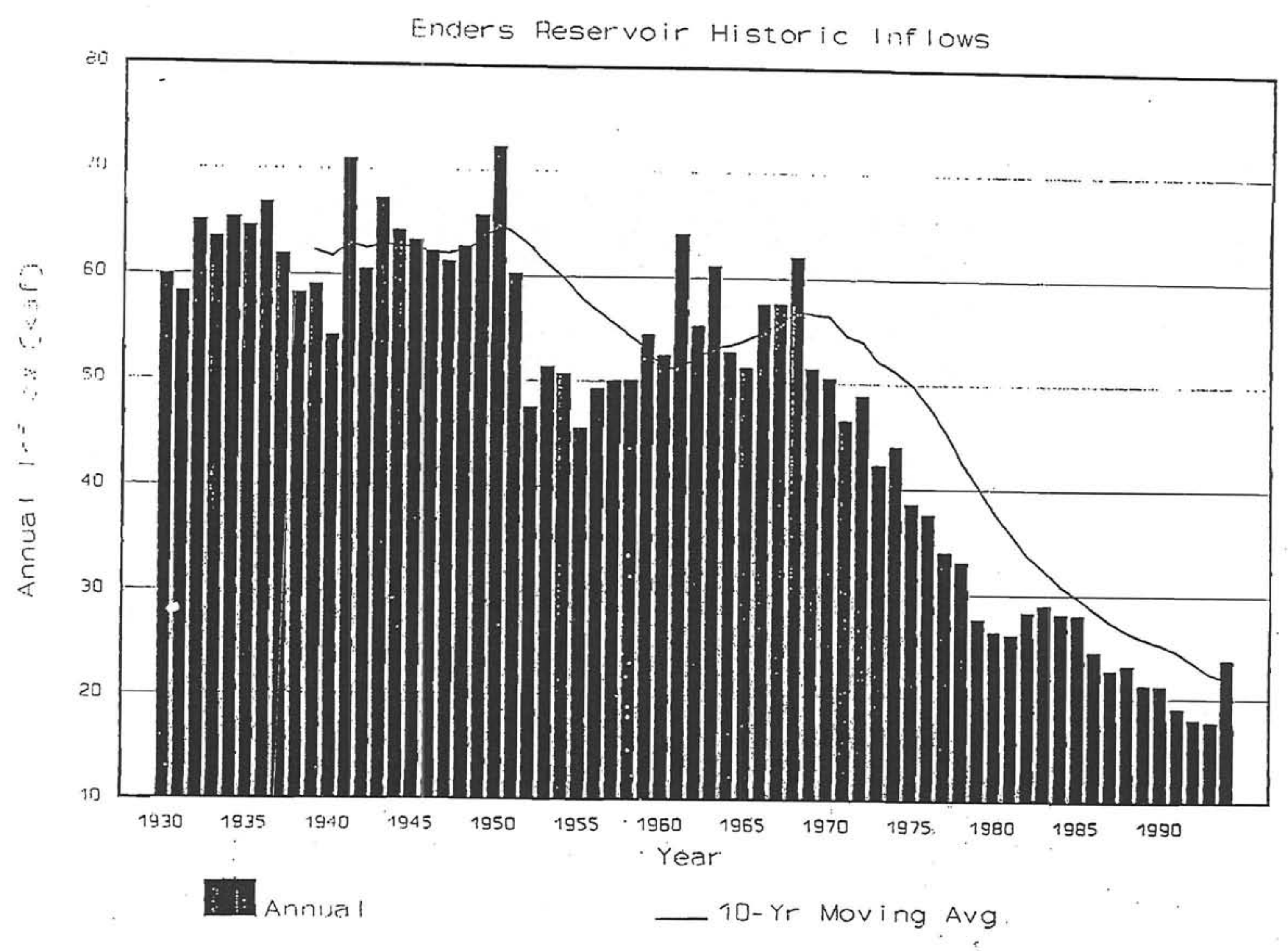
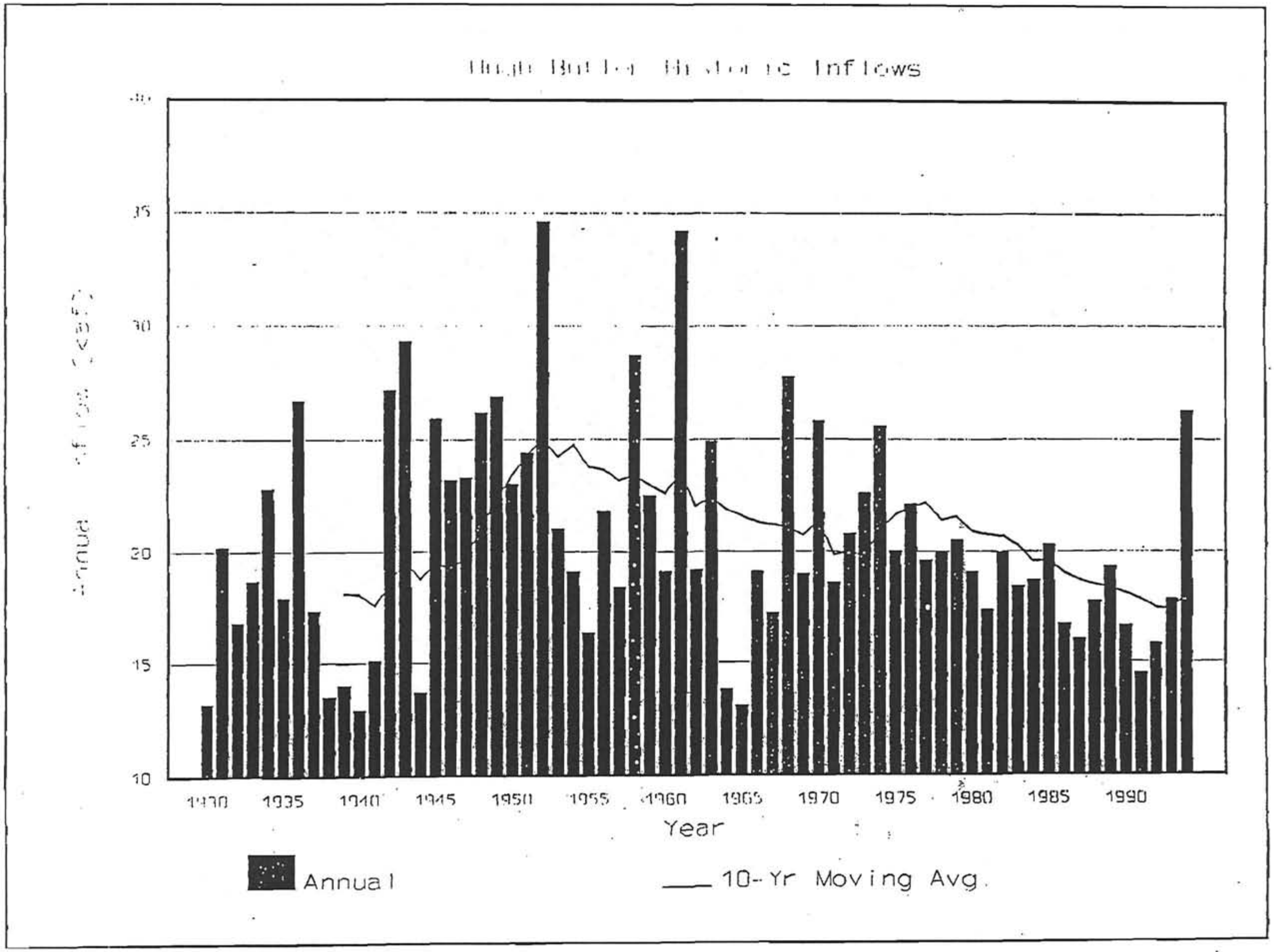

Modeled Swanson Reservoir Inflows
Historic versus 1993 Level of Basin Development
Inflow (kaf)
600
500
400
300
200
100
0
1931
1933
1935
1937
1939
1941
1943
1945
1947
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
Year
Historic
93 Development Level

Figure 4



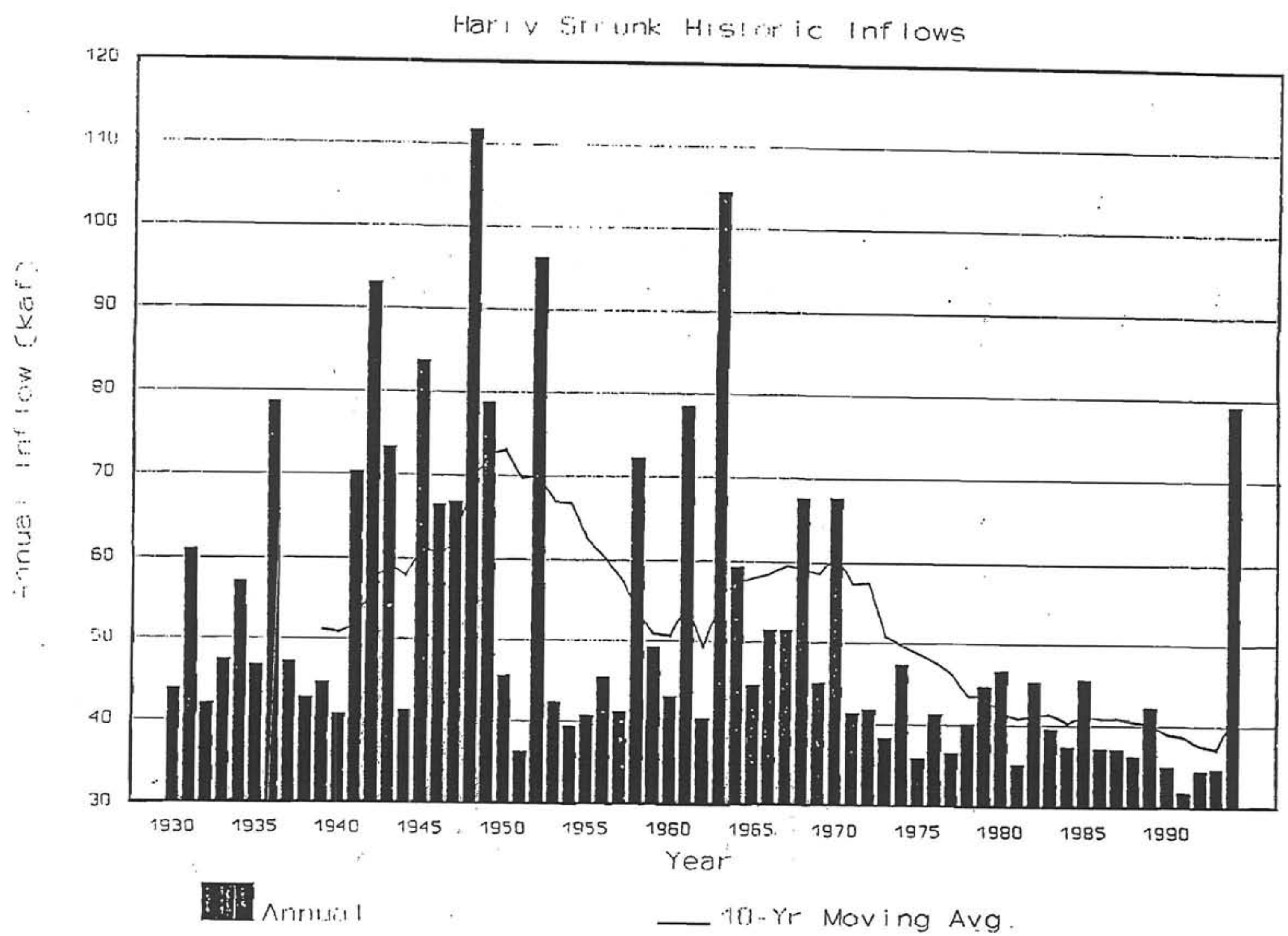
KS001501

Figure 5



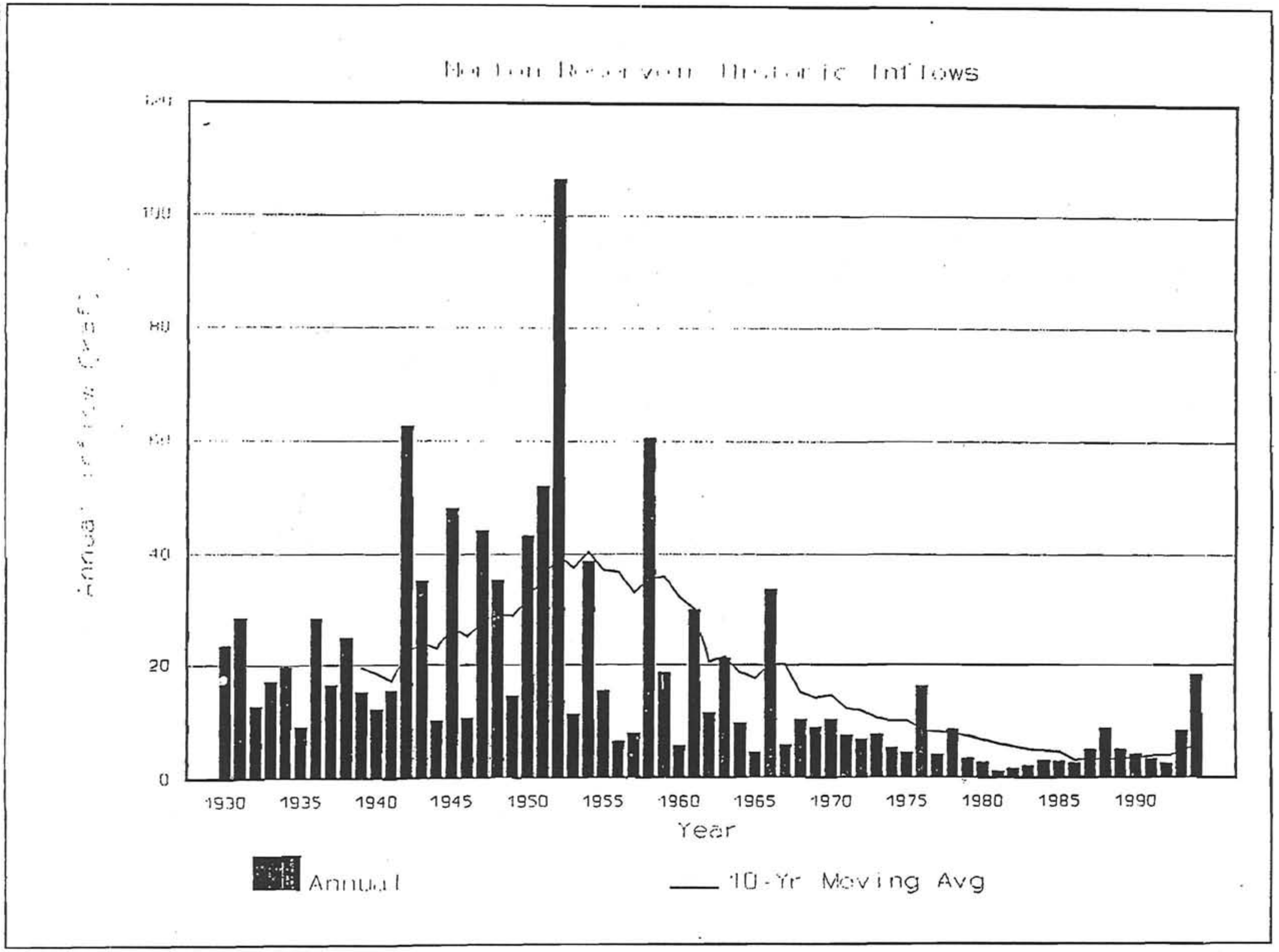
KS001502

Figure 6



KS001503

Figure 7



KS001504

Figure 8

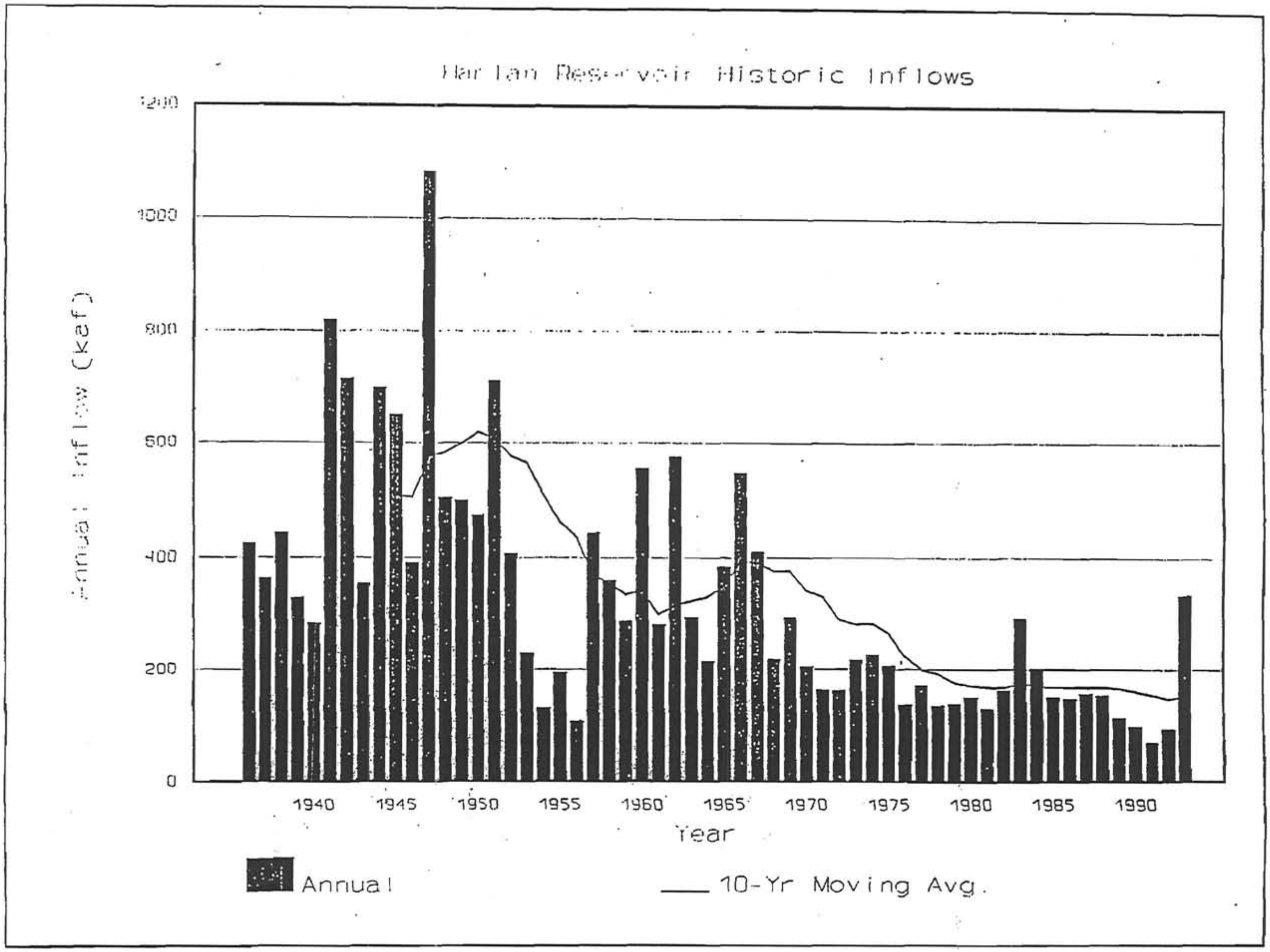

Harlan Reservoir Historic Inflows
Annual Inflow (kaf)
1200
1000
800
600
400
200
0
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
Year
Annual
10-Yr Moving Avg.

Figure 9

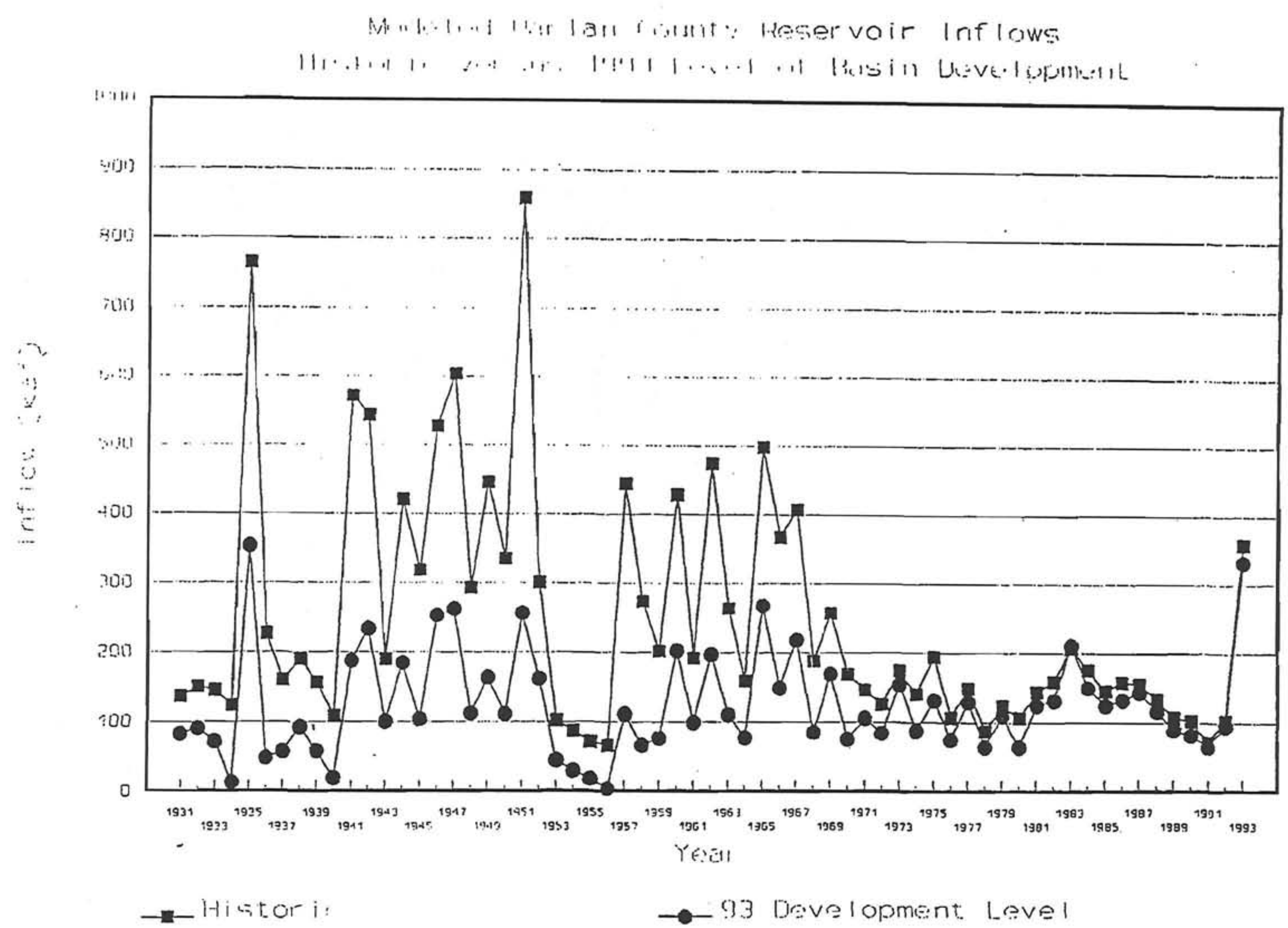
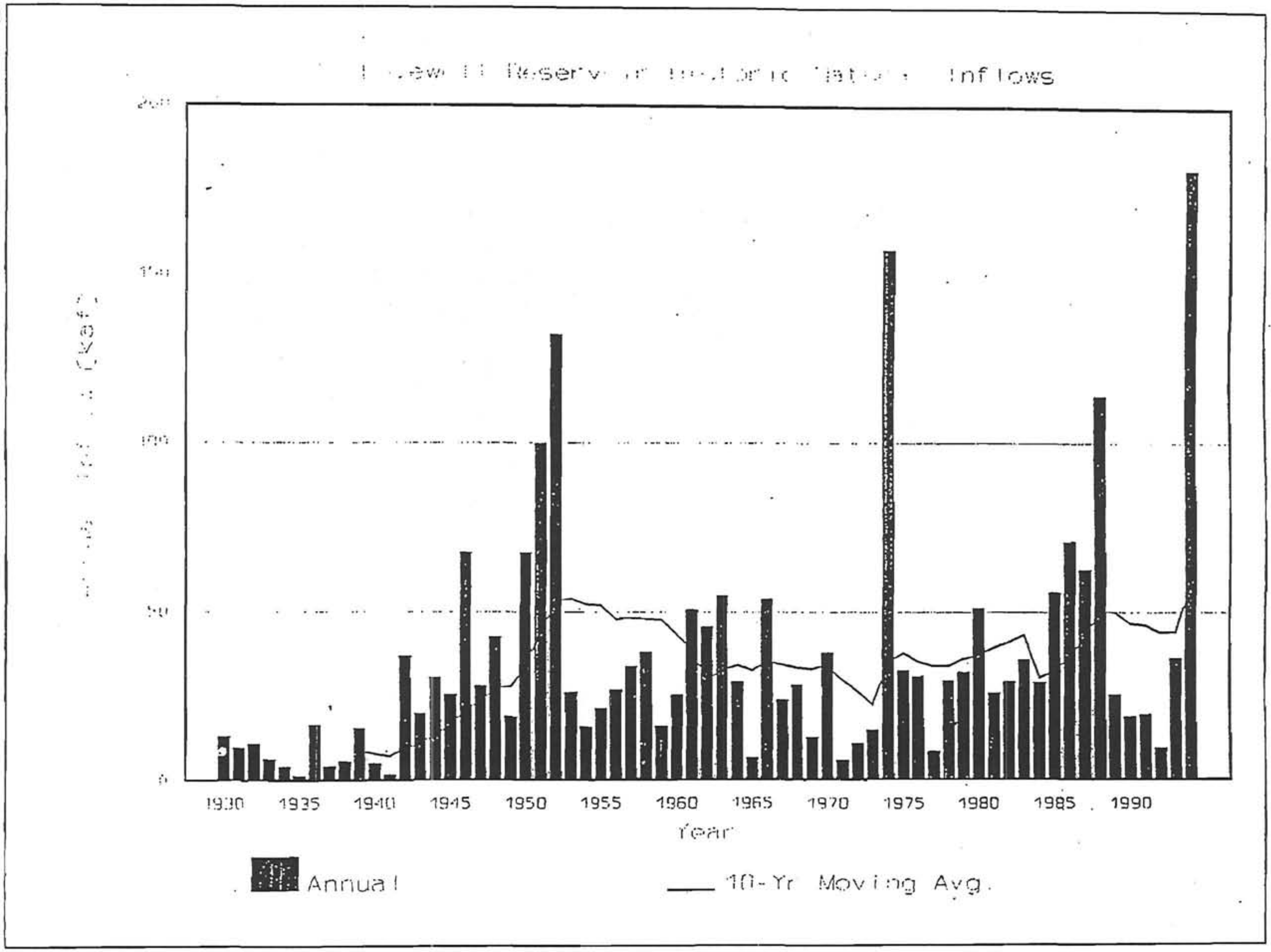
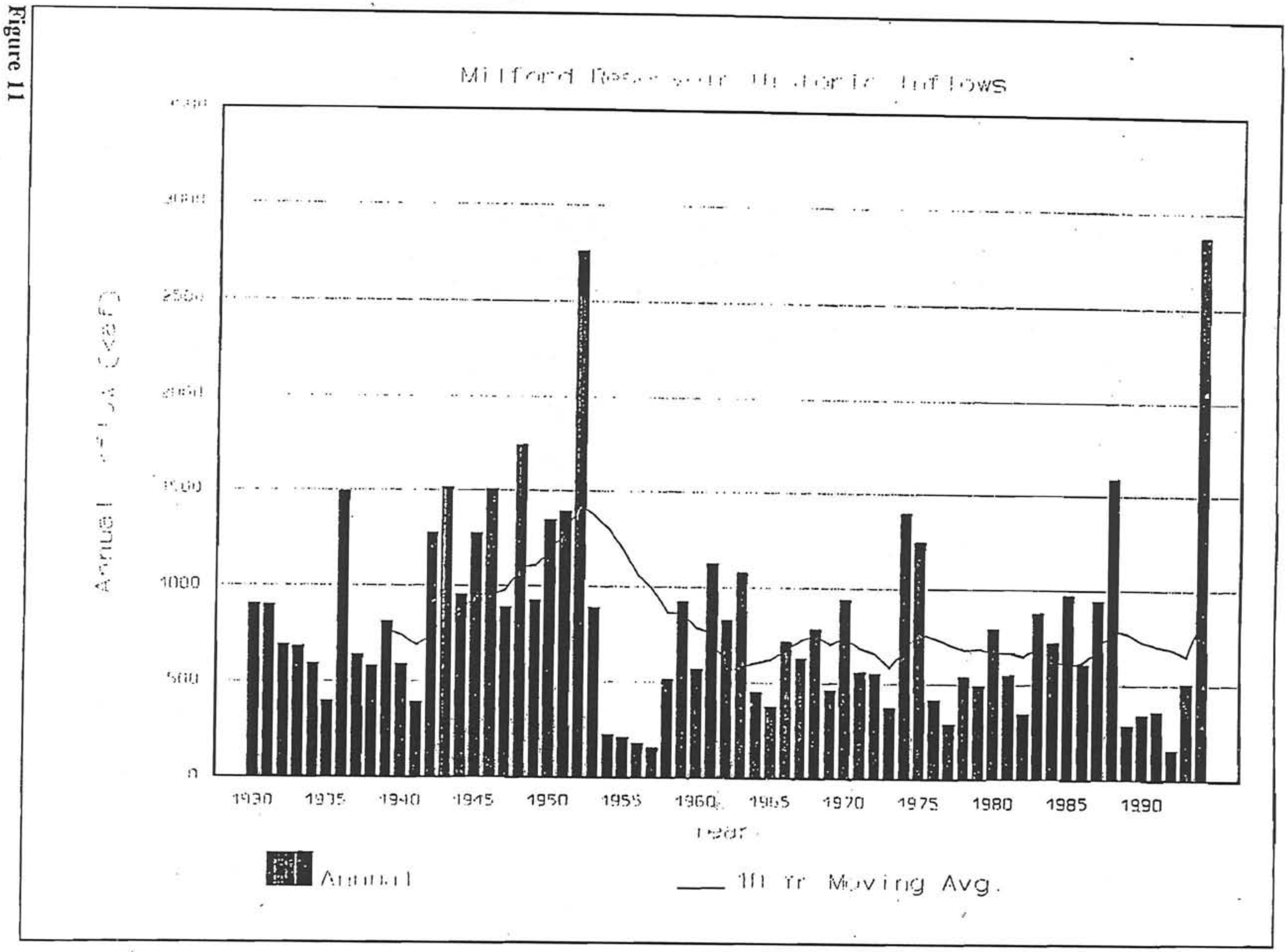

Modeled Harlan County Reservoir Inflows
Historic versus 1993 Level of Basin Development
Inflow (kaf)
1000
900
800
700
600
500
400
300
200
100
0
1931 1933 1935 1937 1939 1941 1943 1945 1947 1949 1951 1953 1955 1957 1959 1961 1963 1965 1967 1969 1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993
Year
Historic
1993 Development Level

Figure 10



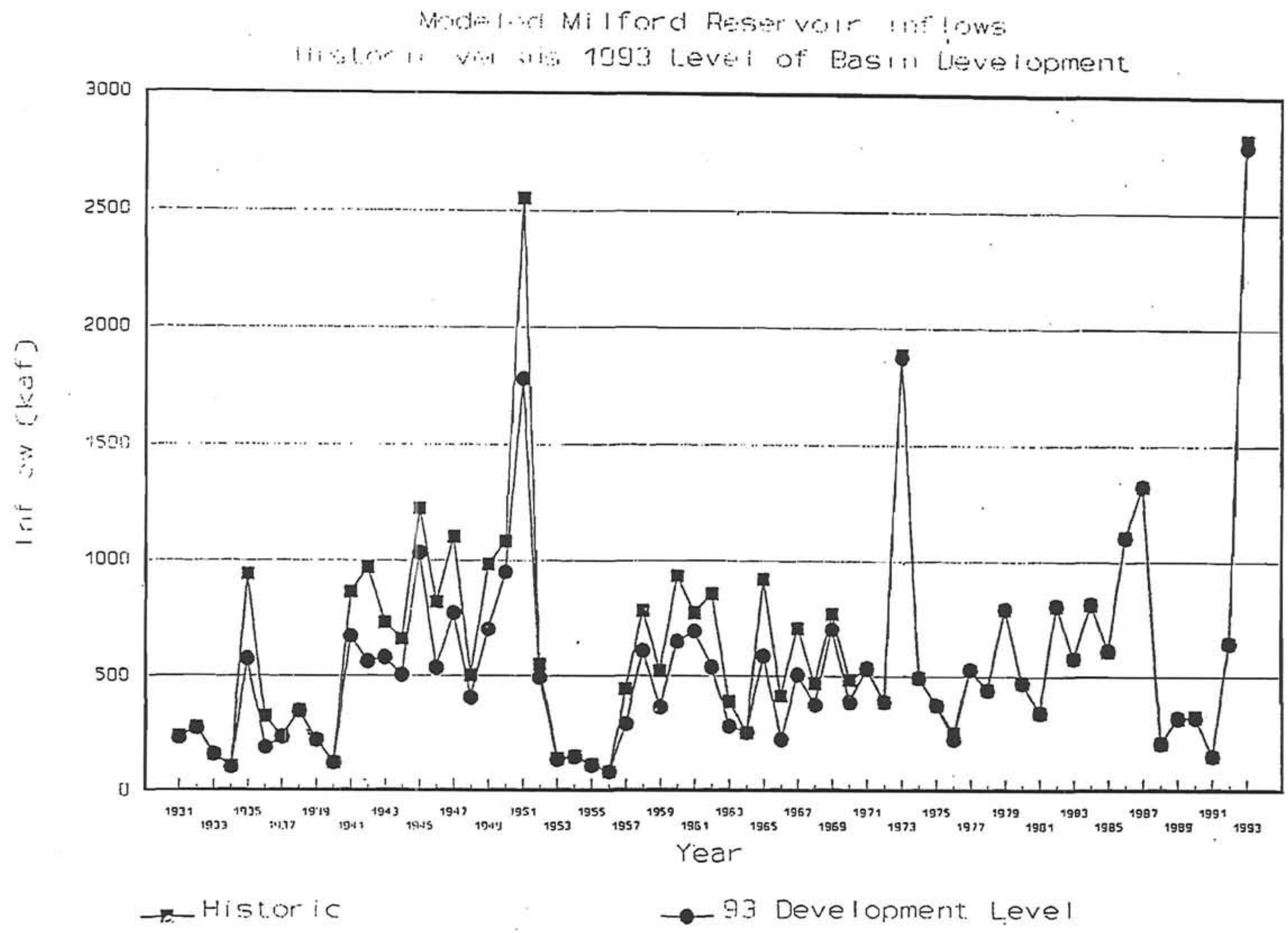
KS001507

Figure 11



Milford Reservoir Historic Inflows
3000
2500
2000
1500
1000
500
0
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
Annual
10 Yr Moving Avg.

Figure 12



KS001509

Part IV

Water Supply Evaluation Computer Analysis

May 14, 1996

Republican River Operation Study

Methodology to Calculate the 2025 Flows in the Scenario Runs

The Republican River water supply evaluation computer analysis is operated using a variety of inflows. It is necessary to evaluate the model and results using the historical database; those flows generated using U.S. Geological Survey data, the current level of development flows; the 1993 level of development flows generated by Reclamation's Denver Technical Service Center using a composite of well development and conservation practices, and a future level of flow; in this case a 2025 level of development. This documentation describes the methodology used to determine a 2025 level of flow development.

Typically, a future level of flow, to whatever point in the future is necessary, is calculated using projections of increased development in irrigation, changes in irrigation practices, development of stock ponds, small reservoirs, and/or changes in livestock to name to few. These changes can be compared against the present level of development, the 1993 level, to determine a future flow scenario. However, the 1993 level must also be calculated using comparable methodologies. In this case, the 1993 level of development was calculated using trend and regression analysis of well development, irrigation practices, and precipitation patterns. (See DTSC October 1995 Report, Republican River Basin Flows - Flows Adjusted to 1993 Level Basin Development). It was decided it would not be possible to extend the 1993 level flows to year 2025 using the same approach because of a lack of pertinent and critical data. It was determined that other options needed to be explored.

In August 1994, the Corps of Engineers, in conjunction with the Bureau of Reclamation, prepared the Preliminary Draft Operation Study and EIS for the Harlan County Reservoir. In this document the COE/BOR prepared estimates of year 2020 inflows into Harlan County. It was determined that this was the best available data for projected out year flows. It would be necessary to evaluate a methodology to distribute the increased depletion at Harlan County throughout the basin upstream of the reservoir.

The projected data in the COE/BOR study was for the time periods, 1990 and 2020, while the data in this evaluation was years 1993 and 2025. These timeframes are close enough together for this purpose and no additional adjustments were made in the data bases.

First, using the Harlan County 1990 and 2020 levels for inflows to the reservoir and the 1993 level inflows calculated by our model, it could be determined that the volume of flow necessary to reduce 1993 inflows to Harlan County to a 2025 level. This volume is 53.2 KAF. This was calculated from the following method.

From the USBR/COE Study

Inflows to Harlan County 1990 Level—105.4 KAF

Inflows to Harlan County 2020 Level—59.6 KAF

From the Republican River 1995-96 Study

Inflows to Harlan County 1993 Level - 122.3

(105.4-59.6)/105.4 = .43454

.43454 *122.3 = 53.2 KAF (Reduction in flows)

This volume of water, 53.2 KAF, is the 2025 depletion effect on 1993 level inflow to Harlan County.

The OPSTUDY computer model uses input from 21 node basins above Harlan County. These basins are listed below:

Arikaree River

South Fork Republican Above Bonny (inflows)

South Fork Republican River at Benkleman

Republican River at Benkleman

Republican River at Trenton (inflows)

Frenchman Creek above Enders (inflows)

Frenchman Creek at Palisade

Stinking Water Creek at Palisade

Frenchman Creek at Culbertson

Driftwood Creek

Blackwood Creek

Republican River at McCook

Red Willow Creek above Hugh Butler (inflows)

Red Willow Creek at Red Willow

Medicine Creek above Harry Strunk (inflows)

Republican River at Cambridge

Beaver Creek nr Beaver City

Sappa Creek near Stamford

Prairie Dog Creek above Norton (inflows)

Prairie Dog Creek at Woodruff

Republican River at Harlan County

Two methods were formulated in an attempt to distribute the depleted inflows at Harlan County throughout the node basins. Those methods were to use the drainage area directly contributing to runoff method and the average annual node basin flow method.

Drainage Area Directly Contributing to Runoff Method

The drainage areas directly contributing to runoff values were taken from the USGS Water Supply Papers. Using these values for each of the node basins above Harlan County, a percent distribution was calculated. These values were multiplied by the total 2020 level depletion, 53.2 KAF. These numbers would be the node basins contribution to total 2020 level depletion at Harlan County. Upon reviewing the results, it was determined that this method was unacceptable. Since some of the greatest portions of the distribution was in the Beaver and Sappa Creek drainage, and these are presently water short node basins, it would not be realistic to believe that additional development would take place in these node basins. Therefore, it was determined that this method was unacceptable.

Average Annual Flow in the Node Basins

The average annual flows from the 1993 study were used to determine a distribution. The rationale was to identify those basins where water was still "available" and target those as areas where potential development may occur. Likewise, in areas where water shortages occur, then it would be unrealistic for additional development to occur. In our opinion, this method provided an acceptable distribution of the flows throughout the basin.

The 1993 level of flows for each node basin were then modified to reflect the additional depletions that were calculated from the distribution.

Please review the attached table for further explanation.

Republican River—level 2025 Inflow analysis

Drainage	Directly contribute to runoff (mi^2)	Directly contribute to runoff (%)	Adjustment to 1993 level for 2025 flows (KAF)	Average annual flow (KAF)	Percent of total	Adjustment to 1993 level for 2025 flows (KAF)
Arikaree	1,020	7.54	4.011	7.3	2.70	1.438
SF @ Bonny (inflows)	1,825	13.49	7.176	17.9	6.63	3.526
SF @ Benkleman	365	2.70	1.435	6.6	2.44	1.300
RR at Benkleman	220	1.63	0.865	25.3	9.37	4.983
RR at Trenton	510	3.77	2.005	12.9	4.78	2.541
Frenchman @ Enders (inflow)	859	6.35	3.378	22.9	8.48	4.510
Frenchman @ Palisade	251	1.86	0.987	15.3	5.66	3.014
Stinking Water Creek	380	2.81	1.494	20.4	7.55	4.018
Frenchman @ Culbertson	100	0.74	0.393	8.0	2.96	1.576
Driftwood Creek	351	2.59	1.380	6.3	2.33	1.241
Blackwood Creek	270	2.00	1.062	3.1	1.15	0.611
RR @ McCook	69	0.51	0.271	11.5	4.26	2.265
Red Willow at HB (inflow)	194	1.43	0.763	17.4	6.44	3.427
Red Willow @ Red Willow	211	1.56	0.830	2.1	0.78	0.414
Medicine @ HS (inflows)	530	3.92	2.084	35.2	13.03	6.933
RR @ Cambridge	625	4.62	2.458	5.4	2.00	1.064
Beaver Creek	1,760	13.01	6.920	7.8	2.89	1.536
Sappa Creek at Stamford	1,610	11.90	6.331	0.0	0.00	0.000
Prairie Dog @ Norton (inflows)	590	4.36	2.320	5.0	1.85	0.985
Prairie Dog Creek	417	3.08	1.640	0.7	0.26	0.138
RR at Harlan County	1,373	10.15	5.399	39.0	14.44	7.682
Total above HC	13,530	1	53.2	270.1	1	53.2

Use our 1993 level inflows to Harlan County—122.3 KAF

Year 2020 to Harlan County would be (105.4 - 59.6) = 45.8 KAF

Total depletion would be 53.2 KAF ((105.4 - 59.6)/105.4) x 122.3 KAF. This would be the amount subtracted from each of the node basins based upon their drainage area.

Part V

Groundwater Research Management Assessment. Republican River Basin Water Supply Study Nebraska, Kansas, and Colorado

Ground-Water Resource Management Assessment, Republican River Basin Water Supply Study, Nebraska, Kansas, and Colorado

July 1995

Bureau of Reclamation
Great Plains Region

This report is a supplement for the Republican River Basin Resource Management Assessment being prepared for the long-term contract negotiations for Bureau of Reclamation irrigation facilities in the basin. This report is only a general assessment of the groundwater conditions in the basin. Much of the data was taken from the ground-water appendices from Reclamation's 1985 water management study of the Republican River Basin (Reclamation, 1984).

Topography and Drainage

The western half of the study area lies within the High Plains Section of the Great Plains Physiographic Province (Fenneman, 1931) which is characterized by flat to gently rolling plains with mild dissection by the major streams. East of that area down to about Clay Center, the study area is located within the Plains Border Section. Within this section, dissection of the plains becomes more pronounced with steeper valley walls.

The land surface of the basin slopes in an easterly direction from an elevation of 5650 feet near the Arikaree River headwaters to 1150 feet near Milford Dam. Topographic gradient averages 14.5 feet per mile from the western edge of the basin to Harlan County Dam, and then averages 5.2 feet per mile from Harlan County Dam to Milford Dam.

The streams within the basin exhibit a dendritic drainage pattern characterized by irregular branching of drainage. This implies that the underlying strata are relatively flat and that there is a lack of geologic structural controls such a folds and faults.

A major physiographic feature in the study area is the sand hills located in the North Fork Republican subbasin, and in the upper reaches of the Frenchman, Red Willow, and Medicine Creek drainage. The sand hills are sand dunes that have been stabilized by a cover of grass. Local relief between dune troughs and crests range from 50 to 150 feet. There is a lack of continuous surface drainage in the sand hills area since surface runoff infiltrates easily into the sandy soil.

Hydrogeology

See **figures 1 and 2** for the generalized near-surface geology of the Republican River Basin. The formations that comprise the major near-surface aquifers are Quaternary alluvium and terrace deposits adjacent to the major streams, Quaternary eolian deposits in the northwestern portion of the basin, the Ogallala Formation of Pliocene age which occurs mainly above Harlan County Dam, and the Pleistocene Grand Island Formation and Cretaceous Dakota Formation located to the east from Harlan County Dam.

The alluvium and terrace deposits are generally comprised of unconsolidated clay, silt, sand, and gravel, and yield small to large quantities of water. The eolian sand deposits found in the northwest sections of the Republican River drainage play an important role in the aquifer since their high permeability allows for rapid recharge to the underlying Ogallala Formation.

The Ogallala Formation consists of unconsolidated to semiconsolidated discontinuous interbedded lenses of gravel, sand, silt, and clay. The Ogallala can yield small to large quantities of water and is the major aquifer in the study area due to its large areal extent.

The Grand Island Formation is a major source of irrigation water in northeastern Jewell and northwestern Republic counties. It consists primarily of coarse sand and medium to coarse gravel interbedded with silty clay.

The Dakota Formation is a principal aquifer in the vicinity of Cloud and Clay counties in Kansas. It is comprised mainly of clay interspersed with lenticular beds of sandstone and yields small to large quantities of water.

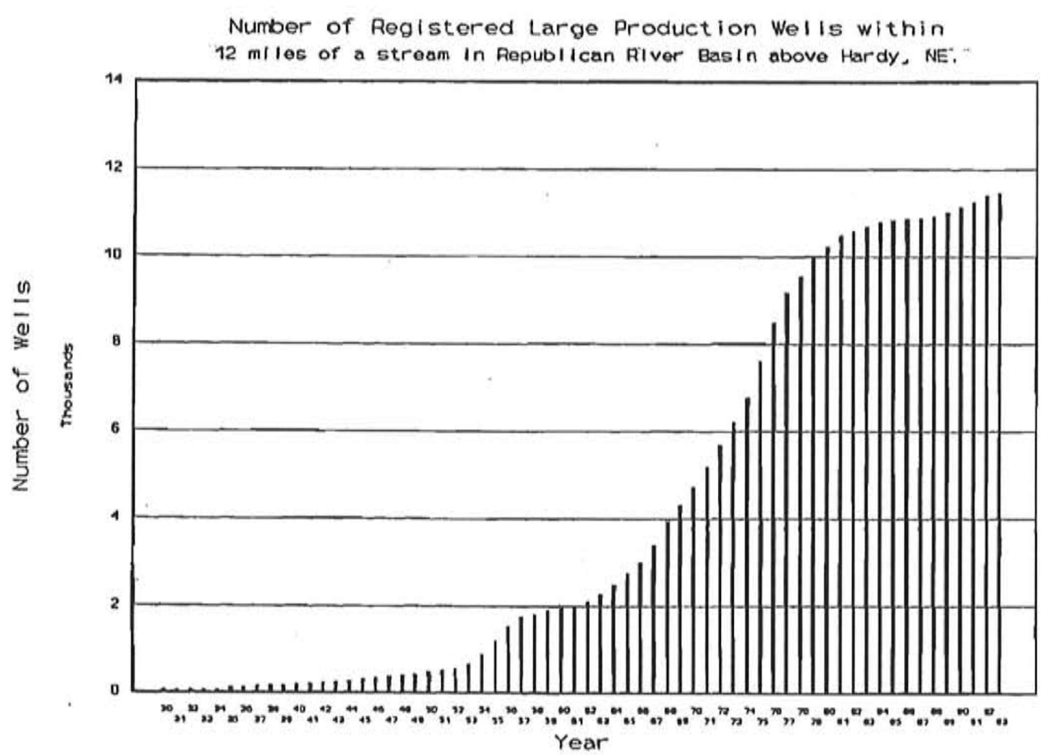
The base (or 'bedrock') for the near surface aquifer system west of Harlan County Dam is comprised of the relatively impermeable Cretaceous Pierre Shale and Niobrara Formation, and the Tertiary White River Group. East of Harlan County Reservoir, the base of the aquifer system is defined by the Cretaceous Pierre Shale and Niobrara Formation, and the Permian Wellington and Chase Group. The Pierre Shale consists of a fissile marine shale. The Niobrara is comprised of chalk, chalky shale, and has bentonite beds interspersed throughout the formation. The White River Group is comprised of clay, claystone, silt, siltstone, and sandstone. The Wellington is comprised mainly of shale with discontinuous beds of gypsum and limestone. The Chase Group consists of alternating limestones and shales.

<u>Ground-Water Levels and Well Development</u>

Groundwater within the basin generally flows in an easterly direction with convergence towards the Republican River. Based on water level measurements during the period of 1976 through 1978, the average gradient of the water table above Harlan County Reservoir is 17.2 feet per mile while below, the average gradient in Nebraska is 10.9 feet per mile.

Irrigation wells are main consumers of groundwater within the basin, with relatively smaller amounts used for municipal, industrial, domestic, and stock watering purposes. **Figure 3** shows the approximate annual number of registered irrigation, municipal, and industrial wells within 12 miles of a perennial stream within the study area [annual delineation was based on water right date]. With the advent of center pivots, the installation of wells proceeded at a high rate during the later 1960's and 1970's.

Figure 3



Following is a list by subbasin of the estimated number of registered irrigation, municipal, and industrial wells within 12 miles of a perennial stream based on recent data received from the states.[1] This study did not attempt to delineate which aquifers the wells were completed in and to what degree the wells are hydraulically connected to nearby streams.

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[1]Nebraska provided registered well data in 1995; Colorado previously provided data in 1992 but would not provide updated data; Kansas previously provided data in 1992 for the portions of the Republican River Basin above Harlan County Reservoir but would not provide updated data; Kansas would not provide updated data for the Republican River Basin below Harlan County Reservoir, therefore used data current as of 1978 from Reclamation's 1985 water management study.

Subbasin (study ID #)		No. of Wells
S. Fork Republican above Bonny Res.	(1)	409
S. Fork Republican below Bonny Res.	(2)	479
N. Fork Republican above Benkelman	(3)	948
Frenchman Ck. above Enders Res.	(4)	1540
Frenchman below Enders to Palisade	(5)	93
Stinking Water Creek	(6)	696
Frenchman from Palisade to Rep. R.	(7)	188
Blackwood Creek	(8)	146
Republican below Trenton to McCook	(9)	391
Driftwood Creek	(10)	32
Red Willow Ck. above Hugh Butler	(11)	319
Red Willow Ck. below Hugh Butler	(12)	84
Republican from McCook to Cambridge	(13)	558
Medicine Ck. above Harry Strunk Lk.	(14)	449
Beaver and Sappa Creeks	(15)	1414
Prairie Dog above Keith Sebelius	(16)	57
Prairie Dog below Keith Sebelius	(17)	321
Republican from Cambridge to Harlan	(18)	1277
Republican below Harlan to Guide Rk	(19)	1422
Republican from Guide Rock to Hardy	(20)	143
White Rock Creek	(21)	26
Republican from Hardy to Milford	(22+23)	759
Arikaree River	(24)	259
Republican from Benkelman to Trenton	(25)	236
		Total = 12,246

Well development has resulted in some areas of the aquifers being heavily developed and the withdrawals for irrigation have exceeded the ability of the aquifer to replenish itself from natural recharge sources. In those areas, significant declines in ground-water levels have occurred. Areas within Nebraska that have experienced the most declines are located in the Frenchman Creek basin where the Ogallala is the predominant aquifer. Ground-water levels within this area have declined up to 30 feet or more (Steele and Wigley, 1994). In Colorado, the greatest ground-water level declines have occurred in the sand hills area in the upper Frenchman Ck. and North Fork Republican drainage where, since the mid 1960's, declines of up to 45 to 50 feet have occurred (Colorado Division of Water Resources, 1995). Within the Kansas portions of the Republican basin, the greatest water level declines since pre-development have occurred at the upstream ends of the Prairie Dog Ck., Beaver Ck., and Sappa Ck. drainage (Woods, et al, 1994). In those areas, declines of up to 25 to 50 feet have occurred and this relates to a reduction of up to 25 percent of the aquifers' pre-development saturated thickness. Hydrographs of wells published by the states indicate that in some areas water levels will continue to decline while in other areas they may have stabilized.

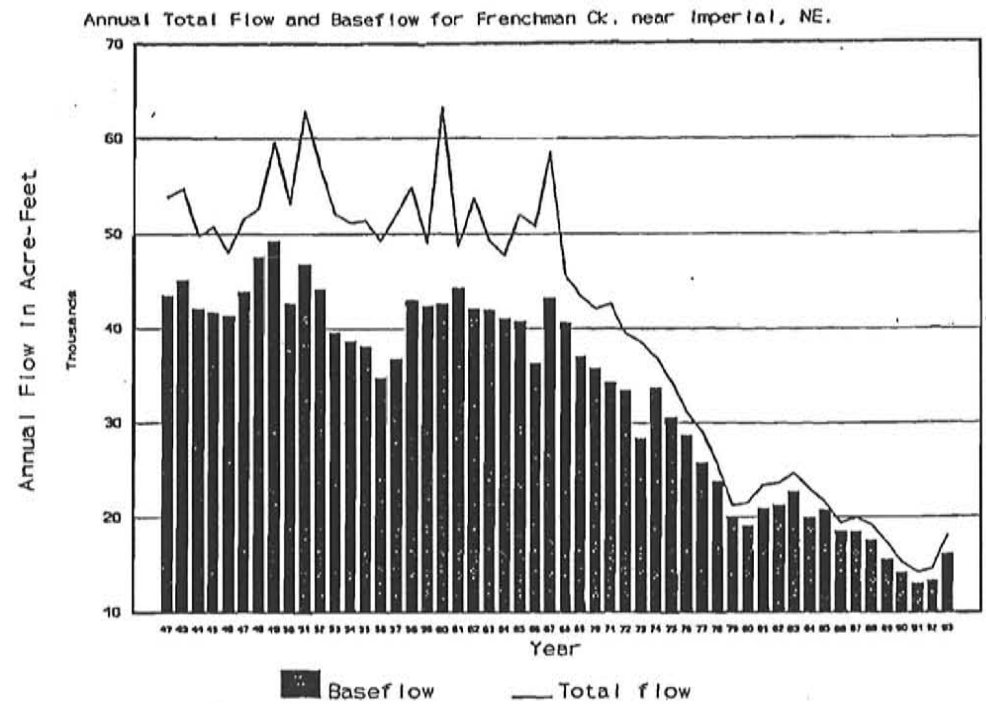
Aquifer-Stream Interaction

What appears to be associated with the declining ground-water levels has been the decline in streamflow in many streams. Many of the streams in the basin receive a portion of their flow from the aquifers. As ground-water levels decline, then the hydraulic gradients towards the streams are reduced and aquifer-to-stream discharge is also reduced. In some instances, nearby pumping wells can lower the water table to the point where the hydraulic gradient to the stream is reversed to a stream-to-aquifer condition. Water from the streams is then induced to flow through the river-bed into the aquifers. The lowering of the water table has resulted in several of the streams within the basin having the point where they become perennial (ie. where they flow continuously year round) move several miles downstream over the historic period.

A good example showing the probable connection between a declining water table and its effects on streamflow would be Frenchman Creek above Enders Reservoir. A majority of the flow in Frenchman Ck. is derived from the adjacent alluvial and Ogallala aquifer system. The drainage basin for the Frenchman is located in the sand hills area where the high permeability of the upper soil zones allows for high infiltration to underlying aquifers and there is a corresponding reduction in direct runoff to the streams. As previously stated, this area has shown appreciable water-table declines. **Figure 4** is a hydrograph of the water levels from a recorder well near Imperial, NE. It provides an example of the temporal changes that have occurred to the water table in areas near Frenchman Creek since pre-development periods. **Figure 5** is a plot of the annual total flow and calculated baseflow[2] for Frenchman Ck. using discharge measured at the USGS streamflow gauging station near Imperial, NE. The plot shows a definitive downward trend in flow in the river since pre-development period. The average baseflow for 1942 to 1951 was 44,360 acre-feet while the average for 1984 to 1993 was 16,740 acre-feet. Historically, the upstream point where Frenchman Ck. was believed to have a perennial flow was located several miles west of the Nebraska-Colorado state line. Now the point of 'perenniality' appears to be several miles to the east of the state line.

[2] Base flow was calculated using a program called BFI2. This program utilizes daily streamflow discharge data to determine turning points in data to separate baseflow from total runoff.

Figure 5



Figures 6 to 19 are plots of accumulated annual baseflow for selected stream nodes in the basin. A change in the slope of the plot line indicates a change in the baseflow regime. As can be seen most of the selected stream nodes show some sort of a decline in baseflow, although there are several that show no change or a increase in flows. Those showing an increase during their period of record is probably due to return flows from irrigation and/or seepage past dams.

Blackwood and Driftwood Creeks both showed a significant increase in baseflow since pre-development, however at Blackwood, indications are that recent annual baseflow gains may be declining back to a pre-development rate. The apparent increase for Driftwood Ck. may be due to several causes. The measured flow in Driftwood includes the effects of return flows from the Meeker-Driftwood Canal which began deliveries in 1957. Also, the gauge has been moved several times beginning in 1962 to different locations and this could result in a change in the apparent flow regime.

Baseflow for White Rock Creek does not appear to be changing and may be exhibiting a slight increase since 1982. The South Fork Republican River near Idalia, CO also appears to be not changing, however, available streamflow discharge data ends in 1971 and present flows are not known. The remainder of the selected stream nodes exhibit some degree of a general decline in baseflow over the period of flow records. For those selected nodes showing a decline, the following is a tabulation of the average baseflow during the subjectively defined 'pre-development' period versus average flows for the last 10 years of record, and the percent of decline in those average flows:

Stream	Average Baseflow
Frenchman Ck. near Imperial	'42 - '67 = 42,000 af '84 - '93 = 16,700 af decline = 60%
Stinking Water Ck. near Palisade	'50 - '76 = 21,500 af '84 - '93 = 16,700 af decline = 22%
Buffalo Ck. near Haigler	'41 - '64 = 5,000 af '84 - '93 = 2,900 af decline = 42%
Arikaree River at Haigler	'33 - '67 = 4,900 af '84 - '93 = 3,400 af decline = 31%
Landsman Ck. near Hale	'51 - '62 = 800 af '67 - '76 = 300 af decline = 63%
Republican River near Benkelman	'48 - '75 = 42,600 af '84 - '93 = 35,800 af decline = 16%
Red Willow Ck. above Hugh Butler	'61 - '76 = 14,800 af '84 - '93 = 11,900 af decline = 20%
Medicine Ck. above Harry Strunk	'51 - '74 = 32,900 af '84 - '93 = 29,600 af decline = 10%
Sappa Creek near Stamford	'48 - '68 = 19,800 af '84 - '93 = 2,400 af decline = 88%
Prairie Dog Ck. above Sebelius	'63 - '76 = 1,600 af '84 - '93 = 1,200 af decline = 25%

The states have recognized the declining water tables and streamflows and have established ground-water control areas for the regulation of ground-water usage and quality in certain areas of the basin. Nebraska has established the Upper Republican Groundwater Control Area to manage ground-water usage in Perkins, Chase, and Dundy counties. Colorado has established several ground-water management districts (GWMD) within the Republican basin: Frenchman GWMD, Sand Hills GWMD, W-Y GWMD, Central Yuma

GWMD, Western Washington GWMD, Arikaree GWMD, and Plains GWMD. Kansas has established the Northwest Kansas GWMD No. 4 which covers portions of the Prairie Dog Creek, Beaver Creek, Sappa Creek, and South Fork Republican basins.

In response to declining flows in the Prairie Dog, Sappa, and Beaver Creek basins, Kansas has closed those areas to new appropriations for wells in the alluvial aquifers since 1984. Within the Northwest Kansas GWMD, appropriations from the Ogallala aquifer were limited to a safe-yield criteria beginning in 1990. The Lower Republican River and tributary alluvial aquifers were closed to new ground-water appropriations in 1992.

Figure 6

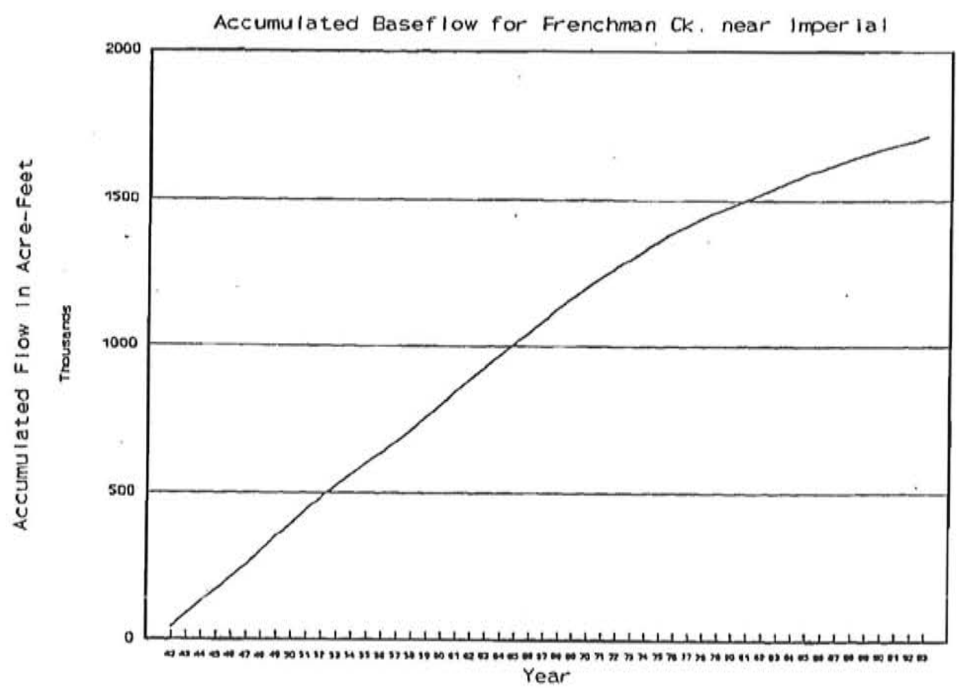


Figure 7

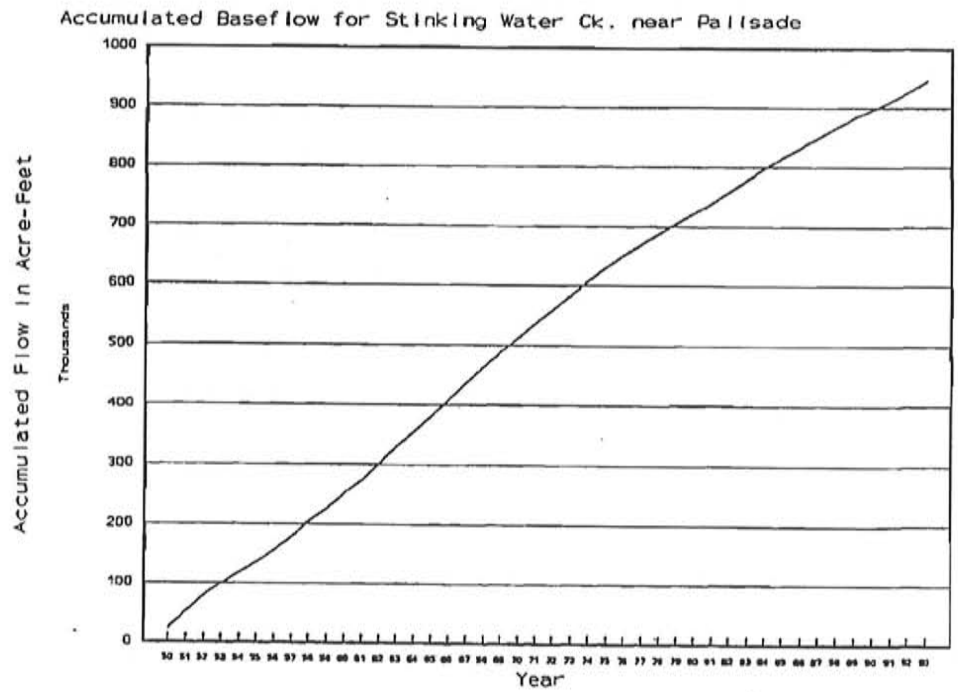


Figure 8

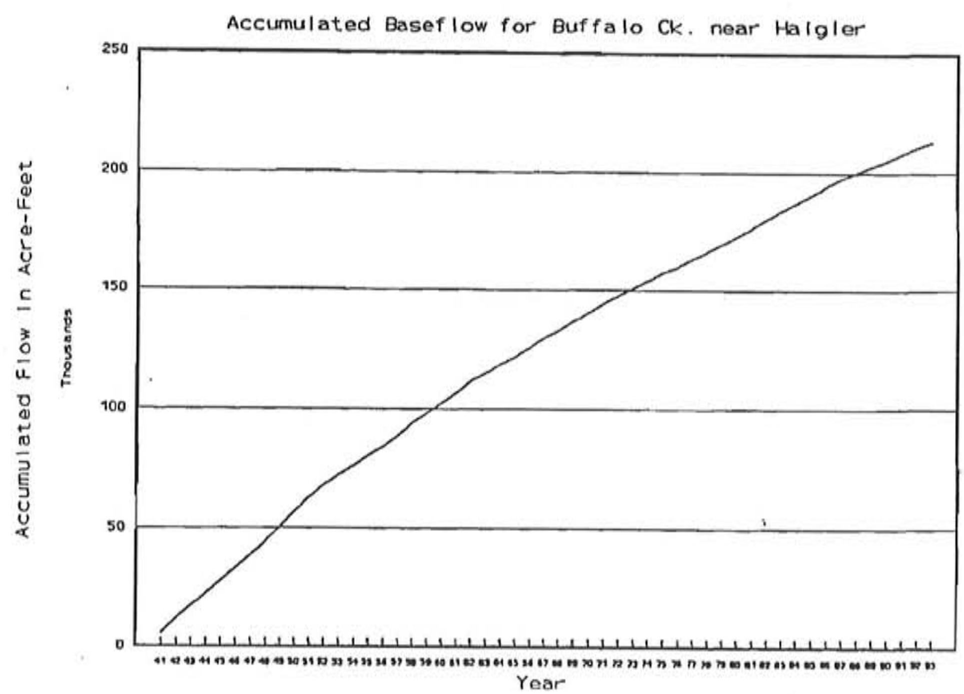


Figure 9

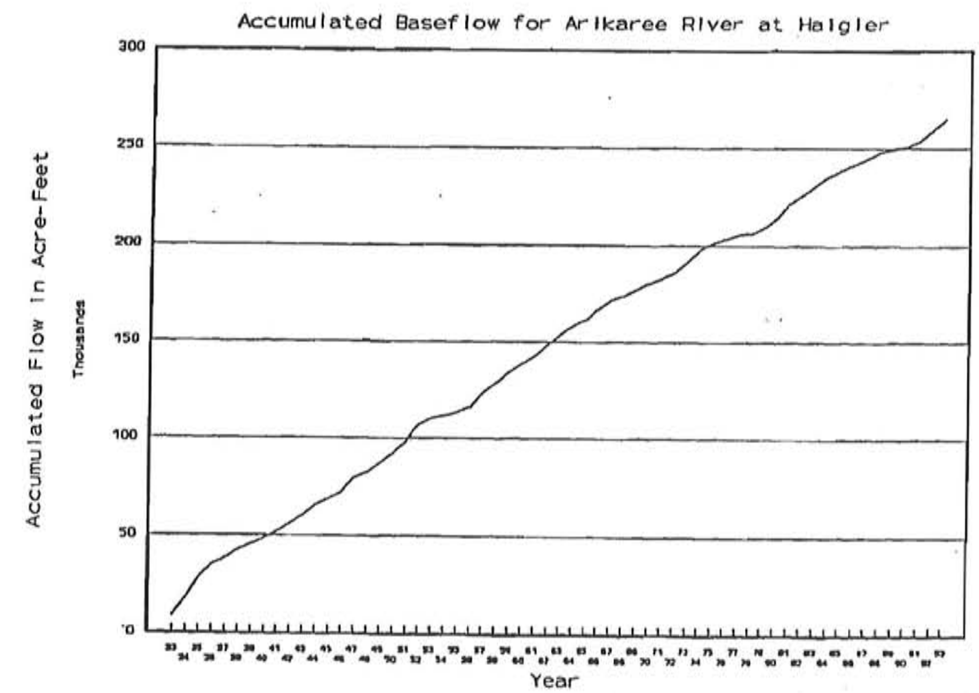


Figure 10

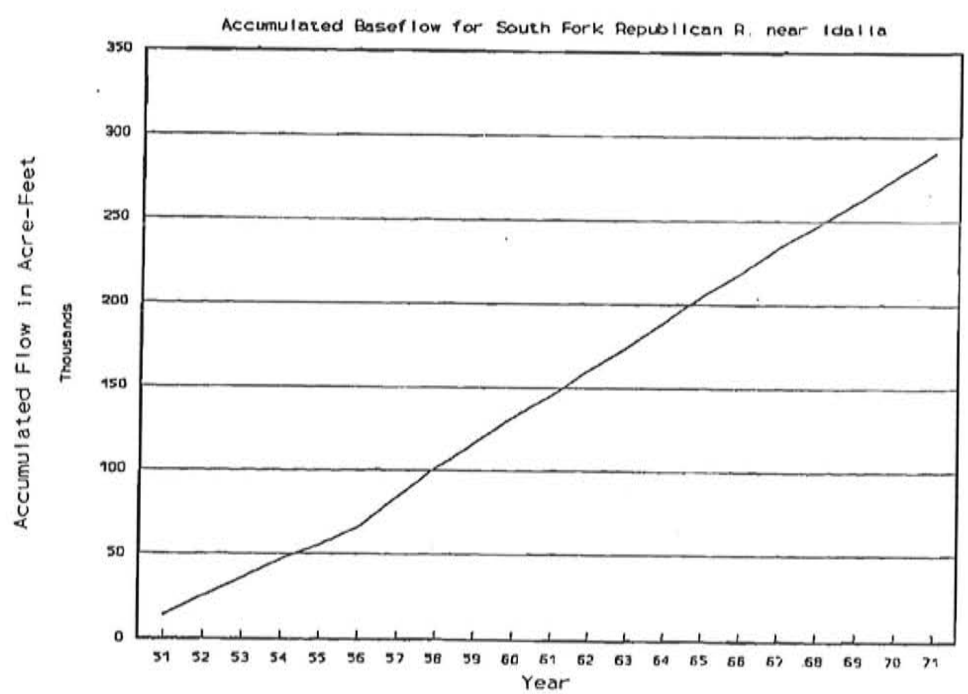


Figure 11

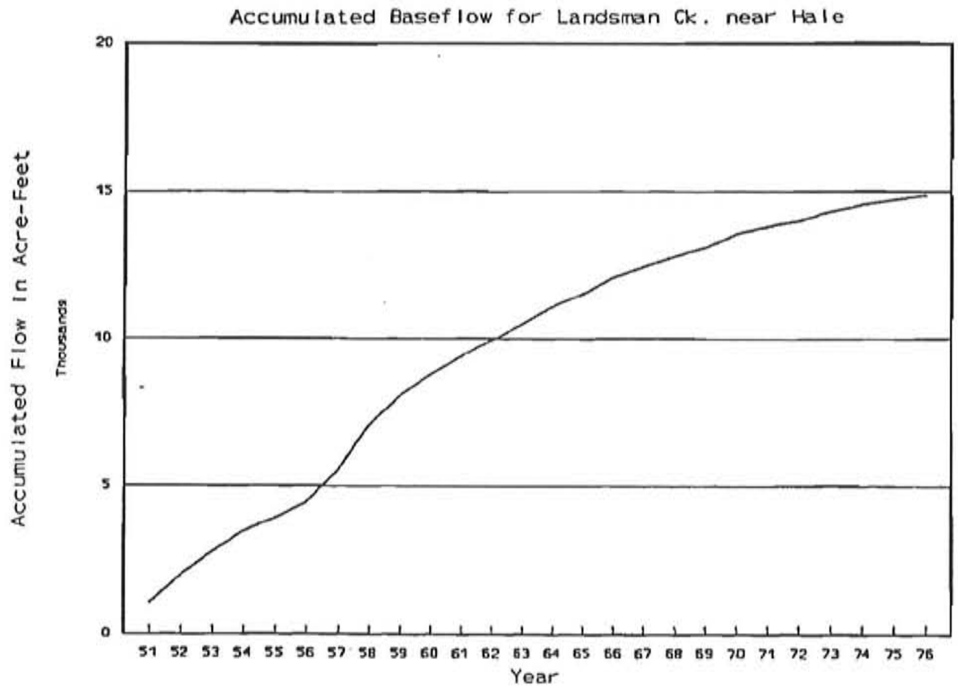


Figure 12

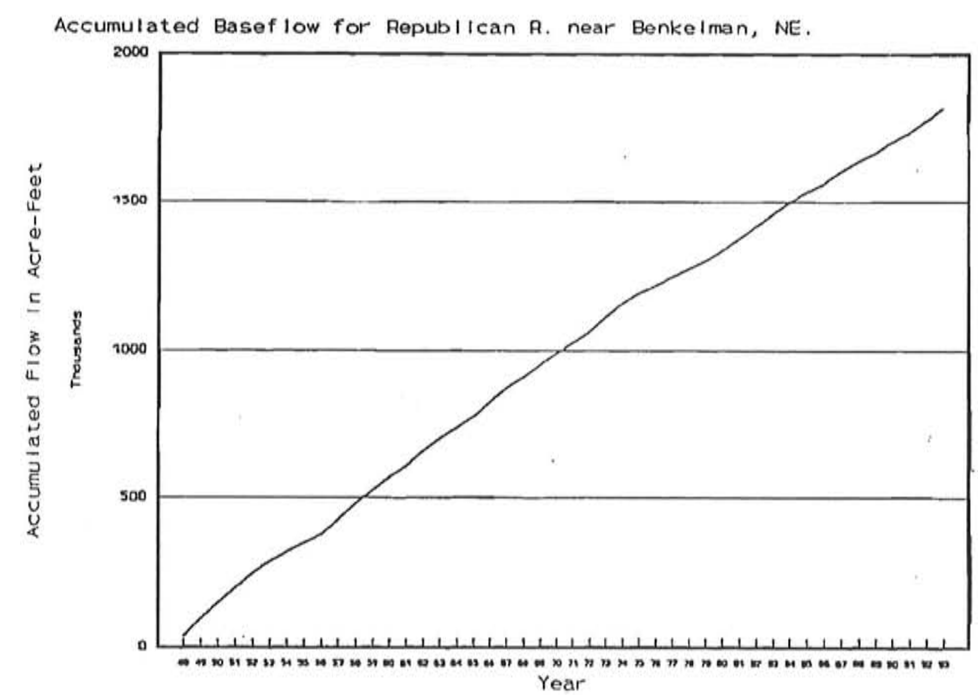


Figure 13

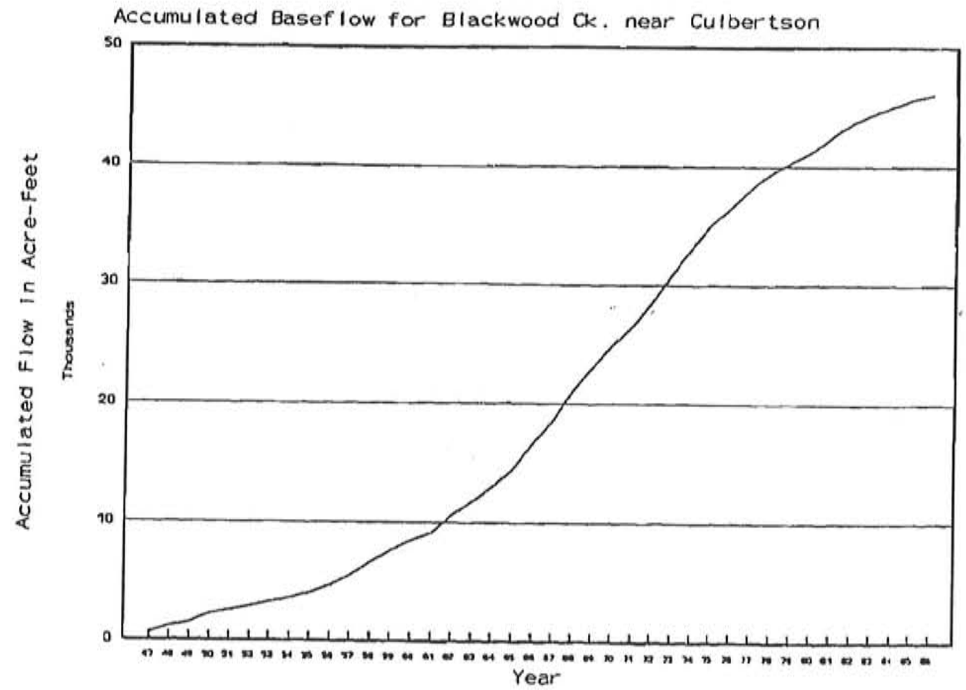


Figure 14

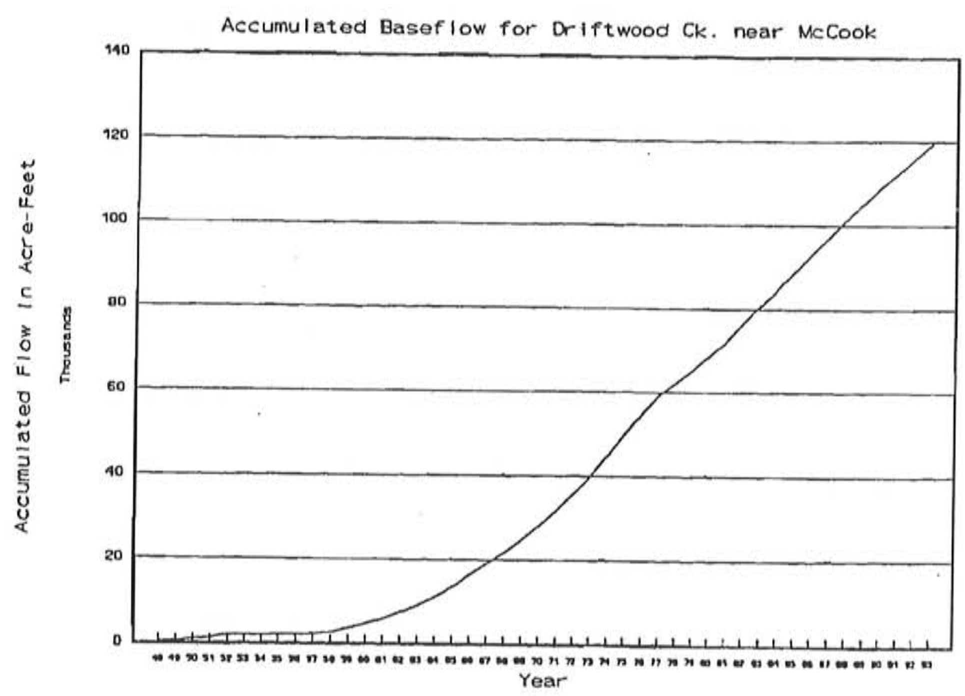


Figure 15

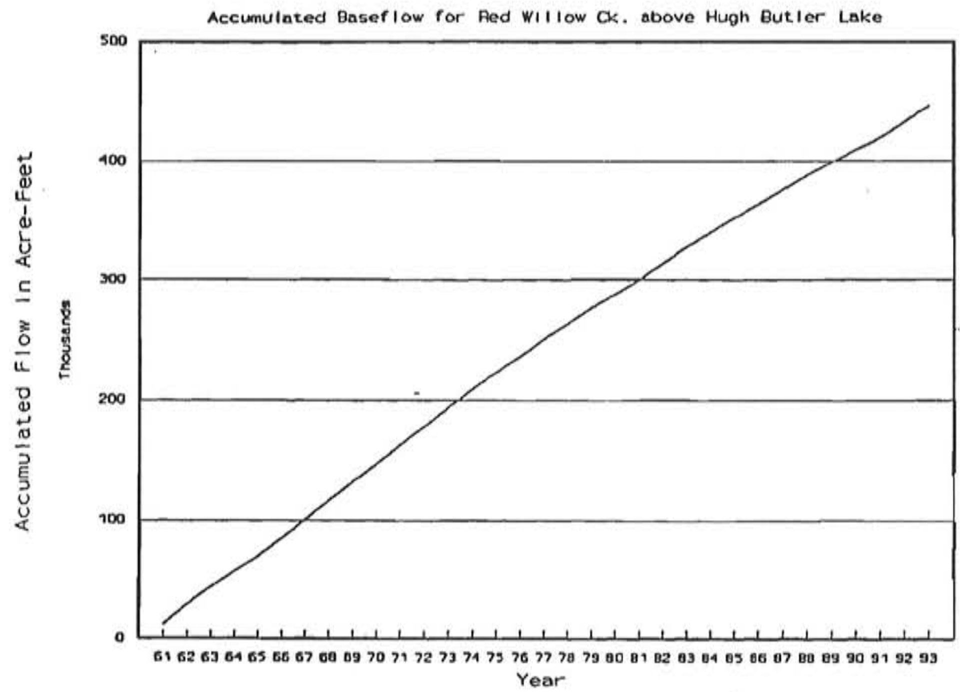


Figure 16

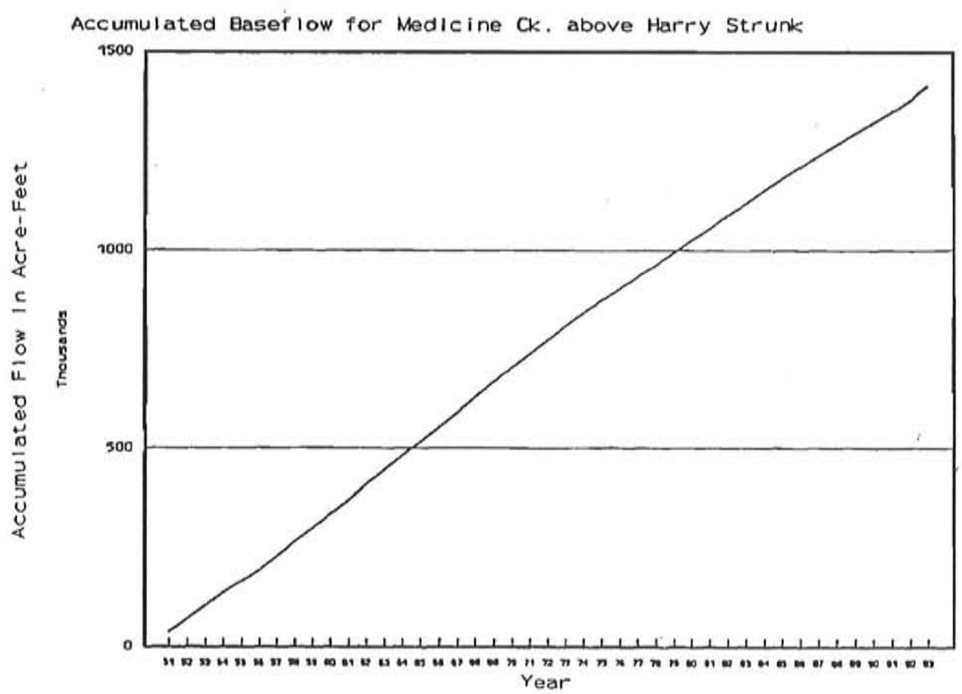


Figure 17

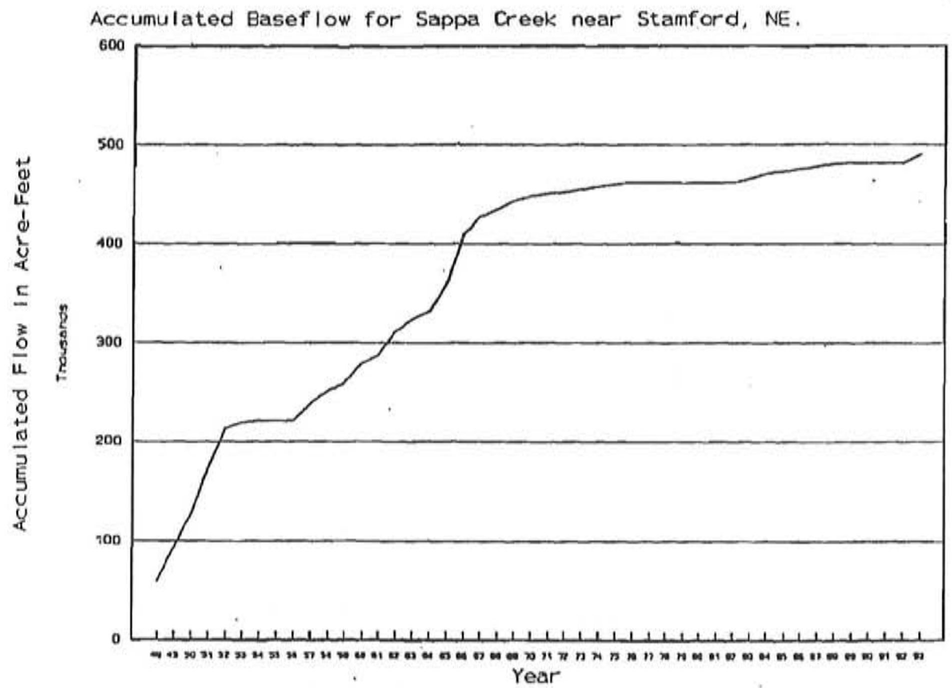


Figure 18

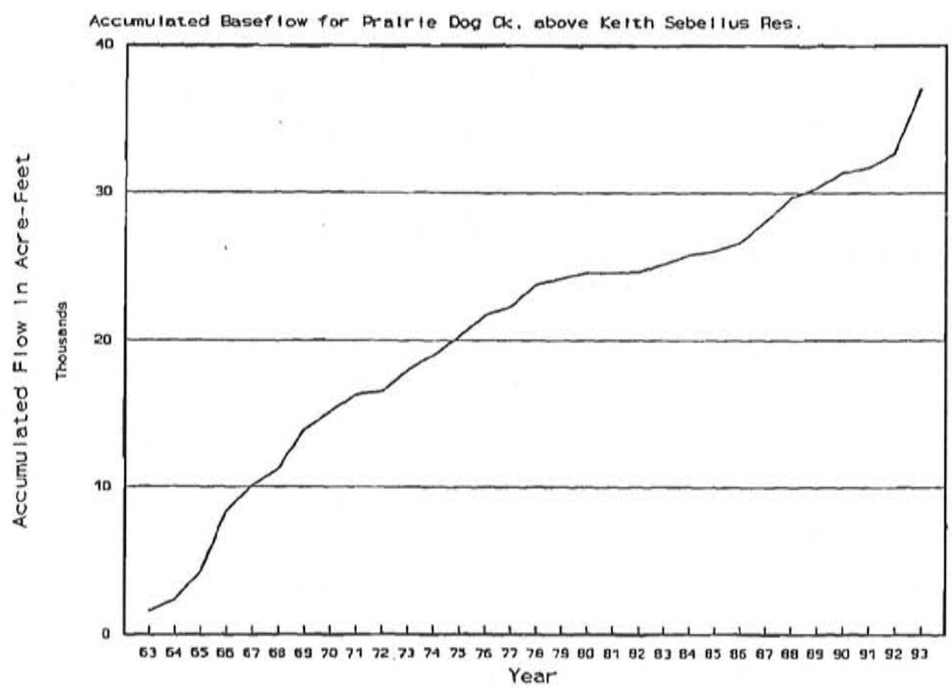
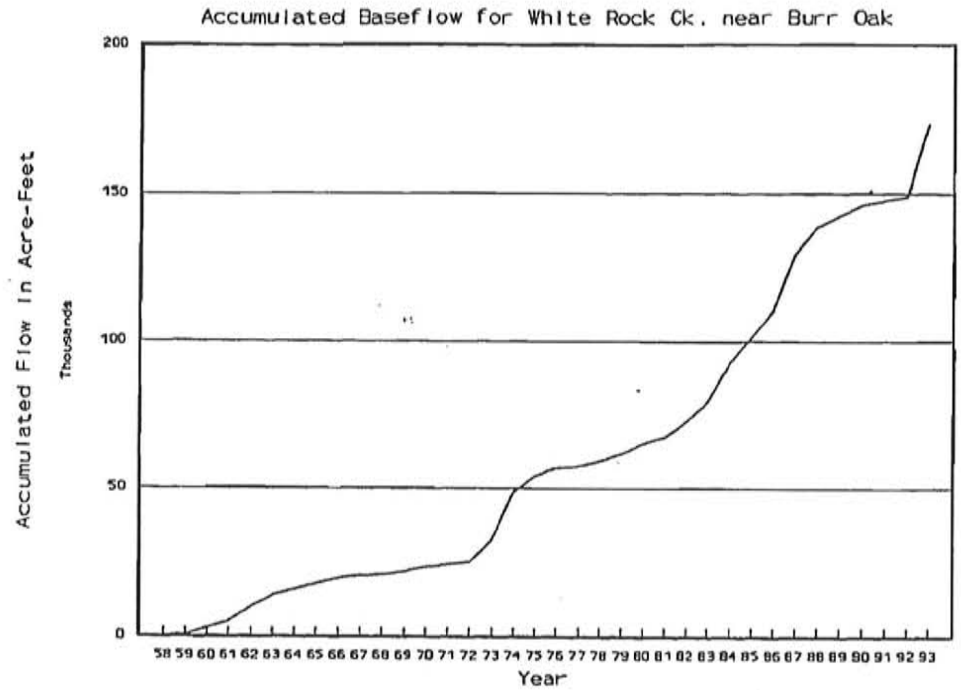


Figure 19



Future Ground-Water Conditions

In some areas of the basin, ground-water levels will continue to decline as long as well pumpage continues to exceed the aquifer's recharge rate. A recently developed ground-water flow model of the Upper Republican Natural Resources District in Nebraska (Peckenpaugh, et al, 1995) indicates that water levels in that area could decline up to another 50 feet or more by the year 2030. The greatest projected declines occurred in northwestern Chase County. Those projections were based on the assumption of no additional well development in that area beyond the 1989 level.

And with any further declines in water levels, it can be expected that baseflow contributions from the adjacent aquifers will also decline. Future simulations by Peckenpaugh using the ground-water flow model indicate that the flow in Frenchman Creek above Enders Reservoir will continue to decline, even with well development maintained at present levels. His predictions showed that by 2030 the flow in Frenchman Ck. near Imperial could decline to approximately one-third of the 1989 flow rate. The shape of the plot-line in **Figure 6** seems to support that conclusion since the slope of the curve is progressively flatter as time progresses and there is no indication of a recent stabilization of the declines in baseflow.

Landsman Ck. near Hale (**Figure 11**) also shows a progressively declining baseflow over its period of record and would be expected to continue to decline. However, there are no recent flow records for Landsman Ck. to confirm if flows in that creek are continuing to decline or whether they stabilized. Flow records for the South Fork Republican River above Bonny suggest baseflow in that stream has not change significantly over its perios of record. A single-mass diagram of annual historic inflow to Bonny Reservoir (not shown) indicates that since 1976, there has not been a significant change in annual inflow to the reservoir. This implies that the baseflow in Landsman Ck. and South Fork Republican River has probably remained generally the same during recent years and is expected not to change significantly in the future.

The baseflow regime of the Republican River near Benkelman (**Figure 12**) appears to have declined around 1975. The decline appears to have stabilized since then and no additional decreases in baseflow are anticipated in the future based on the present level of well development. The same situation is anticipated for Red Willow Ck. above Hugh Butler (**Figure 15**), and Medicine Creek above Harry Strunk (**Figure 16**). The slope of the accumulated-baseflow plot line for the past 10 years appears to be constant and this is expected to continue into the future, barring any significant additional well development.

Since 1969, the annual baseflow in Sappa Creek (**Figure 17**) near its confluence with the Republican River appears to be not changing and this is not expected to change in the future. The Beaver and Sappa Creek basins have been closed to additional well development in the alluvial aquifers. The same situation also appears to be occurring for Prairie Dog Creek above Keith Sebelius Reservoir (**Figure 18**).

The baseflow from White Rock Ck. into Lovewell Reservoir (**Figure 19**) looks like it should not experience any significant changes in the future. The drainage area for White Rock has experienced little well development due the lack of any significant aquifers in that area.

References

Steele, Gregory V. and Perry B. Wigley, 1994, Groundwater-level Changes in Nebraska, 1992: University of Nebraska-Lincoln, Conservation and Survey Division, Nebraska Water Survey Paper Number 72, 6p.

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Woods, John J. and others, 1994, January 1994 Kansas Water Levels and Data Related to Water-level Changes: Kansas Geological Survey, Lawrence, Kansas, Technical Series 5, 106p.

Colorado Division of Water Resources, 1995, Ground Water Levels in the Northern High Plains Designated Basin, 1995: Office of the State Engineer.

Bureau of Reclamation, March 1984, Republican River Basin Water Management Study, Appendix: Ground-Water Reconnaissance of the Upper Republican River Basin above Harlan County Dam, Nebraska.

Bureau of Reclamation, April 1984, Republican River Basin Water Management Study, Appendix: Ground-Water Reconnaissance of the Lower Republican River Basin from Harlan County Dam, Nebraska to Milford Dam, Kansas.

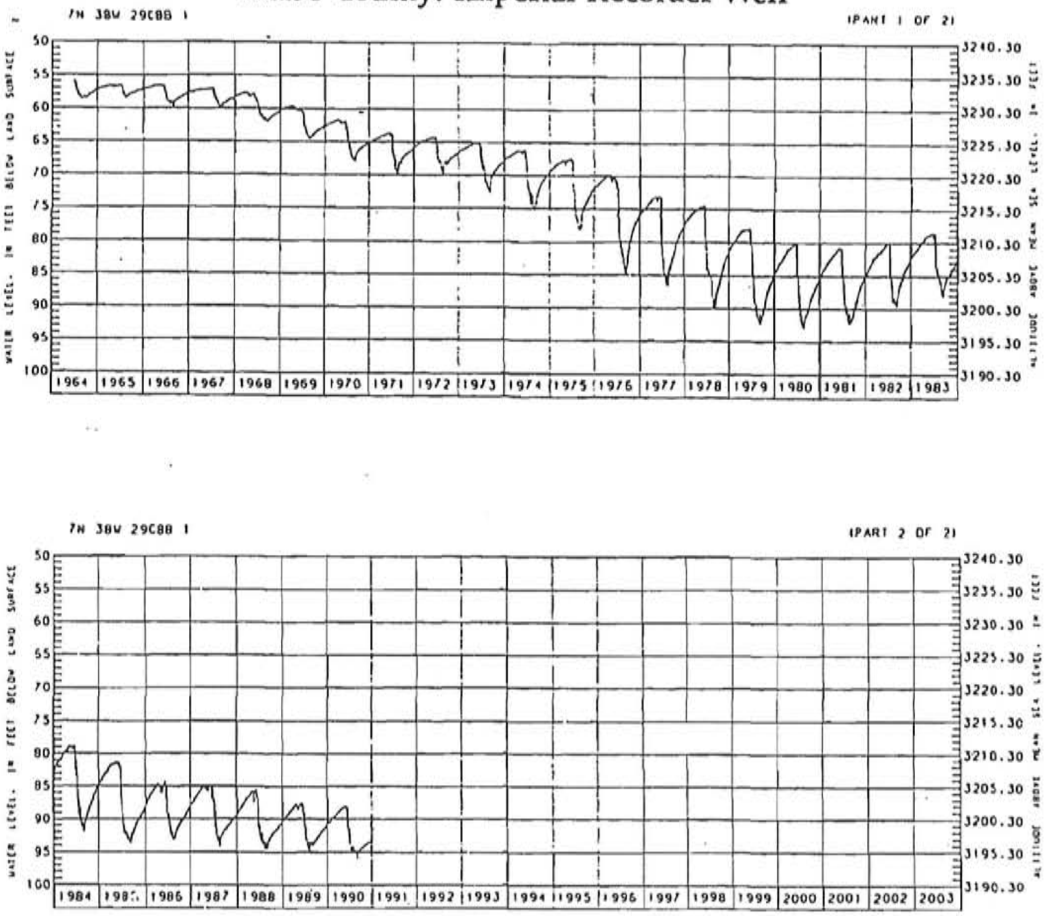
List of Figures

Figure 19 - Accumulated Baseflow for White Rock Ck. near Burr Oak.

Figure 4

[from Steele, Gregory V. and Perry B. Wigley, 1991, Groundwater Levels in Nebraska, 1990: University of Nebraska-Lincoln, Conservation and Survey Division, Water Survey Paper No. 69, 81p.]

Chase County: Imperial Recorder Well



Part VI

Hydrology Assessment for the Republican River Basin

Hydrology Assessment for the Republican River Basin

Project Description

The Republican River is located along the Kansas-Republican border and drains parts of three States, Colorado, Kansas, and Nebraska. The total drainage area is approximately 24,955 square miles, of which 9,714 square miles are in Nebraska, 7,519 square miles are in Kansas, and 7,722 square miles are in Colorado.

The river proper is formed by the junction of the Arikaree and North Fork Republican Rivers near Benklemen, Nebraska. From Benklemen, the river flows in an easterly direction to Junction City, Kansas, where it joins the Smoky Hill River to form the Kansas River. The watershed has an approximate length of 430 miles. The principal tributaries downstream from the confluence of the Arikaree and North Fork Republican Rivers are South Fork Republican and Frenchman, Blackwood, Driftwood, Red Willow, Medicine, Sappa, Prairie Dog, and White Rock Creeks.

Located within the drainage basin are 9 major impoundments on the main-stem Republican River and major tributaries. A listing of these reservoirs, the construction period and date of closure are shown on Table 1 below.

Table 1
Republican River Dams and Reservoirs

Name	River or Tributary	Construction Period	Date of Closure
Bonny	South Fork	1948-1951	July 6, 1950
Enders	Frenchman	1947-1951	Oct 23, 1950
Medicine Creek	Medicine	1948-1949	Aug 8, 1949
Hugh Butler	Red Willow	1960-1962	Sept 5, 1961
Keith Sebelius	Prairie Dog	1961-1964	June, 1964
Trenton	Republican	1949-1953	May 4, 1953
Lovewell	White Rock	1955-1957	June, 1957
Harlan County	Republican	1950-1952	Dec 2, 1952
Milford	Republican		

Climate

The Republican River Basin has a subhumid to semiarid continental climate. The variable weather is typical of the interior of a large land mass in the temperate zone: light rainfall, low humidity, hot summers, and cold winters. Rapid weather changes are causes by invasions of larger masses of warm, moist air from the Gulf of Mexico; hot, dry air from the southwest; cool, dry air from the Pacific Ocean; and cold, dry air from Canada.

There is a large variation in precipitation from year-to-year and station-to-station within the basin (Table 2). The mean annual precipitation varies from nearly 18 inches in the western part of the basin to 30 inches in the eastern portion. The majority of the annual precipitation falls during the growing season April through September. A summary of average and extreme temperature readings for representative climatological stations are shown in Table 3.

Table 2
Precipitation Summary for
Representative Climatological Stations

Station	1929-1993 Mean Annual Inches	Maximum Annual Inches	Minimum Annual Inches
Wray, Co	17.76	30.36	7.29
McCook, NE	20.52	38.26	9.69
Alma, NE	22.54	45.77	11.73
Red Cloud, NE	24.65	40.42	11.94
Clay Center, KS	29.98	53.86	13.88

Table 3
Temperature Summary for
Representative Climatological Stations

Station	1929-1993 Mean Annual Temperature	Maximum Mean Monthly Temperature	Minimum Mean Monthly Temperature
Wray, CO	51.2	81.8	10.8
McCook, NE	52.3	84.6	13.3
Alma, NE	52.8	86.8	10.1
Red Cloud, NE	52.6	87.6	10.0
Clay Center, KS	55.5	89.6	13.2

Project Evaluation

For the purposes of this assessment concerning the climatology and the surface water records, the evaluation will be broken into three separate sections; the pre-development period, 1929 to 1950 period, the post development period, the 1950 through 1993 period, and a prediction of impacts to the water supply in the future based upon projections.

The climate data summaries are divided into three specific areas, one including the western portion of the drainage basin and those respective stations including Wray, Colorado and McCook, Nebraska; the middle portion of the basin and those respective stations, including McCook, Alma, Franklin and Red Cloud, Nebraska; and the eastern portion of the basin and the associated station representing those areas, including Red Cloud, Nebraska and Clay Center, Kansas.

Streamgaging stations are located at many sites throughout the tributaries and the main-stem of the river. However, many of the streamgaging stations lack long term records. Pre-development records (1929 - 1950) are minimal and located only at a few selected sites, thus leading to the difficulty in developing baseline data for comparison purposes. A listing of available streamflow data is displayed in Table 4.

Pre-Development Period 1929 through 1950

Climate

Area I - Western Portion of the Basin

Precipitation

The precipitation records for the 1929 through 1950 period do not differ drastically from the long term average of the 1950 through 1993 period of record. Table 4 displays the average monthly total precipitation for Area I.

Except for isolated thunderstorms which can produce short-term high intensity rainfall, the overall averages indicate no major variation in the precipitation patterns in Area I month-by-month and/or annually.

Temperature

Average temperatures across this portion of the basin for the 1929 through 1950 period were slightly lower than normal, but not sufficiently significant to modify changes in growing pattern for Area I. See Table 7 for a comparison of the averages.

Area II - Middle Portion of the Basin

The precipitation records for the 1929 through 1950 period do not differ drastically from the long-term average of the 1950 through 1993 period of record. Table 5 displays the average monthly total precipitation for Area II.

Except for isolated thunderstorms which can produce short-term high intensity rainfall, the overall averages indicate no major variation in the precipitation patterns in Area II month by month and/or annually.

Temperatures

Average temperatures across this portion of the basin for the 1929 through 1950 period were slightly higher than the long-term average, but not significant enough to modify the growing patterns in the area. See Table 8 for a comparison of the averages.

Area III - Eastern Portion of the Basin

The precipitation records for the 1929 through 1950 period do not differ drastically from the long-term average of the 1950 through 1993 period of record. Table 6 displays the average monthly total precipitation for Area III.

Except for isolated thunderstorms which can produce short-term high intensity rainfall, the overall averages indicate no major variation in the precipitation patterns in Area III month by month and/or annually.

Temperatures

Average temperatures across this portion of the basin for the 1929 through 1950 period were slightly higher than the long-term average, but not significant enough to modify the growing patterns in the area. See Table 9 for a comparison of the averages.

Streamflow

Streamflow records throughout the Republican River drainage basin for the pre-development period are sporadic, with most of the records beginning in the mid- to late 1930's. These records have not been influenced by reservoir operations, although the records may have been reduced by streamflow diversion for irrigation. Listed below are the records which are recorded in the U.S. Geological Survey Water Resources annual water supply papers. The year listed after the gage represents the first year in which records were recorded.

Gaging Stations	Date
Arikaree Creek near Haigler, NE	1932
North Fork Republican River at CO-NE Stateline	1929
South Fork Republican River at Benklemen, NE	1938
Republican River at Max, NE	1930
Frenchman Creek at Imperial, NE	1941
Frenchman Creek nr Hamlet, NE	1931
Frenchman Creek at Culbertson, NE	1935
Republican River at Culbertson, NE	1935
Republican River at Bloomington, NE	1929
Red Willow Creek nr Red willow, NE	1940
Medicine Creek at Cambridge, NE	1937
Sappa Creek nr Beaver City, NE	1938
Prairie Dog Creek nr Woodruff, KS	1945
White Rock Creek at Lovewell, KS	1946

An analysis of these flows for the pre-development flows indicate a variety of streamflow patterns associated with plains-type runoff highly influenced by spring and summer rainfall events. In the majority of these locations, peak runoff periods occurred during the months of May, June, and July. Most stations display a substantial base flow during the fall and winter months. It is expected that the surface water, ground water intertie is responsible for the sustained base flow during these months.

Present Development Period
1950 through 1993

The period 1950 through 1993 displays the effects of all reservoir, canal systems, and irrigation districts development within the Republican River Basin. As shown in Table 1, most of the reservoirs in the drainage were constructed between 1948 and 1964. The development of these systems has changed the flow patterns in the Republican River due to the irrigation releases, the capturing of flood flows, and the coordination of reservoir operations with the U.S. Army Corps of Engineers during periods of high runoff.

Climate

The precipitation and temperature patterns throughout the basin have not changed significantly during the last 40 years. With the exception of the drought cycles, average annual precipitation and temperature have not changed during the present period of development as compared to the long-term and pre-development periods. In 1993, following several years of sustained drought in the area, record rainfall in July and August produced near record inflows to fill many of the basin reservoirs to record levels. These sudden shifts in the weather patterns are not unusual in the Republican River Basin, and can have significant effects on water availability throughout the area.

Streamflows

Streamflows in the river and creeks below the reservoirs have been influenced by reservoir operations. Traditionally, runoff is captured during the non-irrigation season in an effort to refill the reservoir to the top of the active conservation storage pool. Once the irrigation season begins, releases are made in accordance with the need of the downstream irrigators. These releases are coordinated between the irrigation districts and Reclamation's McCook Field Office. Peak releases are generally made during July and August when precipitation is low and irrigation demands are high due to crop needs. In an effort to conserve storage, it became the practice to minimize releases during the non-irrigation season. For the most part, reservoir releases were eliminated during this period.

Since the late 1960's, groundwater development in the Republican River Basin has increased. The drilling of wells and the use of groundwater has had an adverse effect on the available flow in the rivers above the reservoirs. Because of this development, inflows to Reclamation reservoirs have steadily decreased, influencing the ability to capture non-irrigation streamflows at all reservoirs within the system. In addition, climatological factors, drought and heavy rainfall have affected reservoir operations and the available water supply to the districts. For the most part, the irrigation districts have experienced a reduced water supply.

Water supplies in the tributaries and at streamflow locations upstream of the reservoirs have also shown a decline in the available water supply over the years. This trend can be associated with the increases in diversion due to irrigation, groundwater pumping, conservation practices, and stock ponds developed in the basin.

The combination of increased water usage has led to the decline in the available water supply in the Republican River and its tributary streams.

Future Conditions

Streamflows

It is anticipated that the base flow of main-stem and tributary streamflows will continue to decrease throughout the years, especially if groundwater development is continued.

Table 4
Area I
Average Monthly Total Precipitation
in Inches

Month	1929-1993 Average Inches	1929-1950 Average Inches	1950-1970 Average Inches	1970-1994 Average Inches
January	0.46	0.45	0.33	0.56
February	0.50	0.49	0.45	0.54
March	1.15	1.12	0.89	1.38
April	1.92	2.11	1.45	2.00
May	3.18	3.13	3.10	3.27
June	3.00	3.05	3.01	2.87
July	2.96	2.92	3.14	2.96
August	2.31	2.34	2.40	2.19
September	1.48	1.60	1.60	1.20
October	1.04	1.11	1.02	0.95
November	0.71	0.68	0.47	0.92
December	0.45	0.46	0.41	0.44
Average	19.17	19.46	18.25	19.28

Table 5
Area II
Average Monthly Total Precipitation
in Inches

Month	1929-1993 Average Inches	1929-1950 Average Inches	1950-1970 Average Inches	1970-1994 Average Inches
January	0.47	0.49	0.41	0.48
February	0.62	0.61	0.72	0.53
March	1.40	1.14	1.13	1.94
April	2.14	2.30	1.76	2.20
May	3.45	3.07	3.61	3.86
June	3.53	3.44	3.88	3.24
July	3.08	2.73	3.59	3.19
August	2.75	2.52	2.70	3.06
September	2.20	2.00	2.59	2.15
October	1.35	1.31	1.28	1.43
November	0.88	0.82	0.60	1.17
December	0.53	0.50	0.48	0.56
Average	22.39	20.94	22.75	23.80

Table 6
Area III
Average Monthly Total Precipitation
in Inches

Month	1929-1993 Average Inches	1929-1950 Average Inches	1950-1970 Average Inches	1970-1994 Average Inches
January	0.65	0.69	0.53	0.66
February	0.83	0.91	0.90	0.65
March	1.79	1.48	1.46	2.39
April	2.38	2.49	2.19	2.37
May	3.91	3.39	4.24	4.46
June	4.00	4.02	4.50	3.51
July	3.35	2.81	3.72	3.53
August	3.14	3.17	3.18	3.04
September	2.95	2.61	3.43	3.04
October	1.82	1.70	1.77	2.01
November	1.21	1.21	0.89	1.46
December	0.70	0.70	0.68	0.83
Average	26.79	25.19	27.50	27.94

Table 7
Average Monthly Temperatures
in Degrees Fahrenheit
Area I

Month	1929-1993 Average Degrees	1929-1950 Average Degrees	1950-1970 Average Degrees	1970-1994 Average Degrees
January	27.5	27.5	28.2	26.6
February	32.5	32.2	33.3	32.5
March	39.6	39.6	38.3	40.4
April	50.7	50.5	51.0	50.4
May	60.3	59.8	61.5	59.9
June	70.3	69.7	71.2	70.4
July	76.7	77.0	76.8	76.2
August	74.5	74.5	75.0	74.1
September	65.2	65.2	65.4	64.9
October	53.4	53.5	54.4	52.5
November	38.9	39.1	39.8	37.8
December	30.2	30.1	31.2	29.7
Average	51.7	51.6	52.2	51.3

Table 8
Average Monthly Temperatures
in Degrees Fahrenheit
Area II

Month	1929-1993 Average Degrees	1929-1950 Average Degrees	1950-1970 Average Degrees	1970-1994 Average Degrees
January	25.7	26.6	25.7	24.2
February	31.0	31.6	32.0	29.5
March	39.6	40.7	38.3	39.1
April	51.9	52.4	52.1	51.0
May	61.8	61.9	62.8	60.8
June	71.8	72.2	72.0	71.7
July	77.9	78.9	77.8	76.7
August	75.9	76.9	76.2	74.3
September	66.4	67.5	66.4	64.8
October	54.5	55.4	55.8	52.0
November	39.0	39.8	39.8	37.2
December	29.0	29.9	29.7	27.4
Average	52.8	52.8	52.4	50.7

Table 9
Average Monthly Temperatures
in Degrees Fahrenheit
Area III

Month	1929-1993 Average Degrees	1929-1950 Average Degrees	1950-1970 Average Degrees	1970-1994 Average Degrees
January	26.6	27.6	26.0	25.6
February	31.9	32.8	32.1	31.0
March	41.5	42.2	39.8	42.0
April	54.0	54.3	53.6	53.7
May	63.6	63.4	64.5	63.3
June	73.4	73.9	72.9	73.2
July	79.0	79.8	77.8	78.7
August	77.5	78.3	77.4	76.4
September	68.4	69.6	67.7	67.2
October	56.4	57.6	56.7	54.8
November	40.9	41.5	40.9	39.8
December	30.5	31.2	30.4	29.9
Average	53.6	54.3	56.3	53.0

Attachment C—Coordination

Part I MOU Between the Bureau of Reclamation and the Cooperating Agencies

Part II Corps of Engineers Letter to Bureau of Reclamation

Part I

MOU Between the Bureau of Reclamation and the Cooperating Agencies

OCT 3 0 1995

MEMORANDUM OF AGREEMENT

BETWEEN

U.S. BUREAU OF RECLAMATION

AND THE

U.S. FISH AND WILDLIFE SERVICE
ENVIRONMENTAL PROTECTION AGENCY
NATURAL RESOURCES CONSERVATION SERVICE
NEBRASKA GAME AND PARKS COMMISSION
KANSAS DEPARTMENT OF WILDLIFE AND PARKS
NEBRASKA NATURAL RESOURCE COMMISSION
NEBRASKA DEPARTMENT OF WATER RESOURCES
KANSAS DIVISION OF WATER RESOURCES
KANSAS-BOSTWICK IRRIGATION DISTRICT No. 2
ALMENA IRRIGATION DISTRICT No. 5
FRENCHMAN-VALLEY IRRIGATION DISTRICT
FRENCHMAN-CAMBRIDGE IRRIGATION DISTRICT
BOSTWICK IRRIGATION DISTRICT IN NEBRASKA

I. Background

Water service contracts with the Frenchman-Cambridge Irrigation District, Frenchman-Valley Irrigation District, Bostwick Irrigation District in Nebraska, and Kansas Bostwick Irrigation District No. 2 will expire in 1996 and 1997. The contract for the Almena Irrigation District No. 5 will expire in 2007. The United States proposes to renew water delivery contracts in accordance with current policy and law while examining and attempting to balance contemporary surface water uses within the Republican River Basin giving full consideration to existing constraints.

The contract renewal process will yield three products:

1. Resource Management Assessment (RMA) - This document will identify water-related resources in the Republican River Basin, document their historic and existing conditions, and identify trends or predict future conditions, propose goals and objectives for managing these resources, and provide a framework for development of alternatives for a comprehensive environmental impact statement (EIS).

2. Environmental Impact Statement (EIS) - The requirements of the National Environmental Policy Act (NEPA) must be fulfilled prior to executing water service contracts. The EIS will provide a full discussion of significant environmental impacts associated with the proposed alternative to renew water service contracts. In addition, reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment will also be analyzed.

3. Water Service Contracts - The water service contracts in the Republican River Basin will allow for the continued delivery of project water to irrigable lands in Kansas and Nebraska consistent with Reclamation policies as a water resources management agency.

II. PURPOSE

This Memorandum of Agreement (MOA) defines the specific tasks for Reclamation and the above listed agencies for fulfilling the cooperating agency statutory obligations under Council on Environmental Quality (CEQ) regulations (40 CFR 1501.6). The MOA is between the U.S. Bureau of Reclamation and the U.S. Fish and Wildlife Service, Environmental Protection Agency, Natural Resources Conservation Service, Nebraska Game and Parks Commission, Kansas Department of Wildlife and Parks, Nebraska Natural Resource Commission, Nebraska Department of Water Resources, Kansas Division of Water Resources, Kansas-Bostwick Irrigation District, Almena Irrigation District, Frenchman-Valley Irrigation District, Frenchman-Cambridge Irrigation District, and the Bostwick Irrigation District in Nebraska (hereafter referred to as "cooperating agencies). As the lead agency, the U.S.Bureau of Reclamation (Reclamation) has the responsibility to manage the contract renewal process, assure that the environmental issues relating to the renewal of water service contracts are identified, and environmental compliance with NEPA and other environmental laws are addressed. The cooperating agencies listed are also involved in management and/or environmental compliance responsibilities.

III. PROVISIONS

A. Bureau of Reclamation:

Jill Manring is designated as the primary contact, Dennis Allacher is the alternate contact, to obtain information on the status of the RMA and EIS. Reclamation's role and responsibilities include:

1. Providing the cooperating agencies copies of the documents related to the preparation of the RMA that have been developed to date.

2. Providing advanced notification to the cooperating agencies of the dates and times of meetings concerning project planning, and providing a summary of the meeting.

3. Providing cooperating agencies the opportunity to review the methodology for developing inflows for hydrologic modeling of the Republican River Basin.

4. Providing the cooperating agencies the opportunity to develop management scenario objectives for the RMA and develop alternatives for consideration in the development of the EIS.

5. Providing the cooperating agencies the opportunity to review and comment on administrative drafts of the RMA and EIS.

6. Providing the cooperating agencies the opportunity to review and comment on the data from the aquatic and riparian studies.

B. Cooperating Agencies:

Cooperating agencies will designate an individual as the contact point to obtain information for the RMA and EIS. Cooperating agencies' role and responsibilities include:

1. The opportunity to provide Reclamation with inflows for all of the designated sub-basins. If provided, Reclamation will complete a sensitivity analysis using the provided inflow data.

2. Participating in scheduled cooperating agency meetings. Cooperating agencies are encouraged to attend all scheduled meetings. In the event a cooperating agency can not attend a scheduled meeting, Reclamation requests it be notified in advance of the meeting.

3. The opportunity to provide Reclamation with recommended management scenario(s). The necessary information and data must accompany any recommendation to assist Reclamation evaluate the management scenario(s) for the RMA and alternatives for the EIS.

4. Reviewing and providing any comments on the administrative drafts of the RMA and EIS, and other associated documents.

IV. DURATION OF THE MOA

The duration of this MOA shall be from the date of execution for a period not to exceed the date of execution of the new water service contracts. A cooperating agency may chose to terminate its participation in the MOA upon written notice to Jill Manring, Bureau of Reclamation, P.O. Box 1607, Grand Island, NE 68802.

This agreement may be extended by mutual consent by the parties hereto.

IV. DESIGNATED COOPERATING AGENCY POINTS OF CONTACT

Cooperating Agency	Contact	Telephone	Address
Bureau of Reclamation	Jill Manring (Primary)	308-389-4557	P.O. Box 1607 Grand Island, NE 68802
Bureau of Reclamation	Dennis Allacher (Alternate)	308-345-4400	RR 1 McCook, NE 69001
U.S. Fish and Wildlife Service	Wally Jobman	308-382-6468	203 West 2nd Grand Island, NE 68802
Environmental Protection Agency	Kathy Tortorici	913-551-7435	726 Minnesota Kansas City, KS 66101
Natural Resources Conservation Service	Stephen Chick	402-437-5300	Federal Bldg. Rm. 152 100 Centennial Mall-N Lincoln, NE 68508
Nebraska Game and Parks Commission	Mark Brohman	402-472-0641	P.O. Box 30370 Lincoln, NE 68503
Kansas Department of Wildlife and Parks	Troy Schroeder	913-628-8614	P.O. Box 338 Hays, KS 67601

Nebraska Natural Resource Commission	Dayle Williamson	402-471-2081	P.O. Box 94876 Lincoln, NE 68509
Nebraska Department of Water Resources	Don Blankenau	402-471-0592	P.O. Box 94676 Lincoln, NE 68509
Kansas Division of Water Resources	David Pope	913-296-3717	901 S. Kansas Ave. Topeka, KS 66612
Kansas Water Office	Tom Stiles	913-296-3185	109 SW 9th Suite 300 Topeka, KS 66612
Kansas-Bostwick Irrigation District No. 2	Kenny Nelson	913-374-4514	P.O. Box 165 Courtland, KS 66939
Almena Irrigation District No. 5	Roger DeWitt	913-669-2390	P.O. Box 275 Almena, KS 67622
Frenchman-Valley Irrigation District	Norma Sitzman	308-278-2125	Box 297 Culbertson, NE 69024
Frenchman-Cambridge Irrigation District	Roy Patterson	800-841-0419	P.O. Box 116 Cambridge, NE 69022
Bostwick Irrigation District in Nebraska	Mike Delka	308-746-3424	P.O. Box 446 Red Cloud, NE 68970

V. APPROVAL

R. J. Gyllenborg
Bureau of Reclamation

Steve Anschutz
U.S. Fish and Wildlife Service

Gene Gunn
Environmental Protection Agency

Stephen Chick
Natural Resources Conservation Service

Rex Amack
Nebraska Game and Parks Commission

Dayle Williamson
Nebraska Natural Resources Commission

J. Michael Jess
Nebraska Department of Water Resources

Al LeDoux
Kansas Water Office

John Strickler
Kansas Department of Wildlife and Parks

David Pope
Kansas Division of Water Resources

Louis Allen
Kansas-Bostwick Irrigation District No. 2

David Van Patten
Almena Irrigation District No. 5

Willis Barth
Frenchman-Valley Irrigation District

Ralph Best
Frenchman-Cambridge Irrigation District

W. E. Bean
Bostwick Irrigation District in Nebraska

Part II

Corps of Engineers Letter to Bureau of Reclamation

DEPARTMENT OF THE ARMY

KANSAS CITY DISTRICT, CORPS OF ENGINEERS
700 FEDERAL BUILDING
KANSAS CITY, MISSOURI 64106-2896

Al 8/7

REPLY TO ATTENTION OF:

August 3, 1995

Planning and Hydrologic
Engineering Branch
Engineering and Planning Division

AUG 1995
RECEIVED
Official File Copy
BOR - NKPO
Grand Island, NE

Mr. Robert Gyllenborg
Area Manager
Bureau of Reclamation
Great Plains Region
Nebraska - Kansas Projects Office
P.O. Box 1607
Grand Island, Nebraska 68802-1607

Dear Mr. Gyllenborg:

This is in response to Jill Manring's t lephone request of June 21, 1995, asking the Kansas ity District to participate as a Cooperating Ag cy in the National Environmental Policy Act (NEPA, process for the renewal of Bureau of Reclamation (Reclamation) water service contracts with irrigation districts in the Republican River Basin. During the telephone call, she also requested that we review a draft of a Memorandum of Agreement (MOA) in which the specific tasks for both Reclamation and the Cooperating Agencies are defined.

We agree to participate as a Cooperating Agency under NEPA in Reclamation's Republican River Basin water service contract renewals. However, as discussed at your meeting on June 22, in Grand Island, Nebraska--because of potential impacts to Harlan County Lake, as well as our ongoing Harlan County Lake Study of Future Operations, and previous discussions between our two agencies, we are furnishing this letter defining our role in this process rather than signing the MOA.

My staff is represented on the Republican River Basin Study Team, and is participating in all meetings, and we expect to continue to participate in this manner. Members of my staff have met with Reclamation staff to discuss the inflow and hydrologic model for your study, and we expect to continue to be involved in such discussions as your modeling efforts progress.

Attachment D—Socioeconomic/ Agricultural

Table D-1.—Population—1930, 1950, 1970, 1980, 1990 (Republican River Basin)

	1930	1950	1970	1980	1990	Growth rate 1980-90 (percentage)
Chase, NE	5,484	5,176	4,129	4,758	4,381	-7.92
Cheyenne, KS	6,948	5,668	4,256	3,678	3,243	-11.83
Clay, KS	14,556	11,697	9,890	9,802	9,158	-6.57
Cloud, KS	18,006	16,104	13,466	12,494	11,023	-11.77
Decatur, KS	8,866	6,185	4,988	4,509	4,021	-10.82
Dundy, NE	5,610	4,354	2,926	2,861	2,582	-9.75
Franklin, NE	9,094	7,096	4,566	4,377	3,938	-10.03
Frontier, NE	8,114	5,282	3,982	3,647	3,101	-14.97
Furnas, NE	12,140	9,385	6,897	6,486	5,553	-14.38
Gosper, NE	4,287	2,734	2,178	2,140	1,928	-9.91
Harlan, NE	8,957	7,189	4,357	4,292	3,810	-11.23
Hayes, NE	3,603	2,404	1,530	1,356	1,222	-9.88
Hitchcock, NE	7,269	5,867	4,051	4,079	3,750	-8.07
Jewel, KS	14,462	9,698	6,099	5,241	4,251	-18.89
Kit Carson, CO	9,725	8,600	7,530	7,599	7,140	-6.04
Norton, KS	11,701	8,808	7,279	6,689	5,947	-11.09
Nuckolls, NE	12,629	9,609	7,404	6,726	5,786	-13.98
Perkins, NE	5,834	4,809	3,423	3,637	3,367	-7.42
Phelps, NE	9,261	9,048	9,553	9,769	9,715	-0.55
Phillips, CO	5,797	4,924	4,131	4,542	4,189	-7.77
Rawlins, KS	7,362	5,728	4,393	4,105	3,404	-17.08
Red Willow, NE	13,859	12,977	12,191	12,615	11,705	-7.20
Republic, KS	14,745	11,478	8,498	7,569	6,482	-14.36
Sherman, KS	7,400	7,373	7,792	7,759	6,926	-10.74
Thomas, KS	7,334	7,572	7,501	8,451	8,258	-2.28
Washington, CO	9,591	7,520	5,550	5,304	4,812	-9.28
Webster, NE	10,210	7,395	6,477	4,858	4,279	-11.92
Yuma, CO	13,613	10,827	8,544	9,682	8,954	-7.52
Basin total	266,457	215,507	173,581	169,025	152,925	-9.53
Colorado	1,035,791	1,325,089	2,207,259	2,889,964	3,294,394	13.99
Kansas	1,880,999	1,905,299	2,246,578	2,363,679	2,477,574	4.82
Nebraska	1,378,000	1,326,000	1,483,493	1,569,825	1,578,285	0.55
Tri-State total	4,294,790	4,556,388	5,937,330	6,823,468	7,350,353	7.72
Basin vs. tri-State	6.20%	4.73%	2.92%	2.48%	2.08%	-16.01

Table D-2.—Employment by industry 1970 (Republican River Basin)

	Agriculture	Mining	Construction	Manufacturing	Transportation, communication, public utilities	Wholesale trade	Retail trade	Finance, insurance, real estate	Services	Public adminis-tration	Total	Agriculture (% total)
Chase, NE	575	13	112	37	36	42	274	41	348	91	1,569	36.65
Cheyenne, KS	594	4	90	24	75	68	316	36	394	74	1,675	35.46
Clay, KS	939	28	293	347	213	80	781	142	907	167	3,897	24.10
Cloud, KS	889	22	364	321	409	232	903	223	1,678	233	5,274	16.86
Decatur, KS	607	74	77	85	49	70	339	69	435	91	1,896	32.01
Dundy, NE	406	22	55	45	39	9	191	15	264	76	1,122	36.19
Franklin, NE	612	0	113	61	44	75	320	56	458	108	1,847	33.13
Frontier, NE	766	0	51	41	88	51	192	22	289	86	1,586	48.30
Furnas, NE	686	5	156	93	171	38	495	55	596	77	2,372	28.92
Gosper, NE	335	0	71	46	22	5	60	15	110	38	702	47.72
Harlan, NE	520	9	97	124	60	25	318	51	371	96	1,671	31.12
Hayes, NE	291	10	21	5	5	13	25	5	119	9	503	57.85
Hitchcock, NE	477	9	53	105	76	46	232	26	236	72	1,332	35.81
Jewel, KS	900	0	148	53	81	38	384	59	427	75	2,165	41.57
Kit Carson, CO	915	10	238	105	97	88	541	51	669	105	2,819	32.46
Norton, KS	628	0	270	83	169	62	529	112	808	125	2,786	22.54
Nuckolls, NE	869	0	145	274	155	89	544	85	548	72	2,781	31.25
Perkins, NE	514	5	79	51	93	32	267	18	281	60	1,400	36.71
Phelps, NE	718	21	236	567	286	121	765	127	1,044	104	3,989	18.00
Phillips, CO	509	0	71	72	110	69	215	45	424	77	1,592	31.97
Rawlins, KS	613	4	109	32	66	46	221	56	420	85	1,652	37.11
Red Willow, NE	586	51	353	469	455	149	1,077	214	1,164	168	4,686	12.51
Republic, KS	1,006	0	189	154	186	126	631	63	784	146	3,285	30.62
Sherman, KS	719	0	232	142	308	105	701	106	716	141	3,170	22.68
Thomas, KS	640	0	126	115	272	139	660	80	1,028	119	3,179	20.13
Washington, CO	858	19	125	55	119	47	296	18	439	67	2,043	42.00
Webster, NE	655	0	107	119	101	72	258	37	505	83	1,937	33.82
Yuma, CO	1,151	0	199	73	134	82	614	60	792	120	3,225	35.69
Basin total	18,978	306	4,180	3,698	3,919	2,019	12,149	1,887	16,254	2,765	66,155	28.69
Colorado	38,093	14,232	54,668	120,581	60,688	37,798	145,813	46,409	252,594	54,900	825,776	4.61
Kansas	74,794	10,228	51,423	147,933	64,642	37,873	148,236	40,162	234,528	42,494	852,313	8.78
Nebraska	79,067	2,181	34,070	79,127	44,385	24,917	103,902	29,841	153,406	25,169	576,065	13.73
Tri-State total	191,954	26,641	140,161	347,641	169,715	100,588	397,951	116,412	640,528	122,563	2,254,154	8.52
Basin vs. tri-State	9.89%	1.15%	2.98%	1.06%	2.31%	2.01%	3.05%	1.62%	2.54%	2.26%	2.93%	

Table D-3.—Employment by industry 1980 (Republican River Basin)

	Agriculture	Mining	Construction	Manufacturing	Transportation, communication, public utilities	Wholesale trade	Retail trade	Finance, insurance, real estate	Services	Public adminis- tration	Total	Agriculture (% total)
Chase, NE	592	2	154	84	100	141	289	91	469	96	2,018	29.34
Cheyenne, KS	536	2	80	26	95	102	228	57	412	42	1,580	33.92
Clay, KS	905	24	340	709	232	198	743	143	912	134	4,340	20.85
Cloud, KS	754	31	286	457	357	267	892	192	1,957	172	5,365	14.05
Decatur, KS	552	94	125	63	107	89	279	75	571	50	2,005	27.53
Dundy, NE	399	8	36	61	55	44	114	5	287	47	1,056	37.78
Franklin, NE	685	3	82	73	96	123	230	61	498	69	1,920	35.68
Frontier, NE	570	2	95	53	109	122	126	32	451	53	1,613	35.34
Furnas, NE	585	4	184	249	188	121	415	77	747	93	2,663	21.97
Gosper, NE	386	0	69	75	55	24	87	20	182	36	934	41.33
Harlan, NE	496	11	124	150	81	89	317	66	427	60	1,821	27.24
Hayes, NE	330	0	14	17	29	6	49	0	90	13	548	60.22
Hitchcock, NE	490	67	108	161	110	56	190	45	316	70	1,613	30.38
Jewel, KS	632	3	119	185	96	85	252	88	436	83	1,979	31.94
Kit Carson, CO	1,103	8	202	74	289	253	547	109	804	157	3,546	31.11
Norton, KS	487	17	203	139	237	115	373	95	1,026	146	2,838	17.16
Nuckolls, NE	655	3	146	287	163	235	471	89	687	79	2,815	23.72
Perkins, NE	553	5	109	55	82	99	173	48	397	52	1,573	35.16
Phelps, NE	1,013	18	376	644	276	229	749	231	1,221	95	4,852	20.88
Phillips, CO	631	7	147	70	133	90	323	62	473	85	2,021	31.22
Rawlins, KS	598	26	120	45	61	78	226	75	474	68	1,771	33.77
Red Willow, NE	538	138	446	613	648	415	1,339	251	1,297	212	5,897	9.12
Republic, KS	752	11	200	184	165	162	575	144	819	108	3,120	24.10
Sherman, KS	572	0	185	140	283	166	794	116	1,106	139	3,501	16.34
Thomas, KS	648	92	253	194	316	233	736	180	1,202	107	3,961	16.36
Washington, CO	867	32	184	45	172	105	234	55	473	89	2,256	38.43
Webster, NE	636	13	110	115	113	126	250	69	560	69	2,061	30.86
Yuma, CO	1,398	79	267	119	236	197	803	195	925	114	4,333	32.26
Basin total	18,363	700	4,764	5,087	4,884	3,970	11,804	2,671	19,219	2,538	74,000	24.81
Colorado	42,185	36,632	107,063	192,305	108,668	61,712	236,814	96,725	402,846	77,067	1,362,017	3.10
Kansas	69,466	16,526	64,562	207,474	82,715	51,727	172,495	59,504	306,496	47,776	1,078,741	6.44
Nebraska	77,086	1,754	43,296	99,046	66,834	33,961	120,958	44,014	200,940	28,744	716,633	10.76
Tri-State total	188,737	54,912	214,921	498,825	258,217	147,400	530,267	200,243	910,282	153,587	3,157,391	5.98
Basin vs. tri-State	9.73%	1.27%	2.22%	1.02%	1.89%	2.69%	2.23%	1.33%	2.11%	1.65%	2.34%	

Table D-4.—Employment by industry 1990 (Republican River Basin)

	Agriculture	Mining	Construction	Manufacturing	Transportation, communication, public utilities	Wholesale trade	Retail trade	Finance, insurance, real estate	Services	Public adminis-tration	Total	Agriculture (% total)
Chase, NE	475	8	112	57	88	129	302	89	541	79	1,880	25.27
Cheyenne, KS	393	16	56	28	53	88	237	70	408	76	1,425	27.58
Clay, KS	690	1	315	320	220	235	685	109	1,215	194	3,984	17.32
Cloud, KS	568	9	235	417	305	252	914	217	1,875	209	5,001	11.36
Decatur, KS	491	75	92	73	73	119	229	84	560	58	1,854	26.48
Dundy, NE	452	20	71	19	67	33	181	30	296	33	1,202	37.60
Franklin, NE	491	12	100	60	81	63	202	38	490	80	1,617	30.36
Frontier, NE	542	3	68	61	85	56	192	51	364	67	1,489	36.40
Furnas, NE	585	10	127	168	128	104	298	88	749	95	2,352	24.87
Gosper, NE	311	2	78	72	44	44	126	38	211	51	977	31.83
Harlan, NE	499	8	91	126	98	69	305	63	435	74	1,768	28.22
Hayes, NE	222	0	32	17	35	9	32	9	106	33	495	44.85
Hitchcock, NE	441	34	101	71	107	85	224	36	429	60	1,588	27.77
Jewel, KS	604	0	120	98	80	62	236	79	569	101	1,949	30.99
Kit Carson, CO	811	16	245	108	208	145	568	154	965	110	3,330	24.35
Norton, KS	457	4	141	150	163	57	393	114	830	406	2,715	16.83
Nuckolls, NE	459	10	148	228	195	79	426	111	694	81	2,431	18.88
Perkins, NE	426	0	47	59	102	88	200	51	410	55	1,438	29.62
Phelps, NE	842	12	239	673	337	225	747	167	1,517	123	4,882	17.25
Phillips, CO	527	7	124	71	101	73	274	94	489	64	1,824	28.89
Rawlins, KS	439	18	101	87	58	44	245	67	429	67	1,555	28.23
Red Willow, NE	659	167	362	526	473	292	1,206	266	1,472	160	5,583	11.80
Republic, KS	718	11	183	362	215	124	377	96	805	100	2,991	24.01
Sherman, KS	539	12	184	114	186	129	752	169	1,044	163	3,292	16.37
Thomas, KS	706	94	214	106	222	176	808	186	1,351	129	3,992	17.69
Washington, CO	743	24	170	73	157	62	238	118	499	84	2,168	34.27
Webster, NE	377	7	108	120	98	101	230	59	562	66	1,728	21.82
Yuma, CO	1,107	77	217	110	291	179	730	151	1,020	125	4,007	27.63
Basin total	15,574	657	4,081	4,374	4,270	3,122	11,357	2,804	20,335	2,943	69,517	22.40
Colorado	46,010	20,438	94,849	207,423	133,341	70,951	286,630	119,707	570,739	83,193	1,633,281	2.82
Kansas	61,324	11,554	61,897	196,485	87,555	50,637	193,262	73,632	383,995	51,873	1,172,214	5.23
Nebraska	64,381	2,095	40,821	98,344	62,510	35,726	138,179	52,137	248,611	30,009	772,813	8.33
Tri-State total	171,715	34,087	197,567	502,252	283,406	157,314	618,071	245,476	1,203,345	165,075	3,578,308	4.80
Basin vs. tri-State	9.07%	1.93%	2.07%	0.87%	1.51%	1.98%	1.84%	1.14%	1.69%	1.78%	1.94%	

Table D-5.—Total personal income (Republican River Basin)
($)

	Total personal income (1970)	Total personal income (1980)	Total personal income (1990)
Chase, NE	7,780	53,200	85,100
Cheyenne, KS	7,894	31,300	61,500
Clay, KS	19,786	80,200	142,600
Cloud, KS	24,559	119,600	175,400
Decatur, KS	9,428	47,700	103,300
Dundy, NE	5,417	35,500	60,800
Franklin, NE	13,036	44,000	63,700
Frontier, NE	6,529	33,900	49,700
Furnas, NE	11,888	27,000	100,700
Gosper, NE	3,852	22,600	38,800
Harlan, NE	7,968	43,000	59,600
Hayes, NE	2,151	9,400	27,600
Hitchcock, NE	7,145	41,200	61,600
Jewel, KS	12,515	41,000	69,900
Kit Carson, CO	14,828	65,300	156,300
Norton, KS	14,403	63,700	99,800
Nuckolls, NE	13,865	63,700	91,000
Perkins, NE	8,437	54,000	87,200
Phelps, NE	22,218	124,200	201,100
Phillips, CO	8,710	61,200	77,200
Rawlins, KS	7,142	35,600	66,400
Red Willow, NE	24,465	130,800	193,700
Republic, KS	16,315	64,000	104,400
Sherman, KS	16,295	77,200	128,900
Thomas, KS	15,032	89,100	150,600
Washington, CO	10,260	45,500	103,800
Webster, NE	8,194	42,500	76,600
Yuma, CO	15,659	100,500	191,100
Basin total	335,775	1,647,700	2,828,400
Colorado	5,226,520	33,257,400	62,279,700
Kansas	5,056,268	25,789,900	44,906,200
Nebraska	3,203,558	16,344,500	27,641,200
Tri-State total	13,486,346	75,391,800	134,827,100
Basin vs. tri-State	2.49%	2.19%	2.10%

Table D-6.—Per capita income (Republican River Basin)
($1,000)

	Per capita income (1970)	Per capita income (1980)	Per capita income (1990)
Chase, NE	2,212	5,452	8,978
Cheyenne, KS	2,368	6,700	11,165
Clay, KS	2,584	6,113	11,431
Cloud, KS	2,486	5,720	10,853
Decatur, KS	2,431	6,681	10,609
Dundy, NE	2,768	6,061	10,894
Franklin, NE	2,427	5,872	10,968
Frontier, NE	2,217	6,116	9,611
Furnas, NE	2,312	6,428	9,432
Gosper, NE	2,375	5,786	11,738
Harlan, NE	2,314	5,736	9,721
Hayes, NE	1,923	5,237	13,871
Hitchcock, NE	2,284	2,284	10,689
Jewel, KS	2,587	5,597	9,698
Kit Carson, CO	2,692	5,950	11,385
Norton, KS	2,584	6,232	10,912
Nuckolls, NE	2,204	5,960	9,862
Perkins, NE	3,070	5,979	9,933
Phelps, NE	3,027	7,192	12,837
Phillips, CO	2,706	6,325	10,444
Rawlins, KS	2,094	6,093	10,468
Red Willow, NE	2,591	7,040	11,146
Republic, KS	2,586	5,906	10,890
Sherman, KS	2,716	6,554	10,356
Thomas, KS	2,614	5,762	10,551
Washington, CO	2,426	5,764	10,473
Webster, NE	2,172	5,758	9,339
Yuma, CO	2,393	5,958	10,713
Basin total	2,470	5,973	10,677
Colorado	3,106	7,998	14,821
Kansas	2,929	7,350	13,300
Nebraska	2,797	6,936	12,452
Tri-State total	2,944	7,428	13,524
Basin vs. tri-State	83.90%	80.41%	78.95%

TABLE D-7.-- Farms, cropland, and irrigated cropland
(Republican River Basin) 1992

	Farms	Land in farms	Average size farm	Total cropland			Harvested cropland			Irrigated land		
				Farms	Acres	Average	Farms	Acres	Average	Farms	Acres	Average
Chase, NE	368	521,389	1,417	329	319,652	972	309	205,219	664	239	158,256	662
Cheyenne, KS	426	592,207	1,390	388	387,156	998	350	153,633	439	115	38,949	339
Clay, KS	600	380,969	635	538	285,980	532	515	189,528	368	58	11,282	195
Cloud KS	613	407,464	665	564	290,932	516	515	80,085	156	61	10,046	165
Decatur, KS	439	526,064	1,198	395	341,950	866	383	176,764	462	64	7,257	113
Dundy. NE	308	528,731	1,717	283	230,003	813	259	136,789	528	188	89,431	476
Franklin, NE	444	323,315	728	377	191,138	507	349	135,858	389	247	73,268	297
Frontier, NE	419	526,476	1,257	373	231,617	621	362	149,321	412	196	54,024	276
Furnas, NE	459	430,972	939	410	287,315	701	399	171,580	430	194	42,528	219
Gosper, NE	282	229,703	815	236	141,974	602	219	95,370	435	164	60,387	368
Harlan, NE	385	305,724	794	345	209,297	607	319	133,176	417	208	61,210	294
Hayes, NE	273	401,978	1,472	228	195,200	856	211	101039	479	109	32,236	296
Hitchcock, NE	379	403,584	1,065	331	250,985	758	314	126,259	402	128	26,257	205
Jewel, KS	659	484,823	736	601	240,801	401	576	226,980	394	31	7,079	228
Kit Carson, CO	718	1,341,738	1,869	627	832,154	1,327	533	402,326	755	286	139,413	487
Norton, KS	420	465,527	1,108	381	290,649	763	359	152,127	424	42	6,553	156
Nuckolls, NE	541	333,488	616	483	255,048	528	468	175,446	375	155	42,369	273
Perkins, NE	479	532,901	1,113	452	450,965	998	431	242,334	562	215	107,459	500
Phelps, NE	578	375,771	650	530	380,022	717	514	255,245	497	475	219,586	462
Phillips, CO	375	459,659	1,226	345	399,883	1,159	334	229,826	688	150	80,426	536
Rawlins, KS	494	641,109	1,298	469	422,853	902	442	174,962	396	79	10,819	137
Red Willow, NE	425	439,475	1,034	361	254,350	705	340	156,775	461	161	42,309	263
Republic, KS	746	443,290	594	679	338,521	499	661	247,281	374	176	45,947	261
Sherman, KS	500	620,144	1,240	462	501,970	1,087	389	186,076	478	217	84,268	388
Thomas, KS	547	702,549	1,284	514	595,036	1,158	459	242,179	528	184	84,836	461
Washington, CO	784	1,333,577	1,701	676	826,205	1,222	597	339,189	568	137	44,242	323
Webster, NE	448	307,527	686	380	194,601	512	360	128,593	357	134	36,034	269
Yuma, CO	932	1,433,111	1,538	733	696,322	950	687	425,401	619	459	271,781	592
Basin total	14,041	15,493,265	1,103	12,490	10,042,579	804	11,654	5,439,361	467	4,872	1,888,252	388
Colorado	27,152	33,983,029	1,252	21,882	10,933,484	500	18,573	5,532,964	298	15,193	3,169,839	209
Kansas	63,278	46,672,188	738	56,389	31,119,250	552	52,348	18,794,787	359	6,543	2,680,343	410
Nebraska	52,923	44,393,129	839	46,348	22,402,132	483	43,879	16,146,818	368	19,328	6,311,633	327
Tri-State total	143,353	125,048,346	2,828	124,619	64,454,866	1,535	114,800	40,474,569	1,025	41,064	12,161,815	

TABLE D-8.-- Farms, cropland, and irrigated cropland
(Republican River Basin) 1987

	Farms	Land in farms	Average size farm	Total cropland			Harvested cropland			Irrigated land		
				Farms	Acres	Average	Farms	Acres	Average	Farms	Acres	Average
Chase,NE	468	534,369	1,142	413	324,459	786	393	193,967	494	282	141,786	503
Cheyenne,KS	493	619,870	1,257	454	403,719	889	426	176,293	414	151	40,651	269
Clay, KS	672	392,321	584	614	283,874	462	586	176,217	301	49	10,626	217
Cloud KS	659	397,383	603	611	293,364	480	583	184,007	316	76	10,139	133
Decatur,KS	486	543,466	1,118	452	356,393	788	438	175,861	402	92	10,433	113
Dundy. NE	389	536,373	1,379	337	231,710	688	320	133,396	417	208	82,673	397
Franklin,NE	523	354,603	678	456	209,053	458	436	128,483	295	308	67,735	220
Frontier, NE	496	537,240	1,083	448	254,240	568	427	140,652	329	253	54,318	215
Furnas, NE	539	461,029	855	471	297,260	631	459	174,247	380	228	42,337	186
Gosper, NE	345	255,541	741	307	151,763	494	289	88,135	305	198	53,852	272
Harlan, NE	465	318,942	686	421	211,983	504	409	130,450	319	253	61,472	243
Hayes, NE	317	403,549	1,273	279	197,627	708	269	105447	392	141	32,662	232
Hitchcock, NE	426	429,342	1,008	396	252,303	637	379	127,408	336	170	29,279	172
Jewel, KS	736	502,106	682	669	354,217	529	647	208,645	322	52	7,087	136
Kit Carson, CO	793	1,415,879	1,785	715	829,732	1,160	671	434,547	648	320	124,475	389
Norton, KS	470	507,626	1,080	439	323,300	736	415	154,827	373	54	5,893	109
Nuckolls, NE	621	336,016	541	562	251,966	448	548	160,670	293	218	44,617	205
Perkins, NE	591	570,445	965	563	474,119	842	549	257,885	470	250	107,187	429
Phelps,NE	616	371,405	603	562	297,923	530	548	214,195	391	491	187,427	382
Phillips, CO	417	450,277	1,080	386	366,028	948	367	194,641	530	157	70,283	448
Rawlins, KS	541	641,810	1,186	506	414,811	820	497	196,707	396	72	11,547	160
Red Willow, NE	489	451,724	924	430	268,969	626	411	152,348	371	209	46,837	224
Republic, KS	833	440,215	528	765	342,576	448	736	230,517	313	232	45,220	195
Sherman, KS	524	625,942	1,195	487	497,494	1,022	470	251,334	535	246	83,424	339
Thomas, KS	644	677,199	1,052	606	585,763	967	592	296,047	500	218	73,546	337
Washington, CO	854	1,391,208	1,629	761	841,362	1,106	720	416,082	578	140	39,547	282
Webster, NE	508	300,215	591	453	193,369	427	430	112,941	263	143	23,378	163
Yuma, CO	975	1,478,313	1,516	854	709,868	831	777	395,529	509	494	246,116	498
Basin total	15,890	15,944,408	1,003	14,417	10,219,245	709	13,792	5,611,478	407	5,705	1,754,547	308
Colorado	27,284	34,048,433	1,248	22,334	10,988,853	492	19,446	5,522,216	284	14,913	3,013,773	202
Kansas	68,579	46,628,519	680	61,615	31,385,090	509	57,822	17,729,394	307	7,352	2,463,073	335
Nebraska	60,502	45,305,441	749	53,500	23,320,162	436	51,175	15,276,151	299	22,596	5,681,835	251
Tri-State total	156,365	125,982,393	2,677	137,449	65,694,105	1,437	128,443	38,527,761	889	44,861	11,158,681	

TABLE D-9.-- Farms, cropland, and irrigated cropland
(Republican River Basin) 1982

	Farms	Land in farms	Average size farm	Total cropland			Harvested cropland			Irrigated land		
				Farms	Acres	Average	Farms	Acres	Average	Farms	Acres	Average
Chase,NE	433	529,444	1,223	398	314,108	789	389	219,853	565	273	155,845	571
Cheyenne,KS	546	602,726	1,104	509	393,440	773	491	197,174	402	161	44,496	276
Clay, KS	719	365,074	508	668	253,377	379	647	189,827	293	60	11,090	185
Cloud,KS	726	403,290	555	663	279,045	421	642	214,074	333	70	9,146	131
Decatur,KS	516	535,067	1,037	472	338,557	717	459	172,683	376	94	9,548	102
Dundy. NE	382	557,748	1,460	345	217,685	631	326	143,449	440	197	75,512	383
Franklin,NE	530	321,908	607	462	192,804	417	444	139,422	314	287	76,446	266
Frontier, NE	463	506,564	1,094	421	226,591	538	400	146,508	366	226	61,087	270
Furnas, NE	520	433,715	834	465	273,271	588	450	175,475	390	212	41,794	197
Gosper, NE	324	247,071	763	294	147,201	501	278	103,836	374	199	59,714	300
Harlan, NE	453	322,720	712	414	198,037	478	396	138,206	349	245	58,646	239
Hayes, NE	328	416,738	1,271	297	183,433	618	292	118137	405	141	33,029	234
Hitchcock, NE	443	408,346	922	407	228,153	561	398	134,582	338	176	31,847	181
Jewel, KS	808	510,447	632	741	346,850	468	719	249,175	347	52	7,074	136
Kit Carson, CO	763	1,298,079	1,701	679	771,661	1,136	634	418,519	660	297	119,847	404
Norton, KS	517	513,265	993	477	308,192	646	458	170,487	372	64	6,255	98
Nuckolls, NE	624	347,973	558	575	253,248	440	556	184,698	332	194	43,055	222
Perkins, NE	547	547,991	1,002	516	446,324	865	502	252,070	502	230	98,555	429
Phelps,NE	588	384,896	655	545	294,455	540	532	249,097	468	489	214,318	438
Phillips, CO	427	463,171	1,085	394	391,582	994	386	238,242	617	158	89,246	565
Rawlins, KS	621	686,471	1,105	591	443,868	751	579	217,218	375	95	17,719	187
Red Willow, NE	474	442,051	933	414	255,350	617	400	162,113	405	216	53,351	247
Republic, KS	923	441,118	478	855	328,149	384	831	259,275	312	208	42,871	206
Sherman, KS	550	672,254	1,222	529	543,516	1,027	512	296,853	580	261	104,010	399
Thomas, KS	628	658,558	1,049	591	558,816	946	575	307,900	535	196	84,216	430
Washington, CO	854	1,365,488	1,599	756	777,328	1,028	709	401,630	566	141	46,600	330
Webster, NE	500	297,482	595	465	192,455	414	449	132,943	296	153	28,724	188
Yuma, CO	996	1,416,155	1,422	818	D	0	775	419,954	542	467	273,605	586
Basin total	16,203	15,695,810	969	14,761	9,157,496	620	14,229	6,053,400	425	5,562	1,897,646	341
Colorado	27,111	33,537,998	1,237	22,421	10,552,383	471	20,061	6,036,679	301	15,232	3,200,942	210
Kansas	73,315	47,052,213	642	66,481	30,598,859	460	62,860	20,186,974	321	7,257	2,675,167	369
Nebraska	60,243	44,961,371	746	54,475	22,434,059	412	52,497	17,075,625	325	22,190	6,039,292	272
Tri-State total	160,669	125,551,582	2,625	143,377	63,585,301	1,343	135,418	43,299,278	947	44,679	11,915,401	

TABLE D-10.-- Farms, cropland, and irrigated cropland
(Republican River Basin) 1974

	Farms	Land in farms	Average size farm	Total cropland Farms	Total cropland Acres	Total cropland Average	Harvested cropland Farms	Harvested cropland Acres	Harvested cropland Average	Irrigated land Farms	Irrigated land Acres	Irrigated land Average
Chase,NE	407	515,964	1,268	375	251,798	671	368	173,656	472	227	92,461	407
Cheyenne,KS	541	599,232	1,108	515	377,414	733	498	200,898	403	145	35,818	247
Clay, KS	830	382,483	461	782	267,090	342	754	195,383	259	72	10,031	139
Cloud,KS	847	429,991	508	810	309,096	382	791	232,222	294	74	11,614	157
Decatur,KS	574	533,152	929	538	339,799	632	517	157,537	305	73	7,746	106
Dundy. NE	391	528,519	1,352	362	179,499	496	352	125,338	356	185	37,261	201
Franklin,NE	575	337,794	587	541	178,186	329	531	127,722	241	243	41,088	169
Frontier, NE	513	506,564	987	469	217,802	464	458	143,069	312	179	37,490	209
Furnas, NE	594	441,524	743	548	269,443	492	530	159,110	300	207	33,940	164
Gosper, NE	338	243,432	720	322	138,822	431	310	94,113	304	169	41,297	244
Harlan, NE	504	337,408	669	478	207,168	433	463	139,976	302	235	41,853	178
Hayes, NE	335	408,599	1,220	322	179,848	559	308	107433	349	101	18,018	178
Hitchcock, NE	470	432,495	920	455	234,862	516	444	128,880	290	181	28,500	157
Jewel, KS	914	521,962	571	859	336,719	392	834	238,480	286	78	8,270	106
Kit Carson, CO	842	1,373,716	1,631	788	729,229	925	756	402,652	533	343	124,259	362
Norton, KS	590	487,098	826	554	298,505	539	537	152,466	284	62	5,042	81
Nuckolls, NE	694	355,752	513	663	244,123	368	651	176,360	271	207	32,168	155
Perkins, NE	546	521,825	956	526	408,783	777	519	220,774	425	134	39,377	294
Phelps,NE	637	347,722	546	609	268,396	441	603	216,995	360	503	148,573	295
Phillips, CO	444	467,309	1,052	412	217,896	529	412	217,896	529	143	60,942	426
Rawlins, KS	641	652,163	1,017	611	400,378	655	545	238,292	437	81	12,466	154
Red Willow, NE	520	432,510	832	464	235,449	507	437	135,673	310	220	38,144	173
Republic, KS	1,074	428,584	399	1,035	325,980	315	1,006	246,930	245	229	36,164	158
Sherman, KS	544	617,347	1,135	524	442,928	845	512	263,277	514	225	78,895	351
Thomas, KS	648	728,330	1,124	627	559,114	892	621	308,210	496	142	46,547	328
Washington, CO	906	1,381,515	1,525	838	753,195	899	812	380,293	468	141	46,600	330
Webster, NE	595	315,693	531	564	180,122	319	543	121,633	224	152	18,424	121
Yuma, CO	1,065	1,433,473	1,346	955	649,074	680	886	365,958	413	432	173,029	401
Basin total	17,579	15,762,156	897	16,546	9,200,718	556	15,998	5,671,226	354	5,183	1,306,017	252
Colorado	25,501	35,902,165	1,408	22,792	10,512,521	461	21,049	5,956,865	283	12,324	2,788,746	226
Kansas	79,188	47,945,722	605	74,306	29,984,268	404	70,573	19,870,535	282	6,569	2,007,801	306
Nebraska	67,597	46,172,012	683	63,040	22,212,756	352	60,660	16,309,434	269	20,075	3,957,232	197
Tri-State total	172,286	130,019,899	2,696	160,138	62,709,545	1,217	152,282	42,136,834	833	38,968	8,753,779	

TABLE D-11.-- Farms, cropland, and Irrigated cropland
(Republican River Basin) 1964

	Farms	Land in farms	Average size farm	Total cropland Farms	Total cropland Acres	Total cropland Average	Harvested cropland Farms	Harvested cropland Acres	Harvested cropland Average	Irrigated land Farms	Irrigated land Acres	Irrigated land Average
Chase,NE	459	541,388	1,179	432	258,779	599	418	130,334	312	118	17,511	148
Cheyenne,KS	622	674,210	1,084	597	417,494	699	577	191,078	331	104	13,538	130
Clay, KS	1,039	423,380	407	968	265,396	274	952	199,221	209	47	3,636	77
Cloud,KS	1,002	432,410	432	955	304,063	318	940	203,947	217	69	6,637	96
Decatur,KS	692	566,415	819	664	323,075	487	651	159,380	245	75	5,666	76
Dundy. NE	426	555,283	1,303	399	189,842	476	384	112,380	293	109	13,962	128
Franklin,NE	745	359,172	482	689	184,756	268	674	110,265	164	259	24,789	96
Frontier, NE	622	587,579	945	606	244,293	403	604	147,315	244	106	11,635	110
Furnas, NE	790	454,770	576	741	274,243	370	727	152,439	210	249	21,498	86
Gosper, NE	432	277,196	642	413	139,741	338	413	91,946	223	168	21,937	131
Harlan, NE	606	351,509	580	578	210,920	365	569	123,945	218	187	18,710	100
Hayes, NE	367	463,167	1,262	360	185,740	516	356	100034	281	69	6,137	89
Hitchcock, NE	561	434,852	775	532	223,616	420	530	121,780	230	182	21,395	118
Jewel, KS	1,084	525,263	485	1,027	318,058	310	1,013	216,132	213	79	5,685	72
Kit Carson, CO	760	1,272,624	1,675	735	698,506	950	693	265,468	383	213	56,576	266
Norton, KS	757	550,170	727	715	314,339	440	696	161,365	232	57	3,176	56
Nuckolls, NE	858	356,889	416	819	230,570	282	806	156,882	195	219	24,179	110
Perkins, NE	597	567,847	951	575	420,537	731	571	207,787	364	46	5,166	112
Phelps,NE	802	348,960	435	773	249,359	323	768	168,445	219	582	88,586	152
Phillips, CO	460	479,093	1,042	438	353,903	808	417	136,770	328	42	6,400	152
Rawlins, KS	679	685,808	1,010	659	384,787	584	655	191,364	292	51	4,564	89
Red Willow, NE	641	449,402	701	608	256,408	422	598	137,756	230	223	27,188	122
Republic, KS	1,268	450,170	355	1,187	299,053	252	1,174	218,317	186	235	23,467	100
Sherman, KS	517	640,142	1,238	503	453,231	901	486	205,251	422	108	23,223	215
Thomas, KS	632	728,074	1,152	620	569,577	919	614	252,876	412	72	9,990	139
Washington, CO	885	1,431,132	1,617	846	715,379	846	816	286,172	351	105	12,040	115
Webster, NE	730	337,862	463	699	196,060	280	688	114,941	167	132	10,465	79
Yuma, CO	1,009	1,456,038	1,443	933	562,259	603	881	264,891	301	158	20,175	128
Basin total	20,042	16,400,805	818	19,071	9,243,984	485	18,671	4,828,481	259	4,064	507,931	125
Colorado	29,798	38,258,626	1,284	27,103	9,629,384	355	24,938	4,725,734	189	18,317	2,690,018	147
Kansas	92,440	50,271,117	544	86,535	29,421,414	340	84,171	18,160,353	216	5,102	1,004,210	197
Nebraska	80,163	47,792,663	596	75,386	22,099,510	293	73,758	15,229,112	206	18,833	2,169,317	115
Tri-State total	202,401	136,322,406	2,424	189,024	61,150,308	988	182,867	38,115,199	612	42,252	5,863,545	

TABLE D–12.–– Farms, cropland, and irrigated cropland
(Republican River Basin) 1954

	Farms	Land in farms	Average size farm	Total cropland Farms	Total cropland Acres	Total cropland Average	Harvested cropland Farms	Harvested cropland Acres	Harvested cropland Average	Irrigated land Farms	Irrigated land Acres	Irrigated land Average
Chase, NE	612	555,426	908	•561	264,928	472	558	171,627	308	68	7,736	114
Cheyenne, KS	787	654,794	832	752	400,160	532	729	203,797	280	30	1,863	62
Clay, KS	1,335	401,047	300	1,258	256,014	204	1,249	213,832	171	18	1,036	58
Cloud KS	1,338	418,857	313	1,284	276,926	216	1,263	242,458	192	17	1,145	67
Decatur, KS	870	572,704	658	849	322,246	380	843	195,856	232	14	826	59
Dundy, NE	527	564,451	1,071	486	207,475	427	479	146,826	307	66	6,601	100
Franklin, NE	908	360,198	397	872	192,905	221	867	154,263	178	109	8,290	76
Frontier, NE	873	609,056	698	835	259,935	311	833	184,691	222	39	9,674	248
Furnas, NE	1,003	449,118	448	936	265,319	283	927	184,006	198	174	9,674	56
Gosper, NE	559	274,283	491	545	147,155	270	542	109,777	203	124	12,505	101
Harlan, NE	764	334,164	437	731	204,628	280	729	142,988	196	72	4,696	65
Hayes, NE	436	432,252	991	429	188,830	440	427	127,803	299	45	3,731	83
Hitchcock, NE	683	426,479	624	639	223,728	350	632	136,320	216	143	14,759	103
Jewel, KS	1,553	521,786	336	1,423	325,026	228	1,414	277,752	196	15	679	45
Kit Carson, CO	1,085	1,374,159	1,267	1,036	778,237	751	884	264,599	299	47	4,396	94
Norton, KS	993	532,670	536	948	321,960	340	940	204,041	217	38	2,584	68
Nuckolls, NE	1,172	354,052	302	1,078	233,238	216	1,071	199,984	187	117	9,363	80
Perkins, NE	685	559,952	817	673	415,381	617	666	233,375	350	26	3,061	118
Phelps, NE	998	341,828	343	961	253,100	263	958	199,376	208	573	63,982	112
Phillips, CO	560	515,597	921	545	348,102	639	541	202,209	374	14	1,940	139
Rawlins, KS	813	691,410	850	788	392,591	498	780	203,472	261	16	1,562	98
Red Willow, NE	828	452,512	547	772	252,039	326	759	164,687	217	104	7,144	69
Republic, KS	1,705	442,791	260	1,603	313,947	196	1,583	267,857	169	31	1,734	56
Sherman, KS	573	630,597	1,101	564	439,595	779	556	231,993	417	12	934	78
Thomas, KS	731	741,285	1,014	702	562,001	801	697	301,608	433	7	868	124
Washington, CO	1,162	1,384,642	1,192	1,094	690,801	631	1,055	339,169	321	105	10,750	102
Webster, NE	1,013	343,470	339	966	217,356	225	956	166,166	174	46	3,036	66
Yuma, CO	1,307	1,476,580	1,130	1,238	579,444	468	1,200	343,747	286	64	5,117	80
Basin total	25,873	16,416,160	634	24,568	9,333,067	380	24,138	5,814,279	241	2,134	199,686	94
Colorado	40,749	38,385,234	942	37,070	11,062,683	298	33,599	5,219,689	155	23,355	2,262,921	97
Kansas	120,167	50,023,538	416	110,350	29,577,170	268	107,602	21,440,232	199	2,736	331,551	121
Nebraska	100,846	47,486,580	471	95,570	22,867,514	239	94,580	18,874,341	200	12,500	1,171,369	94
Tri–State total	261,762	135,895,352	1,829	242,990	63,507,367	806	235,781	45,534,262	554	38,591	3,765,841	

TABLE D-13.-- Farms, cropland, and irrigated cropland
(Republican River Basin) 1949

	Farms	Land in farms	Average size farm	Total cropland Farms	Total cropland Acres	Total cropland Average	Harvested cropland Farms	Harvested cropland Acres	Harvested cropland Average	Irrigated land Farms	Irrigated land Acres	Irrigated land Average
Chase,NE	599	551,863	921	585	272,963	467	571	139,376	244	29	3,176	110
Cheyenne,KS	768	629,729	820	753	399,664	531	726	169,223	233	9	432	48
Clay, KS	1,506	400,954	266	1,407	265,505	189	1,383	229,560	166	0	0	
Cloud KS	1,549	420,845	272	1,416	283,614	200	1,392	250,037	180	2	18	9
Decatur,KS	939	552,403	588	909	319,449	351	897	174,158	194	8	331	41
Dundy. NE	558	575,525	1,031	542	219,058	404	536	142,212	265	43	4,100	95
Franklin,NE	1,037	353,725	341	973	196,506	202	951	156,709	165	41	2,259	55
Frontier, NE	916	608,296	664	897	262,225	292	893	189,635	212	5	500	100
Furnas, NE	1,103	446,115	404	1,038	272,476	263	1,007	171,974	171	51	2,558	50
Gosper, NE	608	278,513	458	592	150,292	254	588	114,889	195	69	5,998	87
Harlan, NE	833	345,474	415	802	216,117	269	792	154,578	195	46	2,599	57
Hayes, NE	474	460,105	971	469	200,489	427	465	133,450	287	11	1,344	122
Hitchcock, NE	703	429,324	611	672	226,095	336	661	137,337	208	118	11,065	94
Jewel, KS	1,749	537,579	307	1,636	352,881	216	1,615	287,464	178	2	80	40
Kit Carson, CO	1,067	1,253,327	1,175	1,041	650,871	625	1,020	355,500	349	8	1,530	191
Norton, KS	1,064	536,116	504	1,030	311,877	303	1,011	169,717	168	12	220	18
Nuckolls, NE	1,191	350,811	295	1,136	244,083	215	1,122	209,801	187	44	2,686	61
Perkins, NE	735	557,917	759	706	416,961	591	689	222,683	323	3	135	45
Phelps,NE	1,054	33,678	32	999	248,412	249	988	209,051	212	517	48,542	94
Phillips, CO	593	485,035	818	565	373,407	661	561	208,654	372	7	2,089	298
Rawlins, KS	875	698,706	799	850	401,433	472	832	194,064	233	0	0	
Red Willow, NE	863	453,047	525	826	257,869	312	812	163,396	201	67	4,430	66
Republic, KS	1,876	436,922	233	1,686	304,241	180	1,666	269,673	162	1	45	45
Sherman, KS	603	717,264	1,189	582	526,670	905	560	261,126	466	4	293	73
Thomas, KS	755	688,205	912	735	537,062	731	686	256,521	374	4	270	68
Washington, CO	1,263	1,402,362	1,110	1,206	687,928	570	1,186	397,856	335	82	8,505	104
Webster, NE	1,130	350,790	310	1,077	226,730	211	1,059	173,615	164	20	960	48
Yuma, CO	1,436	1,449,140	1,009	1,358	578,254	426	1,346	358,667	266	33	1,586	48
Basin total	27,847	16,003,770	575	26,488	9,403,132	355	26,015	5,900,926	227	1,236	105,751	86
Colorado	45,578	37,953,099	833	42,103	11,027,572	262	40,497	6,892,904	170	27,121	2,872,348	106
Kansas	131,394	48,611,366	370	1,231,081	29,439,625	24	117,481	21,493,734	183	1,166	138,686	119
Nebraska	107,183	47,466,828	443	102,525	23,776,470	232	100,984	19,406,990	192	9,680	876,259	91
Tri-State total	284,155	134,031,293	1,646	1,375,709	64,243,667	518	258,962	47,793,628	545	37,967	3,887,293	
Basin vs tri-State	9.80%	11.94%	34.93%	1.93%	14.64%	68.57%	10.05%	12.35%	41.59%	3.26%	2.72%	

Attachment D

Table D-14.—Tax base (Republican River Basin)

	Total agricultural taxable ($)	Total taxable ($)	Agricultural vs. total taxable (%)
Chase, NE	174,601,591	281,482,379	62.03
Cheyenne, KS	50,245,196	97,452,369	51.56
Clay, KS	49,261,314	174,386,972	28.25
Cloud, KS	46,790,662	165,286,830	28.31
Decatur, KS	39,420,586	91,695,761	42.99
Dundy, NE	125,512,124	169,134,469	74.21
Franklin, NE	174,375,215	230,922,609	75.51
Frontier, NE	162,392,310	210,689,021	77.08
Furnas, NE	152,142,725	226,281,967	67.24
Gosper, NE	144,867,702	190,074,048	76.22
Harlan, NE	136,367,175	202,567,950	67.32
Hayes, NE	95,331,371	115,043,793	82.87
Hitchcock, NE	115,667,233	190,207,912	60.81
Jewel, KS	57,671,078	84,289,513	68.42
Kit Carson, CO	33,228,570	69,630,640	47.72
Norton, KS	33,530,843	99,327,147	33.76
Nuckolls, NE	170,468,000	250,799,860	67.97
Perkins, NE	169,816,339	237,293,940	71.56
Phelps, NE	393,254,445	635,700,275	61.86
Phillips, CO	21,218,720	39,603,780	53.58
Rawlins, KS	46,561,046	81,316,318	57.26
Red Willow, NE	146,082,478	374,971,611	38.96
Republic, KS	58,520,896	126,852,681	46.13
Sherman, KS	62,990,918	185,451,210	33.97
Thomas, KS	66,056,677	219,623,490	30.08
Washington, CO	32,553,030	68,658,270	47.41
Webster, NE	138,714,845	193,977,798	71.51
Yuma, CO	40,795,130	101,446,700	40.21
Basin total	2,938,438,219	5,114,169,313	57.46
Colorado	687,304,530	29,831,046,660	2.30
Kansas	4,886,862,468	63,946,045,651	7.64
Nebraska	18,432,100,466	56,207,563,555	32.79
Tri-State total	24,006,267,464	149,984,655,866	16.01
Basin vs. tri-State	12.24%	3.41%	

Attachment E—Administration

Part I Republican River Compact

Part II Water Rights - General

Part III Republican Basin Water Rights

Part IV Operating Agreement

Part V Lease Agreements

Part I

Republican River Compact

REPUBLICAN RIVER COMPACT

The Republican River Compact of 1942 is an agreement between the States of Colorado, Nebraska, and Kansas, governing the waters of the Republican River and its tributaries and providing for their most efficient use. Specific allocations in acre-feet are made to each state derived from the computed average annual virgin water supply originating in the following designated drainage subbasins of the Republican River Basin, in the amounts shown:

North Fork of the Republican River drainage basin in Colorado, 44,700 acre-feet
Arikaree River drainage basin, 19,610 acre-feet
Buffalo Creek drainage basin, 7,890 acre-feet
Rock Creek drainage basin, 11,000 acre-feet
South Fork of the Republican River drainage basin, 57,200 acre-feet
Blackwood Creek drainage basin, 6,800 acre-feet
Driftwood Creek drainage basin, 7,300 acre-feet
Red Willow Creek drainage basin in Nebraska, 21,900 acre-feet
Medicine Creek drainage basin, 50,800 acre-feet
Beaver Creek drainage basin, 16,500 acre-feet
Sappa Creek drainage basin, 21,400 acre-feet
Prairie Dog Creek drainage basin, 27,600 acre-feet
The North Fork of the Republican River in Nebraska and the main stem of the Republican River between the junction of the North Fork and the Arikaree River and the lowest crossing of the river at the Nebraska-Kansas State line and the small tributaries thereof, 87,700 acre-feet

Should the computed annual virgin water supply of any source vary more than 10 percent from the original compact virgin water supply as set forth above, the following allocations made from the above water sources shall be increased or decreased in the relative proportions such that the future yearly computed virgin water supply bears to the computed virgin water supply used above.

A total of 54,100 acre-feet of water is allocated for beneficial consumptive use in Colorado annually to be derived from the sources in the amount specified below and is subject to such quantities being physically available from the sources:

North Fork of the Republican River drainage basin, 10,000 acre-feet
Arikaree River drainage basin, 15,400 acre-feet
South Fork of the Republican River drainage basin, 25,400 acre-feet
Beaver Creek drainage basin, 3,300 acre-feet
In addition, for beneficial consumptive use in Colorado annually, the entire water supply of the Frenchman Creek drainage basin in Colorado and of the Red Willow Creek drainage basin in Colorado.

For beneficial consumptive use in Nebraska, 234,500 acre-feet of water is allocated annually. This water is to be derived from the sources in the amounts specified below and again is subject to such quantities being physically available from the sources:

North Fork of the Republican River drainage basin in Colorado, 11,000 acre-feet
Frenchman Creek drainage basin in Nebraska, 52,800 acre-feet
Rock Creek drainage basin, 4,400 acre-feet
Arikaree River drainage basin, 3,300 acre-feet
Buffalo Creek drainage basin, 2,600 acre-feet
South Fork of the Republican River drainage basin, 800 acre-feet
Driftwood Creek drainage basin, 1,200 acre-feet
Red Willow Creek drainage basin in Nebraska, 4,200 acre-feet
Medicine Creek drainage basin, 4,600 acre-feet
Beaver Creek drainage basin, 6,700 acre-feet
Sappa Creek drainage basin, 8,800 acre-feet

Prairie Dog Creek drainage basin, 2,100 acre-feet
From the North Fork of the Republican River in Nebraska, the main stem of the Republican River between the junction of the North Fork and Arikaree River and the lowest crossing of the river at the Nebraska-Kansas State line, from the small tributaries thereof, and from water supplies of upstream basins otherwise unallocated herein, 132,000 acre-feet

Within Kansas, a total of 190,300 acre-feet of water is allocated for beneficial consumptive use and is to be derived from the sources in the amounts specified below and likewise is subject to such quantities being physically available from the sources:

Arikaree River drainage basin, 1,000 acre-feet
South Fork of the Republican River drainage basin, 23,000 acre-feet
Driftwood Creek drainage basin, 500 acre-feet
Beaver Creek drainage basin, 6,400 acre-feet
Sappa Creek drainage basin, 8,800 acre-feet
Prairie Dog Creek drainage basin, 12,600 acre-feet
From the main stem of the Republican River upstream from the lowest crossing of the river at the Nebraska-Kansas State line and from water supplies of upstream basins otherwise unallocated herein, 138,000 acre-feet provided that Kansas shall have the right to divert all or any portion thereof at or near Guide Rock, Nebraska

In addition, there is hereby allocated for beneficial consumptive use in Kansas, annually, the entire water supply originating in the basin downstream from the lowest crossing of the river at the Nebraska-Kansas State line.

WATER RIGHTS LAW

The Republican River Basin is located within the States of Colorado, Nebraska, and Kansas. Each state has specific water rights laws which govern the use of both surface and ground water. The following summarizes the laws by which each state appropriates its surface water and ground water supply.

Colorado Water Rights Law

Surface Water

Water rights in the State of Colorado follow what is known as the Colorado Doctrine which is based upon the principle of appropriation for beneficial use. Under this law, the entire flow of a stream can be diverted from its natural watercourse provided the water is used beneficially.

Water rights are established at general adjudication proceedings in the District Courts. In these proceedings, the first date of beneficial use is determined for each claimant to water, and priority numbers are assigned to appropriators in chronological order. Thus, the appropriator with No. 1 priority on the stream has first right and can force all appropriators above him to allow all flows required to satisfy his appropriation to pass by.

Water rights are divided into two classes--direct-flow and storage. Direct-flow rights are decreed in terms of a given quantity per unit of time, usually cubic feet per second. In most cases, these rights do not specifically limit the period during which diversion can be made; however, limitations are imposed in that the water must be used beneficially. Water obtained under such rights may not be stored but must be used as diverted. Storage rights are decreed in terms of cubic feet or acre-feet, and the total decree is usually equal to the capacity of the reservoir. It is only in unusual cases that a reservoir is allowed more than one filling a year.

Prior to 1936, the practice was to give direct-flow rights precedence over storage rights regardless of priority date, and storage rights were denied water if direct-flow rights required the water for immediate beneficial use. In 1935, a case involving relative priority dates of direct-flow and storage rights was brought before the court, and a decision was rendered in favor of the junior direct-flow user. In 1936, this decision was reversed by the Colorado Supreme Court, which stated in part . . . "The effect of the reversal being to deny preference to either group otherwise than on a basis of priority. The individual priority of an appropriation governs regardless of its classification as a direct flow or storage right."[1] In most cases, this ruling has little effect on present practices since most storage rights are junior in time to direct-flow rights. However, it does protect present storage decrees against future direct-flow decrees.

Another provision recognized in Colorado laws concerning water rights is the right of exchange. Under such practice, decreed water from one source on a stream may be passed down the stream in exchange for water at some other point, usually higher on the stream. This is allowed only if the exchange is not detrimental to other rights on the stream.

Water rights are administered under the authority of the State Engineer by division engineers and water commissioners who apportion the waters of the streams to the appropriators, in order of priority, until the supply is exhausted. The State is divided geographically into seven divisions. Each division consists of a major or part of a major river basin and operates

[1] 98 Colorado. 505; 57 Pac. 2 894-1936

under the supervision of a division engineer. The seven divisions, which include the watershed areas of the tributaries to the major streams, are divided into 70 districts. Each district is under the administration of a water commissioner who is responsible to the division engineer.

Ground Water

Ground water in the State of Colorado is, like surface water, subject to the law of appropriation. This water is characterized as either tributary to a natural stream or not tributary to a major stream.

Tributary ground water includes seepage, underflow, or percolating water, if that water would eventually become a part of a natural stream. A natural stream's waters include water in the unconsolidated alluvial aquifer of sand, gravel, and other sedimentary materials, and other waters hydraulically connected which can influence the rate or direction of movement of the water in that stream. Water rights for tributary water wells must be adjudicated in order to be given priority as to their actual dates of initiation. Ground water is classified as tributary if its withdrawal will significantly deplete any adjacent streams within 100 years at its adjudicated rate of withdrawal as specified on the well permit application.

Nontributary ground water includes all subsurface waters which are not hydraulically connected to any adjacent surface streams and whose withdrawal will not affect the rate or direction of movement of the water in those surface streams. Nontributary ground-water appropriation is based on the area of an applicant's property to which the water is to be put to beneficial use, the estimated quantity of water stored in the aquifer(s) underlying the applicant's property, the estimated annual rate of recharge, the estimated use of ground water in the area, and the number of users drawing water at the time of determination. If there are no unappropriated waters in the designated source, or if the appropriation would unreasonably impair existing water rights, then the application is denied. If the proposed appropriation will not unreasonably impair existing rights, then the permit is granted, subject to any specified conditions or limitations.

Kansas Water Rights Law

Surface Water

As part of the early development of the State, Kansas adopted the riparian common law doctrine to govern the use and enjoyment of the State's water resources. In 1886, the appropriation doctrine was first recognized,[1] and in 1891, it was recognized as applying to the portion of the state west of the ninety-ninth meridian.[2] In 1944, the courts recognized only the common law doctrine of riparian rights and definitely stated that the Division of Water Resources, State Board of Agriculture, could not appropriate water.[3] In 1945, House Bill No. 322, an appropriation act, was passed by the Kansas legislature for the control of state water. This law became effective June 28, 1945,[4] and the constitutional validity of this law was upheld in a decision of the Kansas Supreme Court on June 11, 1949.

[1] Kansas Gen. Stats., 1935, sec. 42-101.

[2] Kansas Gen. Stats., 1935, sec. 42-301.

[3] State, ex-rel-v. Board of Agriculture, 158, Kan. 603 (1944).

[4] Sections of 82A-701 to 82A-722, 1945 Suppl. to the General Statutes of Kansas, effective June 28, 1945.

The general administrative control of water rights has been vested in the Division of Water Resources, Kansas State Board of Agriculture. This division is administered by the chief engineer, who is charged with the responsibility of administering the statutes governing the appropriation and distribution of the water.

The Water Appropriation Act was amended by the legislature of 1957. This amendment clarified the 1945 Water Appropriation Act in several respects and made some important changes in the law.

Some of the principles established by the Kansas law are:

1. All water within the State is dedicated to the use of the people of the State.

2. Water may be appropriated subject to vested rights.

3. No person may acquire an appropriation right to the use of water of the State for other than domestic purposes without making application to the chief engineer for permit to make such appropriation.

4. A "vested right" is defined to be the right of a person under common law or statutory claim to continue the use of water having actually been applied to beneficial use on or before June 28, 1945.

Ground Water

Kansas ground water, since the adoption of the water code of 1945, is now subject to State administration and control. Prior to this enactment, ground water belonged to the owner of the land overlying it for use as he wished. However, ground water hydraulically connected to a surface stream never belonged to the overlying landowner, but has always been governed by appropriation. The 1945 act dedicated all of the unallocated water to the use of the people of the State and provided that rights, except for domestic use, could only be acquired by filing an application for a permit with the State Chief Engineer. All prior water rights were protected if the ground water was previously put to beneficial use or put to beneficial use within a reasonable time after the act was passed. The owner of an existing right did not acquire a vested right to the existing water level. In considering the effect of new applications on existing ground-water rights, the act specified that impairment is limited to the unreasonable raising or lowering of the static water level. The approval of each application is subject to the express condition that the water right must allow for a reasonable raising or lowering of the static water level.

Special provisions relate to artesian rights. Water obtained by an artesian well and put to beneficial use is considered to be appropriated. In addition, regulation of the drilling, construction, and use of artesian water is specified.

Nebraska Water Rights Law

Surface Water

Nebraska law distinguishes between surface water and water flowing in a definite channel with a bed and banks or sides. Surface water may be retained by the owner upon whose land it falls, so long as it has not become part of a watercourse or natural lake. The latter category, including floodwaters, is subject to the complex interaction of Nebraska's dual approach to water rights.

The Riparian Doctrine states that each landowner may enjoy the use of streams flowing past his land provided that this use does no injury downstream. Because this doctrine made no provision for consumptive uses such as irrigation, many of the semiarid western states, including Nebraska, modified the doctrine to apply a new rule of "reasonable use." Contrary to prevalent application in the United States, Nebraska has ruled that one requirement for vesting of a riparian right is ownership of part of the streambed. Another Nebraska limitation is that all excess flow must be returned to the watercourse from which it was withdrawn.

The Appropriation System is defined as a doctrine whereby a property interest in the use of a definite quantity of streamflow may be acquired by diverting and applying it to a beneficial use. Subsequent to the act of 1895, an appropriation is obtained by applying to the Department of Water Resources, which then decides whether an unappropriated water supply does exist and whether granting the appropriation would be detrimental to the public welfare. Although the Nebraska Constitution, Article XV, Section 6, states that the right to divert unappropriated waters for beneficial use may be denied "when such denial is demanded by the public interest," the provision is omitted from Nebraska revised statutes, Section 46-204, which states that "the right to divert unappropriated waters of every natural stream beneficial use shall never be denied." The right once granted is attached to the lands upon which it is to be used. Prior to the 1895 act, rights were acquired by the simple act of diverting water and could be transferred or assigned in the same manner as any other property.

After, and only after, all the water in a watercourse has been allocated for use under the water rights system of the state, constitutional and legislative authority provide a means for a superior use to take preference over an inferior use. This procedure of acquisition is an exercise of the power of eminent domain. Accompanying this power, however, is the obligation to adequately compensate the deprived party. In Nebraska, domestic uses have preference over all other uses, and agricultural uses have preference over manufacturing uses and the generation of electric power.

Conflicting claims as to the better right in law between appropriators seeking water for the same purpose, and hence not subject to the Preference System, are subject to the principle that first in time is first in right. Between riparians, the common-law doctrine of reasonable use governs their relative rights to the water.

Between a riparian and an appropriator, early Nebraska court decisions found for the superiority of the appropriator. In 1966, however, the courts laid down a different ruling. It appears that hereafter the court intends to consider and decide water right disputes between riparians and appropriators on the basis of equity, having now recognized that both sides possess equally protected interests. Since the preference system applies only to appropriators, riparians may seek the protection of equitable remedy regardless of the contesting use.

Ground Water

Before 1963, the Nebraska Court followed the "reasonable use" rule as a guide to a landowner's right to appropriate ground water. There was no requirement that a permit be obtained by an appropriator of ground water. A ground-water code adopted in 1963 defines this water as water which occurs, seeps, filters, or percolates through the ground under the surface. Due to the fact that pumping water for irrigation near streams may affect those streams, the legislature required appropriators to secure a permit in such a situation from the Nebraska Department of Water Resources before initiating such use. The department may take into consideration the effect of the pumping on the amount of water in the stream, and the ability of the stream to meet the requirements of appropriators from the stream. Municipalities receive a special preference for domestic use.

RECLAMATION IRRIGATION DIVISIONS WATER RIGHT FILINGS

Within the Republican River Basin of Colorado, Kansas, and Nebraska are located four divisions of the Pick-Sloan Missouri Basin Program (figure 1). These are the Upper Republican, Frenchman-Cambridge, Kanaska, and Bostwick Divisions. A list of the applications for permit to appropriate water within these four divisions is provided in table 1. These applications, or water right filings are for both the storage of water within the eight storage facilities utilized to supply the irrigation divisions and for the application of water on the districts' lands.

Upper Republican Division

The Upper Republican Division contains the Armel Unit, which consists of Bonny Reservoir and Hale Ditch. This unit is located in eastern Colorado on the South Fork of the Republican River. A water right to store 351,460 acre-feet in Bonny Reservoir was filed in November 1950. As this water right filing exceeds the conservation storage of the reservoir, it was likely based on a larger proposed structure rather than the present Bonny Reservoir. The Bonny Reservoir water right is now in state court and should be reduced when it becomes adjudicated.

Originally, irrigation was to have been one of the benefits derived from Bonny Reservoir; however, later investigations disclosed that an economically feasible plan for Federal development could not be formulated within the 24,000-acre area previously studied. As a result, Bonny Reservoir's conservation space was sold to the State of Colorado for fish, wildlife, and recreation use. The only land irrigated by this reservoir is the 750 acres of nonproject land located south of the river and supplied by the Hale Ditch. The State of Colorado operates a fish hatchery and manages a wildlife habitat on 400 acres of the nonproject land.

Frenchman-Cambridge Division

The Frenchman-Cambridge Division is located in southwestern Nebraska and extends from Palisade southeastward along the Frenchman River and from Swanson Lake eastward along the Republican River to Harlan County Lake.

Storage facilities for this division consist of Enders Reservoir and Swanson, Hugh Butler, and Harry Strunk Lakes. Irrigation releases are made from all reservoirs to the stream for diversion into downstream canal systems. In addition, irrigation releases are made from Swanson Lake directly into the Meeker-Driftwood system canal. Enders Reservoir, Swanson Lake, Hugh Butler Lake, and Harry Strunk Lake are located on the Frenchman River, Republican River, Red Willow Creek, and Medicine Creek, respectively. Water right filings and their associated priority dates for these reservoirs are as follows:

Enders Reservoir, 44,079 acre-feet, May 1946
Swanson Lake, 122,800 acre-feet, July 1951
Hugh Butler Lake, 38,400 acre-feet, July 1951 and August 1960 (2 filings)
Harry Strunk Lake, 40,000 acre-feet, May 1946

Four irrigation districts are located within the Frenchman-Cambridge Division. These are the Meeker-Driftwood Unit, the Frenchman Unit, the Red Willow Unit, and the Cambridge Unit.

The Meeker-Driftwood Unit, which is served by the Meeker-Driftwood Canal, is located along the south side of the Republican River immediately below Swanson Lake in Hitchcock and Red Willow Counties. Water right filings have been made for this unit providing for the irrigation of 34,783 acres.

The Frenchman Unit is served by the Culbertson Canal and the Culbertson Canal Extension. Water for this irrigation district is stored in Enders Reservoir, located on the Frenchman River near Enders, Nebraska. It is located along the north side of the Frenchman River between the Culbertson

Diversion Dam and Culbertson, Nebraska, and on the north side of the Republican River from near Culbertson to just east of McCook, Nebraska. Water right filings for this unit provide for the irrigation of 43,022 acres.

A third irrigation district, the Red Willow Unit, is served by Red Willow and Bartley Canals. Hugh Butler Lake, located on Red Willow Creek north of McCook, Nebraska, and the Republican River, are the source of water for these canals.

Red Willow Canal serves lands along the north side of the Republican River from the confluence of Red Willow Creek and the Republican River to Cambridge, Nebraska. The lands irrigated by the Bartley Canal are located on the south side of the Republican River between the confluence of Red Willow Creek, and the Cambridge Diversion Dam. Water is diverted to the Bartley Canal at the Bartley Diversion Dam, located 2 miles southeast of Indianola, Nebraska. Water right filings for the Red Willow Canal and Bartley Canal supplied portions of the Red Willow Unit and provided for the irrigation of 11,943 acres and 13,086 acres, respectively.

The Cambridge Unit is served by the Cambridge Canal and is located in the Republican River Valley between the towns of Cambridge and Alma, Nebraska, in Furnas and Harlan Counties. The water supply for this canal is obtained from water stored in Harry Strunk Lake and from natural flow of the Republican River. Irrigation water is released from Harry Strunk Lake and flows down Medicine Creek to the Republican River, where it is then diverted from the Republican River approximately 2 miles east of Cambridge, Nebraska. Water rights filed for the Cambridge Unit provide for the irrigation of 34,994 acres.

Kanaska Division

The Kanaska Division, located along Prairie Dog Creek in north-central Kansas, contains the Almena Unit, which consists of Keith Sebelius Lake and the Almena Irrigation District. A water right to store 36,700 acre-feet within Keith Sebelius Lake was filed in February 1957. The corresponding Almena Irrigation District has water right filings which provide for irrigation of 5,350 acres.

Bostwick Division

The Bostwick Division is located in south-central Nebraska and north-central Kansas. It extends from Harlan County Lake, located on the Republican River in Nebraska, to Concordia, Kansas, and includes lands on both sides of the Republican River.

Water for the Bostwick Division is stored in Harlan County Lake in Nebraska and Lovewell Reservoir located on White Rock Creek in Kansas. A water right to store 350,000 acre-feet in Harlan County Lake was filed in January 1948. Lovewell Reservoir has a water right which was filed in October 1955 and provides for the storage of 41,690 acre-feet. Of this storage within Lovewell, 19,700 acre-feet annually can be supplied from White Rock Creek with the remaining to come from the Republican River through canal diversion.

Three irrigation districts are located within the Bostwick Division. These are the Franklin Unit, the Superior-Courtland Unit, and the Lower Courtland Unit.

The Franklin Unit is served by the Franklin and Naponee Canals which divert water directly from Harlan County Lake and by the Franklin South Side Pump Canal, which receives water from the Republican River through a pumping station 17 miles downstream from the reservoir. The Franklin Canal runs from Harlan County Lake along the north side of the Republican River to a point 47.9 miles east. Water right filings associated with this canal allow for the irrigation of 22,760 acres of the Franklin Unit. Along the south side of the Republican River, the Naponee Canal extends eastward from Harlan County Lake. Related water right filings provide for the irrigation of 3,604 acres of the Franklin Unit.

The Franklin Pump Canal located on the south side of the river is 4.9 miles in length. Associated water right filings provide for the irrigation of 4,243 acres within the Franklin Unit.

The Superior-Courtland Unit is served by the Superior and Courtland Canals which originate at the Superior-Courtland Diversion Dam located on the Republican River in Nebraska. The Courtland Canal serves the Superior-Courtland Unit in both Nebraska and Kansas. The Superior Canal begins at the north side of the Superior-Courtland Diversion Dam and continues 30 miles eastward through Webster and Nuckolls Counties, Nebraska, to near the Nebraska-Kansas State line. It's water right filings provide for the irrigation of 14,235 acres north of the Republican River within the Nebraska portion of the Superior-Courtland Unit. The Courtland Canal originates at the south side of the Superior-Courtland Diversion Dam and follows the Republican River past the Nebraska-Kansas State line to Lovewell Reservoir in Kansas. Water right filings associated with this canal provide for the irrigation of 4,335 acres in Nebraska, and 12,771 acres in Kansas, of the Superior-Courtland Unit.

The Lower Courtland Unit is served by the Lower Courtland Canal which is located in Republic and Jewell Counties, Kansas. Water is diverted from Lovewell Reservoir and conveyed southeast to the vicinity of Courtland, Kansas. Water right filings for this unit provide for the irrigation of 27,329 acres.

NONPROJECT WATER RIGHTS FILINGS FOR THE REPUBLICAN RIVER BASIN

Application for permit to appropriate surface water for beneficial use in the Republican River drainage has been summarized from the Kansas State Board of Agriculture, Division of Water Resources; Colorado State Engineer's Office; and the Nebraska State Department of Water Resources (table 2). Ground-water rights have been summarized in a supporting document and are not dealt with here. As the four divisions of the Pick-Sloan Missouri Basin Program located in the Republican River Basin have previously been discussed, they are not included in this summary. These applications are for the use of surface water taken from the Republican River Basin.

Part II

Water Rights - General

KANSAS WATER RIGHTS GENERAL
REPUBLICAN RIVER BASIN

General: Generally, water rights are a matter of state law, not federal law. Water is considered to be the property of the state. An individual may acquire a right to the use of water by obtaining a state water right. Under Section 8 of the 1902 Reclamation Act, the Bureau of Reclamation is required to conform with state law and ensure that state water rights are acquired for each of its projects.

System: Kansas is an appropriation state. The Kansas Water appropriation Act, passed in 1945, provides for two types of water rights; vested rights and appropriation rights. A vested right is the right to continue the use of water actually applied to beneficial use on or before June 28, 1945 (the date the act was effective). An appropriation right is a right, acquired pursuant to the provisions of the Water Appropriation Act, to divert from a definite water supply a specific quantify of water at a specific rate of diversion and apply such water to a specific beneficial use or uses in preference to all appropriation rights of later date. Although the 1945 act established a process for acquiring a water right based on the principle of prior appropriation, the act did not make it illegal to appropriate water without a permit.

In 1978, the act was amended to make it illegal to appropriate or threaten to appropriate water without the prior approval of the chief engineer of the Division of Water Resources. Also in 1978, the act was amended to require all persons claiming a vested right to file a verified claim with the chief engineer by July 1, 1980.

A water right is appurtenant to and severable from the land as soon as beneficial use is made of the water pursuant to an approved application. The Certificate of Appropriation is evidence of the extent to which a water appropriation right has been perfected.

Administrative Agency/Body: The State Board of Agriculture, Division of Water Resources administers the water within the State.

State Board of Agriculture
Division of Water Resources
109 SW Ninth St.
Topeka, KS 66612-1283
(913) 296-3717

Permits: Required for surface water and groundwater (Kansas Water Appropriation Act)

Change is Use, Buying-Selling: Prior approval of the Chief Engineer is required for a transfer of ownership of a water right only if the water rights is severed from the land that is the authorized place of use for that right. Prior approval of the Chief Engineer is required for a change in the place of use, type of use, or point of diversion, whether or not there is a change in ownership involved.

Preference System: Where uses of water for different purposes conflict such uses shall conform to the following preference order: Domestic, municipal, irrigation, industrial, recreation and water power uses. However, the date of priority of an appropriation right, and not the purpose of use determines the right to divert. The preference system is applied when necessary by condemnation (higher public interest).

Groundwater: Five ground water management districts have formed in the south-central and western parts of the State. These districts develop management programs and recommend rules and regulations to the chief engineer to implement policies necessary to the conservation and management of ground water supplies. Mandatory metering, well-spacing restrictions, safe yield criteria, enforcement against water waste and other programs have been used to protect ground water supplies. Kansas' ground water management laws also expand the chief engineer's authority to manage and regulate water use in area of serious ground water decline. These areas are called Intensive Ground Water Use Control Areas. The chief engineer has designated several such areas, in which more restrictive measures now apply. Reductions in authorized quantity, multi-year allocation systems, mandatory metering and conservation plans are examples of corrective control provisions that have been implemented in these areas.

Instream Flow: The Appropriation Act established minimum desirable streamflow requirements MDS(levels set by law for particular streams and rivers). Water right applications received after April 12, 1984, are considered to be junior in priority to these minimum desirable streamflow requirements. In the event that MDS seems seriously threatened, the Kansas Water Office has the responsibility of requesting the chief engineer to administer rights to protect the MDS. The Reblublican River has MDSs established at Concordia and Clay Center.

Abandonment: Any water right shall be deemed abandoned and terminated when without due and sufficient cause no lawful beneficial use is made of the water for three successive years.

Disputes: Disputes are handled by the Chief Engineer and/or general court.

Safe Yield Concept: Two criteria the chief engineer must consider in evaluating applications are (1) whether the proposed use will impair an existing permit or water right and (2) whether the proposed use will adversely affect the public interest. One key factor in determining whether there will be an adverse affect on the public interest is whether a proposed use will meet safe yield. This standard refers to the long-term heath of the system, basically looking to balance the amount of water being used under existing permits and water rights with the system's ability to restore its supply. If safe yield cannot be met, an application will be denied. Because most areas of the State are either near safe yield, fully appropriated or over-appropriated, the likelihood of obtaining approval of new application is questionable.

Compact: Republican River Compact, 1942. A compact providing a division of water between the states of Nebraska, Kansas and Colorado. The compact allocates specific quantities of water to Colorado, Nebraska, and Kansas.

Reclamation Policy: Our policy in Kansas has been to let the contracting agency (irrigation district or municipality) make the water right filings and take the necessary steps to perfect them. This has been true for both direct flow and storage rights. Most of the earlier filings that were in the name of the United States have been cancelled in favor of later filings by irrigation districts.

NEBRASKA WATER RIGHTS, GENERAL
REPUBLICAN RIVER BASIN

General: Generally, water rights are a matter of state law, not federal law. Water is considered to the property of the state. An individual may acquire a right to the use of water by obtaining a state water right. Under Section 8 of the 1902 Reclamation Act, the Bureau of Reclamation is required to conform with state law and ensure that state water rights are acquired for each of its projects.

System: Nebraska is an appropriation state but a few riparian rights do exist as a results of court decisions.

Administrative Agency/Body: The Department of Water Resources administers the water within the State.

Department of Water Resources
301 Centennial Mall South
P.O. Box 94676
Lincoln, NE 68509-4676
(402) 471-2363

Permits: Required for surface water and not required for groundwater, but well must be registered. Well permits are required in control areas.

Change in Use, Buying Selling: Generally water rights may be transferred in location only, not for different use. Transfers of existing surface water rights are permitted by the Department of Water Resources under limited circumstances by legislation passed in 1983. Existing rights cannot be transferred for use in a different river basin and the purpose of the use cannot be changed. For example, an agricultural right could be transferred to another agricultural user but not to an industrial user. In addition, other water users must not be harmed by the transfer. Transfers of surface water from one type of use to another can occur only through the exercise of a "preference." This type of transfer is not a transfer of a right from one user to another. The preferred user must already have a right. The "preference" only grants the right to interfere with another's use and is normally temporary in nature, occurring only when water is insufficient for both users (Refer to the Report on the Water and Water rights Transfers Study, State of Nebraska, Water Management Board, November 1988).

Preference System: Courts have required recognition of preference for out-of-priority use with compensation to senior appropriators. This system operates secondarily to the priority system. Domestic use is given preference over all other uses, and agriculture has preference over manufacturing and power uses. However, a junior preferred user doesn't have the right to water being used by a senior but subordinate user, unless that user is compensated for damages.

Groundwater: Groundwater is not allocated, but three local areas do require permits before large capacity wells can be drilled. Recent laws have also been passed to recognize incidental and intentional underground storage of surface water. The Ground Water Management and Protection Act gives authority to twenty-four natural resources districts to establish ground water control and management areas. Well spacing, rotation of pumping, water allocation and moratoriums on drilling are some of the management alternatives described in the act. Best management practices are also required to protect water quality. Several "control" and "management" areas have been established in Nebraska to protect ground water resources by providing a means to regulate withdrawals and prevent the leaching of agricultural chemicals.

Instream Flow: Instream flow rights may be obtained in a manner similar to other surface rights. They are given a priority date like all other rights and are regulated accordingly. Only a natural resource district or the Nebraska Game and Parks Commission may apply for instream flow rights.

Disputes: Initially handled by The Department of Water Resources, with appeal going forward to the Court.

Adjudication Procedure: Nebraska law provides that the Department of Water Resources examine water appropriations to determine if water rights are being used and whether all diversions of water are legally valid. This process, which began in the late 1960s, is Nebraska's water adjudication procedure. To accomplish adjudication, the state was divided into sub-basins. Every water appropriation was investigated within approximately fifteen years, except those owned by irrigation districts and canal companies. In 1983, investigations of irrigation districts and canal companies were begun. This process continues to the present time. The Nebraska adjudication process involves seven steps: (1) a record search, (2) investigation, (3) review of the investigation report, (4) public notice, (5) a hearing, (6) a decision and (7) appeals and rehearing.

Compact: Republican River Compact, 1942. A compact providing a division of water between the states of Nebraska, Kansas and Colorado. The compact allocates specific quantities of water to Colorado, Nebraska, and Kansas.

Reclamation Policy: As a rule, all natural flow or direct flow rights were filed for by the irrigation districts. Storage and storage use rights were filed for by the United States Bureau of Reclamation. The storage rights for Reclamation reservoirs in Nebraska were filed for multiple use.

Part III

Republican Basin Water Rights

REPUBLICAN BASIN WATER RIGHTS
Reservoirs/Lakes/Canals

UNIT DISTRICT	WATER RIGHT ENTITY	FACILITY /1	WATER SOURCE	WATER RIGHT FILING			ADJUDICATION QUANTITY	PRIORITY DATE	WATER RIGHT TYPE /2
				QUANTITY	USES	NUMBER			
NEBRASKA Frenchman–Cambridge	United States	Enders Reservoir 04–05N–37W, Chase	Frenchman River	44,079 AF	Multi–Use	3899	----	5–1946	SI
Division Frenchman Unit	United States	Culbertson Canal 31–05N–33W, Hayes	Frenchman–Cambridge Div. Reservoirs		Irrigation	6225H	10,957 Acres	4–1954	SI
					Irrigation	9782	9,514 Acres	12–1959	SI & SO
					Irrigation	15839	767 Acres	4–1981	SI
	Frenchman Valley Irrig. Dist.	Culbertson Canal 31–05N–33W, Hayes	Frenchman River	134.5 cfs 9,416.3 acres	Irrigation	D24–25 29–30	9,160.4 Acres	5–1890	IR
	Frenchman Valley Irrig. Dist.	Culbertson Canal 31–05N–33W, Hayes	Frenchman River	1.9 cfs 132.0 acres	Irrigation	9802	132 Acres	3–1960	IR
	H&RW Irrig. Dist.	Culbertson & Culbertson Ext. Canal 31–05N–33W, Hayes	Frenchman River	17.5 cfs 1,491.0 Acres	Irrigation	3869AR	1,415 Acres	4–1946	IR
				142.6 cfs 9,985.0 acres	Irrigation	6214	9,576 Acres	4–1954	IR
				2.2 cfs 157.0 acres	Irrigation	9697	2.2 cfs 157 Acres	3–1959	IR
				9.9 cfs 692.0 acres	Irrigation	13016	683 Acres	4–1974	IR
				0.9 cfs 60.0 acres	Irrigation	14249	60 Acres	6–1976	IR
				43.0 acres	Irrigation	15678	24 Acres	7–1980	IR

REPUBLICAN BASIN WATER RIGHTS
Reservoirs/Lakes/Canals

UNIT DISTRICT	WATER RIGHT ENTITY	FACILITY /1	WATER SOURCE	WATER RIGHT FILING QUANTITY	USES	NUMBER	ADJUDICATION QUANTITY	PRIORITY DATE	WATER RIGHT TYPE /2
Frenchman–Cambridge Div. Continued	United States	Harry Strunk Lake 25–05N–26W, Frontier	Medicine Creek	40,000 AF	Multi–Use	3900	------	5–1946	ST
Cambridge Unit	United States	Cambridge Canal 27–04N–25W, Furnas	Frenchman–Cambridge Div. Reservoirs		Irrigation	6225L	14,262 Acres	4–1954	SI
	Frenchman–Cambridge Irr. Dist	Cambridge Canal 27–04N–25W, Furnas	Republican River	184.5 cfs 18,450 acres	Irrigation	3869E	14,094 Acres	4–1946	IR
				7.2 cfs 724 acres	Irrigation	6218	447 Acres	4–1954	IR
				3.2 cfs 220 acres	Irrigation	9479	217 Acres.	4–1957	IR
				1.9 cfs 132 acres	Irrigation	9763	119 Acres	9–1959	IR
				6.5 cfs 456 acres	Irrigation	10591	448 Acres	3–1965	IR
				3.9 cfs 270 acres	Irrigation	11041	250 Acres	2–1967	IR
				11.7 cfs 828 Acres	Irrigation	12067	812 Acres	8–1970	IR
				4.1 cfs 286 Acres	Irrigation	12200	259 Acres	4–1971	IR
				1.7 cfs 117 Acres	Irrigation	13228	97 Acres	10–1974	IR
				2.8 cfs 179 Acres	Irrigation	14181	161 Acres	4–1976	IR
				1.5 cfs 105 Acres	Irrigation	15131	77 Acres	10–1977	IR
	United States	Cambridge Canal 27–04N–25W, Furnas	Frenchman–Cambridge Div. Reservoirs	301 Acres	Irrigation	15804	300 Acres	3–1981	IR
				2,695 acres	Irrigation	14159	2,642 Acres	4–1976	SI
				291 acres	Irrigation	15814	300 Acres	3–1981	SI
				77 acres	Irrigation	15137	77 Acres	11–1977	SI

REPUBLICAN BASIN WATER RIGHTS
Reservoirs/Lakes/Canals

UNIT DISTRICT	WATER RIGHT ENTITY	FACILITY /1	WATER SOURCE	WATER RIGHT FILING QUANTITY	USES	NUMBER	ADJUDICATION QUANTITY	PRIORITY DATE	WATER RIGHT TYPE /2
Frenchman–Cambridge Div. Continued	United States	Swanson Lake 08–02N–33W, Hitchcock	Republican River	122,800 AF	Multi–Use	4884	----	7–1951	ST
Meeker–Driftwood Unit	United States	Meeker–Driftwood Canal 08–02N–33W, Hitchcock	Frenchman–Cambridge Div. Reservoirs		Irrigation	6225G	14,508 AF	4–1954	SI
					Irrigation	14157	2,098 AF	4–1976	SI
					Irrigation	15138	107 Acres	11–1977	SI
				140 Acres	Irrigation	15811	137 Acres	3–1981	SI
	United States	Meeker–Driftwood Canal 08–02N–33W, Hitchcock	Republican River	41.88 cfs 2,930 Acres	Irrigation	D4,7–9	2,709 Acres	12–1890	IR
	Frenchman–Cambridge Irr. Dist.	Meeker–Driftwood Canal 08–02N–33W, Hitchcock	Republican River	46.96 cfs 4,226 Acres	Irrigation	3869BR	2,569 Acres	4–1946	IR
				1.47 cfs 132 Acres	Irrigation	3887CR	92 Acres	4–1946	IR
				125.61 cfs 10,049 Acres	Irrigation	6213	9,170 Acres	4–1954	IR
	Frenchman–Cambridge Irr. Dist.	Meeker–Driftwood Canal 08–02N–33W, Hitchcock	Republican River	2.67 cfs 257 Acres	Irrigation	9690	197 Acres	2–1959	IR
				8.91 cfs 624 acres	Irrigation	9911	500 Acres	3–1961	IR
				1.09 76 acres	Irrigation	10590	56 Acres	3–1965	IR
				0.86 cfs 60 acres	Irrigation	11946	60 Acres	5–1970	IR
				1,284 acres	Irrigation	13227	1,272 Acres	10–1974	IR
				13 acres	Irrigation	14180	13 Acres	4–1976	IR
				141 acres	Irrigation	15130	107 Acres	10–1977	IR
				140 acres	Irrigation	15805	110 Acres	3–1981	IR
	United States	Bartley Canal 17–03N–27W, Red Willow	Frenchman–Cambridge Div. Reservoirs		Irrigation	6225K	6,228 Acres	4–1954	SI

REPUBLICAN BASIN WATER RIGHTS

Reservoirs/Lakes/Canals

UNIT DISTRICT	WATER RIGHT ENTITY	FACILITY /1	WATER SOURCE	WATER RIGHT FILING QUANTITY	USES	NUMBER	ADJUDICATION QUANTITY	PRIORITY DATE	WATER RIGHT TYPE /2
Frenchman–Cambridge Div. Continued Meeker–Driftwood Unit	United States	Bartley Canal 17–03N–27W, Red Willow	Frenchman–Cambridge Div. Reservoirs		Irrigation	11533	130 Acres	4–1954	SI
	United States	Bartley Canal 17–03N–27W, Red Willow	Frenchman–Cambridge Div. Reservoirs		Irrigation	14158	142 Acres	4–1976	SI
				9 Acres	Irrigation	15812	9 Acres	3–1981	SI
	Frenchman–Cambridge Irr. Dist	Bartley Canal 17–03N–27W, Red Willow	Republican River	78.1 cfs 7,416 acres	Irrigation	3869DR	5,983 Acres	4–1946	IR
				2.9 cfs 273 acres	Irrigation	6217	246 Acres	4–1954	IR
	Frenchman–Cambridge Irr. Dist	Bartley Canal 17–03N–27W, Red Willow	Republican River	2.2 cfs	Irrigation	10196	115 Acres	5–1963	IR
				0.2 cfs	Irrigation	11042	14 Acres	2–1967	IR
	Frenchman–Cambridge Irr. Dist	Bartley Canal 17–03N–27W, Red Willow	Republican River	1.8 cfs 123 acres	Irrigation	11920	123 Acres	4–1970	IR
				0.1 cfs 6 acres	Irrigation	13229	6 Acres	10–1974	IR
				0.2 cfs 13 acres	Irrigation	14179	13 Acres	4–1976	IR
				9 acres	Irrigation	15803	9 Acres	3–1981	IR

REPUBLICAN BASIN WATER RIGHTS
Reservoirs/Lakes/Canals

UNIT DISTRICT	WATER RIGHT ENTITY	FACILITY /1	WATER SOURCE	WATER RIGHT FILING QUANTITY	USES	NUMBER	ADJUDICATION QUANTITY	PRIORITY DATE	WATER RIGHT TYPE /2
Frenchman–Cambridge Div. Continued Red Willow Unit	United States	Hugh Butler Lake 36–05N–30W, Frontier	Red Willow Creek	26,400 AF	Multi–Use	4885	----	7–1951	ST
				12,000 AF	Multi–Use	9858	----	8–1960	SS
	United States	Red Willow Canal 25–04N–29W, Red Willow	Frenchman–Cambridge Div. Reservoirs		Irrigation	6225J	3,324 Acres	4–1954	SI
	United States	Red Willow Canal 25–04N–29W, Red Willow	Frenchman–Cambridge Div. Reservoirs		Irrigation	11532	479 Acres	8–1968	SI
	United States	Red Willow Canal 25–04N–29W, Red Willow	Hugh Butler Lake	34 Acres	Irrigation	16602	----	11–1987	SI
	United States	Red Willow Canal 25–04N–29W, Red Willow	Frenchman–Cambridge Div. Reservoirs		Irrigation	14156	1,256 Acres	4–1976	SI
				52 Acres	Irrigation	15813	41 Acres	3–1981	SI
	Frenchman–Cambridge Irr. Dist	Red Willow Canal 25–04N–29W, Red Willow	Red Willow Creek	45.3 cfs 4,306 Acres	Irrigation	3869CR	2,847 Acres	4–1946	IR
				8.3 cfs 579 acres	Irrigation	6216	477 Acres	4–1954	IR
	Frenchman–Cambridge Irr. Dist	Red Willow Canal 25–04N–29W,	Red Willow Creek	8.4 cfs 590 acres	Irrigation	10195	483 Acres	5–1963	IR
				10.1 cfs 706 acres	Irrigation	12068	677 Acres	8–1970	IR
				52 acres	Irrigation	15806	41 Acres	3–1981	IR
				1.2 cfs 82 acres	Irrigation	12201	82 Acres	4–1971	IR
				242 acres	Irrigation	13230	234 Acres	10–1974	IR
				275 acres	Irrigation	14178	240 Acres	4–1976	IR
				39 acres	Irrigation	16601	----	11–1987	IR

REPUBLICAN BASIN WATER RIGHTS

Reservoirs/Lakes/Canals

UNIT DISTRICT	WATER RIGHT ENTITY	FACILITY /1	WATER SOURCE	WATER RIGHT FILING QUANTITY	WATER RIGHT FILING USES	WATER RIGHT FILING NUMBER	ADJUDICATION QUANTITY	PRIORITY DATE	WATER RIGHT TYPE /2
Bostwick Division	United States (Corps of Engineers)	**Harlan County Res.** 11-01N-17W, Harlan	Republican River	350,000 AF	Multi-Use	4190	----	1-1948	ST
Franklin Unit	United States	Franklin Canal 11-01N-17W, Harlan	Harlan County Res.	10,565 acres	Irrigation	62250	10,142 Acres	4-1954	SI
	United States	Franklik Canal 11-01N-17W, Harlan	Harlan County Res.	636 acres	Irrigation	13268	633 Acres	11-1974	SI
	United States	Franklin Canal 11-01N-17W, Harlan	Harlan County Res.	21 acres	Irrigation	14163	21 Acres	4-1976	SI
	United States	Franklin Canal 11-01N-17W, Harlan	Harlan County Res.	57 Acres	Irrigation	15518	57 Acres	12-1979	SI
	United States	Franklin Canal 11-01N-17W, Harlan	Harlan County Res.	101 acres	Irrigation	16108	101 Acres	5-1982	SI
	Bostwick Irr. Dist.	Franklin Canal 11-01N-17W, Harlan	Republican River	4,441 acres	Irrigation	2691A	4,303 Acres	4-1946	IR
	Bostwick Irr. Dist	Franklin Canal 11-01N-17W, Harlan	Republican River	4,013 acres	Irrigation	2691BR	3,757 Acres	4-1946	IR
	Bostwick Irr. Dist	Franklin Canal 11-01N-17W, Harlan	Republican River	1,958 acres	Irrigation	4216	1,929 Acres	2-1948	IR
	Bostwick Irr. Dist	Franklin Canal 11-01N-17W, Harlan	Republican River	168 acres	Irrigation	6221	153 Acres	4-1954	IR
	Bostwick Irr. Dist	Franklin Canal 11-01N-17W, Harlan	Republican River	145 acres	Irrigation	8259	145 Acres	11-1955	IR
	Bostwick Irr. Dist	Franklin Canal 11-01N-17W, Harlan	Republican River	53 acres	Irrigation	9623	53 Acres	5-1958	IR
	Bostwick Irr. Dist	Franklin Canal 11-01N-17W, Harlan	Republican River	18 acres	Irrigation	9724	18 Acres	4-1959	IR
	Bostwick Irr. Dist	Franklin Canal 11-01N-17W, Harlan	Republican River	314 acres	Irrigation	10964	314 Acres	10-1966	IR
	Bostwick Irr. Dist	Franklin Canal 11-01N-17W, Harlan	Republican River	106 acres	Irrigation	12796	103 Acres	2-1973	IR
	Bostwick Irr. Dist	Franklin Canal 11-01N-17W, Harlan	Republican River	21 acres	Irrigation	14162	21 Acres	4-1976	IR
	Bostwick Irr. Dist	Franklin Canal 11-01N-17W, Harlan	Republican River	57 acres	Irrigation	15488	57 Acres	6-1979	IR
	Bostwick Irr. Dist	Franklin Canal 11-01N-17W, Harlan	Republican River	101 acres	Irrigation	16099	101 Acres	5-1982	IR

REPUBLICAN BASIN WATER RIGHTS
Reservoirs/Lakes/Canals

UNIT DISTRICT	WATER RIGHT ENTITY	FACILITY /1	WATER SOURCE	WATER RIGHT FILING			ADJUDICATION QUANTITY	PRIORITY DATE	WATER RIGHT TYPE /2
				QUANTITY	USES	NUMBER			
Bostwick Division **Franklin Unit**	Bostwick Irr. Dist –Nebraska (Natural Flow)	Franklin Pump Canal 03–01N–14W, Franklin	Republican River	2,102 acres	Irrigation	4227	1,866 Acres	2–1948	IR
				190 acres	Irrigation	6222	184 Acres	4–1954	IR
	Bostwick Irr. Dist –Nebraska (Natural Flow)	Franklin Pump Canal 03–01N–14W, Franklin	Republican River	8 acres	Irrigation	10962	8 Acres	10–1966	IR
				24 acres	Irrigation	16150	23 Acres	9–1982	IR
	United States	Franklin Pump Canal 03–01N–14W, Franklin	Harlan County Reservoir	2,110 acres	Irrigation	6225P	2,050 Acres	4–1954	SI
				8 acres	Irrigation	15266	8 Acres	5–1978	SI
	Bostwick Irr. Dist			24 acres	Irrigation	16158	23 Acres	10–1982	SI
	–Nebraska (Natural Flow)	Naponee Canal 11–01N–17W, Harlan	Republican River	1,476 acres	Irrigation	4217	1,239 Acres	2–1948	IR
				125 acres	Irrigation	6220	80 Acres	4–1954	IR
				87 acres	Irrigation	9463	86 Acres	4–1957	IR
				11 acres	Irrigation	9722	11 Acres	4–1959	IR
				234 acres	Irrigation	10965	169 Acres	10–1966	IR
				65 acres	Irrigation	16148	65 Acres	9–1982	IR
	United States (Storage Use)	Naponee Canal 11–01N–17W, Harlan	Harlan County Res.	1,430 acres	Irrigation	6225N	1,396 Acres	4–1954	SI
				331 acres	Irrigation	13269	270 Acres	11–1974	SI
				65 acres	Irrigation	16156	65 Acres	10–1982	SI
Superior–Courtland Unit	Bostwick Irr. Dist	Superior Canal 07–01N–09W, Webster	Republican River	7,538 acres	Irrigation	2691CR	5,386 Acres	4–1946	IR
	Bostwick Irr. Dist	Superior Canal 07–01N–09W, Webster	Republican River	57 acres	Irrigation	4221	57 Acres	2–1948	IR
	Bostwick Irr. Dist	Superior Canal 07–01N–09W, Webster	Republican River	264 acres	Irrigation	6223	252 Acres	4–1954	IR
	Bostwick Irr. Dist	Superior Canal 07–01N–09W, Webster	Republican River	45 acres	Irrigation	9723	45 Acres	4–1959	IR

REPUBLICAN BASIN WATER RIGHTS
Reservoirs/Lakes/Canals

UNIT DISTRICT	WATER RIGHT ENTITY	FACILITY /1	WATER SOURCE	WATER RIGHT FILING			ADJUDICATION QUANTITY	PRIORITY DATE	WATER RIGHT TYPE /2
				QUANTITY	USES	NUMBER			
	Bostwick Irr. Dist	Superior Canal 07-01N-09W, Webster	Republican River	49 acres	Irrigation	9875	49 Acres	12-1960	IR
	Bostwick Irr. Dist	Superior Canal 07-01N-09W, Webster	Republican River	93 acres	Irrigation	10966	73 Acres	10-1966	IR
	United States	Superior Canal 07-01N-09W, Webster	Harlan County Reservoir	5,720 acres	Irrigation	6225R	5,638 Acres	4-1954	SI
	United States	Superior Canal 07-01N-09W, Webster	Harlan County Reservoir	187 acres	Irrigation	13271	167 Acres	11-1974	SI
	United States	Superior Canal 07-01N-09W, Webster	Harlan County Reservoir	141 acres	Irrigation	16107	117 Acres	5-1982	SI
	Bostwick Irr. Dist	Superior Canal 07-01N-09W, Webster	Republican River	141 acres	Irrigation	16100	117 Acres	5-1982	IR
	Bostwick Irr. Dist -Nebraska (Natural Flow)	Courtland Canal 07-01N-09W, Webster	Republican River	3,185 acres	Irrigation	4222	1,613 Acres	2-1948	IR
				218 acres	Irrigation	6224	114 Acres	4-1954	IR
				146 acres	Irrigation	10963	136 Acres	10-1966	IR
				42 acres	Irrigation	13210	34 Acres	9-1974	IR
				50 acres	Irrigation	16149	49 Acres	9-1982	IR
	United States (Storage Use)	Courtland Canal 07-01N-09W, Webster	Harlan County Res.	1,837 acres	Irrigation	6225S	1,727 Acres	4-1954	SI
				185 acres	Irrigation	13270	136 Acres	11-1974	SI
				92 acres	Irrigation	16157	83 Acres	10-1983	SI
	Kansas-Bostwick Irr. Dist No. 2	Courtland Canal 07-01N-09W, Nuckolls 11-01S-06W, Jewell	Republican River	827 cfs 130,000 AF	Irrigation	385	700 cfs 102,521 Acres	7-1948	IR & SI

REPUBLICAN BASIN WATER RIGHTS
Reservoirs/Lakes/Canals

UNIT DISTRICT	WATER RIGHT ENTITY	FACILITY /1	WATER SOURCE	WATER RIGHT FILING QUANTITY	USES	NUMBER	ADJUDICATION QUANTITY	PRIORITY DATE	WATER RIGHT TYPE /2
COLORADO Upper Republican Division Armel Unit	United States	Bonny Reservoir 15-05S-43W, Yuma	Republican River	351,460 AF	Multi-Use	18460	351,460 AF	11-1950	ST
KANSAS Kanaska Division Almena Unit	City of Norton	Norton Dam 08-35S-23W, Norton	Prairie Dog Creek (Norton Reservoir)	6.7 cfs 1,600 AF	Municipal	6917	4.9 CFS	2-1957	ST
	Almena Irr. Dist. No. 5	Norton Dam 08-35S-23W, Norton Almena Canal 24-02S-22W, Norton	Prairie Dog Creek	100 cfs 36,700 AF	Irrigation	6938A (Covers both Canal & Storage)	100 cfs 36,700 AF	2-1957	ST, IR & SI
Bostwick Division Courtland Unit	Kansas-Bostwick Irr. Dist. No. 2	Lovewell Reservoir & Courtland Canal 18-02S-06W, Jewell	White Rock Creek	635 cfs 41,690 AF	Multi-Use	4673	19,700 AF	10-1955	ST, IR

/1 Location of facility or point of Diversion = Section - Township - Range (Prime Meridian) - County. Prime Meridian shown only for states or areas where more than one exist. Section number may not show due to facility being in unsurveyed area or not recieved from Project Office.

/2 IR Irrigation from Stream using Natural Flow Appropriation
ST Storage
SO Stor only - Irrigation From Reservoir on Lands not Covered by Natural Flow Appropriations
SI Supplemental Irrigation - Irrigation from Reservoir on Lands also Covered by Natural Flow Appropriation
SS Supplemental Storage - an Appropriation that has a prior appropriation for storage

Part IV

Operating Agreement

FIELD WORKING AGREEMENT BETWEEN
DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS, AND
DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION
REGARDING OPERATION OF
HARLAN COUNTY DAM AND RESERVOIR
REPUBLICAN RIVER, HARLAN COUNTY, NEBRASKA

THIS AGREEMENT, made and entered into this 30 day of April, 1957, between the Corps of Engineers and Bureau of Reclamation, WITNESSETH THAT:

WHEREAS, the Department of the Army, acting through the Corps of Engineers, represented by its appropriate District Engineer, hereinafter referred to as the District Engineer, has constructed the Harlan County Dam and Reservoir on the Republican River near Alma, Nebraska, and is responsible for the safety of the structure, for flood-control operations of the reservoir, and for certain other operations as defined herein, and

WHEREAS, the Department of the Interior, acting through the Bureau of Reclamation, represented by its appropriate Project Manager, hereinafter referred to as the Project Manager, is responsible for irrigation operation of the comprehensive system of irrigation works in the Republican River Basin, and

WHEREAS, the irrigation storage in said dam and reservoir serves the comprehensive system of irrigation works, and

WHEREAS, a statement of operational objectives for purposes of flood control, irrigation, public health, recreation and fish and wildlife preservation has been agreed upon by the various Federal and State agencies concerned (a copy of the statement of operational objectives is attached as Appendix A), and

WHEREAS, the District Engineer and the Project Manager, together with other Federal and State agencies, are considered to have a varying degree, a joint interest in operational objectives other than flood control and irrigation, and

WHEREAS, there is need for a working agreement in order that there will be a clear understanding between the District Engineer and the Project Manager as to reservoir operations for irrigation and related conservation uses, including details of storage allocations and possible reallocations, hydrologic data collection and reporting arrangements.

NOW, THEREFORE, it is mutually understood and agreed by and between the parties hereto as follows:

1. Storage capacity allocations.--The storage capacity allocations of Harlan County Dam and Reservoir, exclusive of surcharge storage capacity above elevation 1973.5 feet, m.s.l., which is provided in combination with spillway capacity to insure safety of the structure, are defined in the following subparagraphs:

a. Flood-control storage.--Flood-control storage capacity shall include the storage capacity between elevation 1946.0 feet, m.s.l., and elevation 1973.5 feet, m.s.l. (initially amounting to 500,000 acre-feet).

b. Irrigation, conservation and sediment reserve storage.--Irrigation, conservation and sediment reserve storage capacity shall include the storage capacity below elevation 1946.0 feet, m.s.l. This capacity initially amounts to 350,000 acre-feet, of which 150,000 acre-feet are specifically planned for irrigation and 200,000 acre-feet are provided as a reserve for the accumulation of sediment. Until such time as sediment fully occupies the allocated reserve capacity, it will be used for irrigation and various conservation purposes including public health, recreation, and fish and wildlife preservation.

2. Storage reallocations.--The District Engineer shall at reasonable intervals make necessary field surveys and office studies to prepare estimates of the volume and location of sediment deposits in the reservoir. If the results of these studies show that the storage available for flood-control and irrigation, respectively, is reduced by an amount exceeding 10 percent of the specific allocation for either purpose, the operating plan described herein with respect to storage allocations and/or the elevation limits of the storage allocations shall be reviewed with the view of compensating for such reduction in storage capacity by assignment of equitable shares of an appropriate part of the remaining sediment reserve capacity.

3. Plan of operation.

a. The District Engineer will operate the storage capacity in the Harlan County Reservoir referenced in paragraph 1b, above, through appropriate instruction to the Reservoir Manager to supply the water requirements for the Bostwick Irrigation Project as prescribed by the Bureau of Reclamation, and to fulfill the other operational objectives stated in Appendix A insofar as may be practicable in accordance with general storage and release schedules worked out with the Project Manager and representatives of other interested agencies and agreed upon with the States in annual and more frequent conferences as may be necessary.

b. The Project Manager will furnish the District Engineer with weekly estimates of daily irrigation release requirements, which shall be subject to interim adjustment by the Project Manager as required.

The weekly estimates and interim adjustments shall be furnished simultaneously to the District Engineer and to operating personnel at the dam, using communication methods under detailed arrangements as may be made from time to time. Oral messages shall be confirmed in writing.

c. When the reservoir level is in the flood-control pool, the District Engineer will make such minimum releases as the Project Manager may prescribe as necessary to meet irrigation requirements. Procedures will be the same as given in paragraph 3b, insofar as applicable.

4. Operation and hydrologic data and reporting arrangements.--Proposed schedules of flood-control releases and flood-control storage changes, if available, and current operating data shall be provided to the Project Manager by the District Engineer. The current reservoir operating data shall be tabulated daily and furnished periodically as required, and shall include such items as: reservoir elevation, storage, inflow, and outflow. All available reports from meteorologic and stream-flow stations pertinent to the operation of the reservoir obtained by either the District Engineer or the Project Manager shall be exchanged as required. These data shall be furnished or exchanged by the most expeditious method of communication under detailed arrangements as may be made from time to time.

IN WITNESS WHEREOF, the parties hereto have caused this memorandum of agreement to be executed as of the day and date first above written.

CORPS OF ENGINEERS

By /s/ E. C. Adams
E. C. ADAMS
Colonel, Corps of Engineers
District Engineer
Kansas City District

BUREAU OF RECLAMATION:

By /s/ Paul H. Berg
PAUL H. BERG
Project Manager
Kansas River Projects Office

Attachment:
Appendix A - Statement of Objectives dated 27 June 1952